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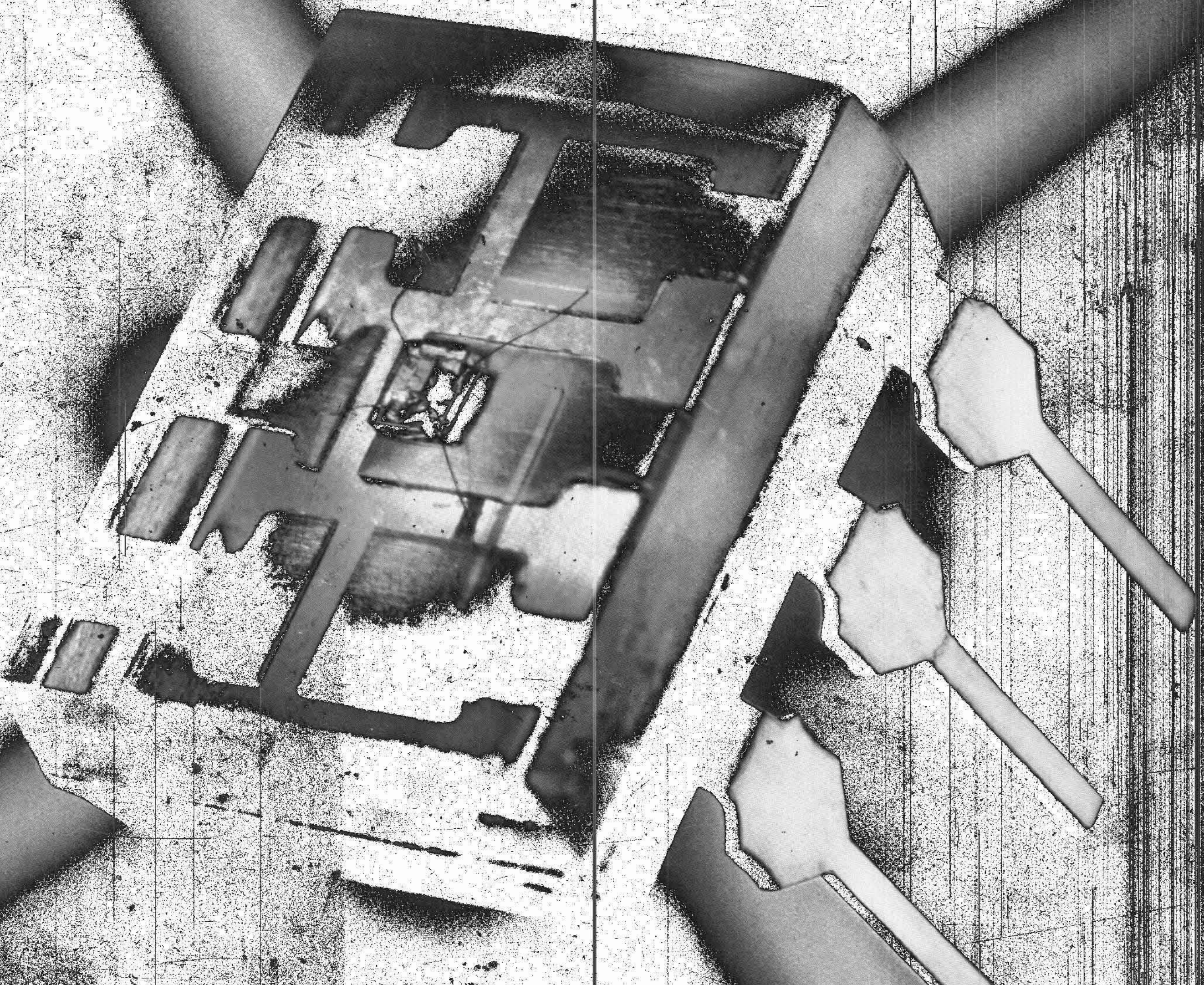
Optoelectronics



GENERAL ELECTRIC

General Electric Optoelectronics Manual

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GENERAL ELECTRIC

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INTRODUCTION

Optoelectronics, based on mass production semiconductor technology, is having a strong influence on the design of electronic control circuitry. Optoelectronic components sense the presence and strength of light, the position of objects which break or reflect a light beam, and transmit electronic signals without electrical connection. This provides, with the low cost, high speed, and high reliability of other mass-produced semiconductor devices, a variety of useful functions: from automatic light level control in copy machines, or sensing the right instant to fire an automobile's spark plug, to allowing delicate computer circuitry to control high power machine tools by passing logic signals to the power line circuitry, without allowing line voltages and noise back into the logic.

General Electric, being a continuing leader in both optoelectronics and semiconductor technology, has contributed heavily to optoelectronics from the invention of the light emitting diode and the first commercially successful opto SCR through to today's broadest line of optoelectronic circuit components. This handbook is written to provide the circuit designer knowledge of the operation, interfacing, and detailed application of these components, that he may successfully design practical, cost effective, and reliable circuitry. It also provides the specification sheets, selection guides and cross-reference information needed to obtain the optimum device for the task.

This handbook provides separate sections containing application information, specifications, and selectors with cross-references. In the application section, the handbook begins with basic devices and their operation and smoothly flows to circuit and system design interfacing the devices. It then discusses reliability and life considerations, and completes the picture with circuit designs grouped by function. In addition to the table of contents and logical ordering of material, a comprehensive index to the application information and glossary of terms allows "instant recall" of information as required. Since not all questions can be answered in the space provided, a list of further reference material is included.

TABLE OF CONTENTS

I. OPTOELECTRONIC THEORY

SECTION I: OPTOELECTRONICS THEORY

A. Optoelectronic Devices

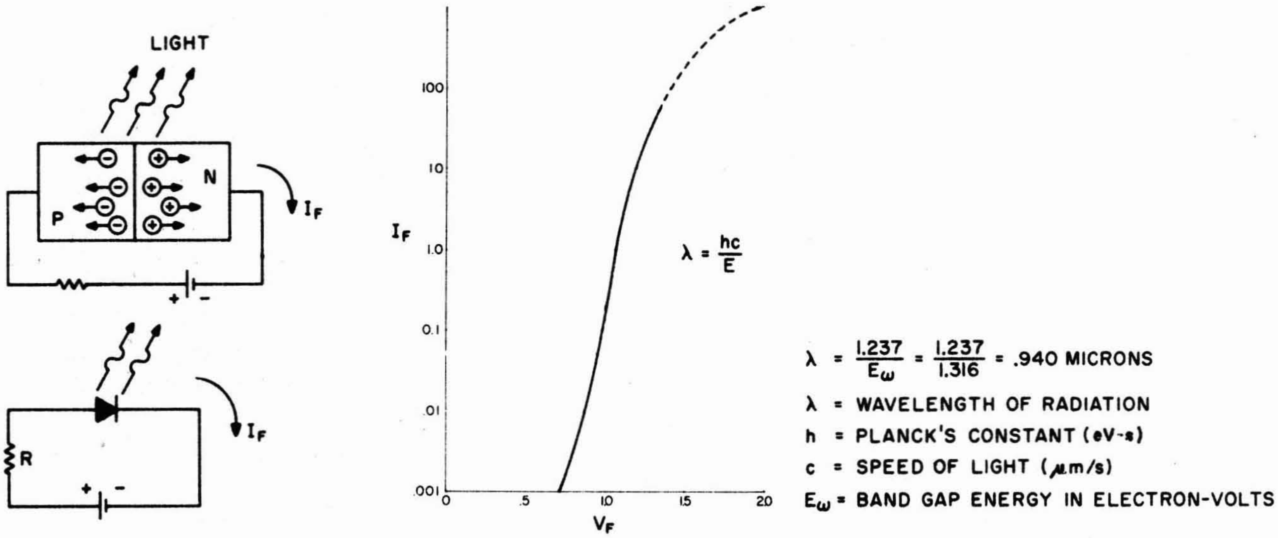
A basic knowledge of the devices used in optoelectronic applications is helpful in designing and optimizing circuits using them. Following is a brief description of the devices and the characteristics of interest in optoelectronic applications.

1. Light Sources

There are many different light sources to be considered, such as light emitting diodes, tungsten lamps (evacuated and gas filled), neon lamps, fluorescent lamps and Xenon tubes. Because all of these light emitters, except the LED, are designed to work as visible light sources, the information on their specification sheets is mainly concerned with the visible part of the spectrum. The information is given in photometric rather than radiometric terms. Many references contain excellent discussions of terms and definitions used in "light" measurement; a brief coverage of the quantitative aspects of light in optoelectronics is covered in a later section of these notes. Since the characteristics and operation of the conventional light sources (i.e., lamps, flash tubes, sunlight) is familiar, the only light source to be detailed is the light emitting diode (LED).

Junction luminescence, or junction electroluminescence, occurs as a result of the application of direct current at a low voltage to a suitably doped crystal containing a pn junction. This is the basis of the Light Emitting Diode (LED), which is a pn junction diode which emits light when biased in a forward direction. The light emitted can be either invisible (more precisely infrared), or can be light in the visible spectrum. Semiconducting light sources can be made in a wide range of wavelengths, extending from the near-ultraviolet region of the electromagnetic spectrum to the far-infrared region, although practical production devices are limited at this time to wavelengths longer than $\approx$ 500 nm. LED's for electronic applications, due to the spectral response of silicon and efficiency considerations, are normally infrared emitting diodes (IRED). The IRED is just an LED which emits invisible light in the near infrared region. Forward bias current flow in the pn junction causes holes to be injected into the N-type material and electrons to be injected into the P-type material; i.e., minority carrier injection. When these minority carriers recombine, energy proportional to the band gap energy of the semiconductor material is released. Some of this energy is released as light, while the remainder is released as heat, with the proportions determined by the mixture of recombination processes taking place. Since the energy contained in a photon of light is proportional to its frequency i.e., color, the higher the band gap energy of the semiconductor material forming the LED, the higher frequency light emitted. The GE – IRED has a relatively low band gap silicon doped, liquid epitaxy grown gallium arsenide material which provides superior efficiency and reliability in infrared light production (940 nm).

The electrical characteristics of the IRED are similar to any other pn junction diode, having a slightly higher forward voltage drop than a silicon diode due to the higher band gap energy, and a fairly low reverse breakdown voltage due to the doping levels required for efficient light production.



$\lambda = \frac{hc}{E}$

$\lambda = \frac{1.237}{E_\omega} = \frac{1.237}{1.316} = .940$ MICRONS

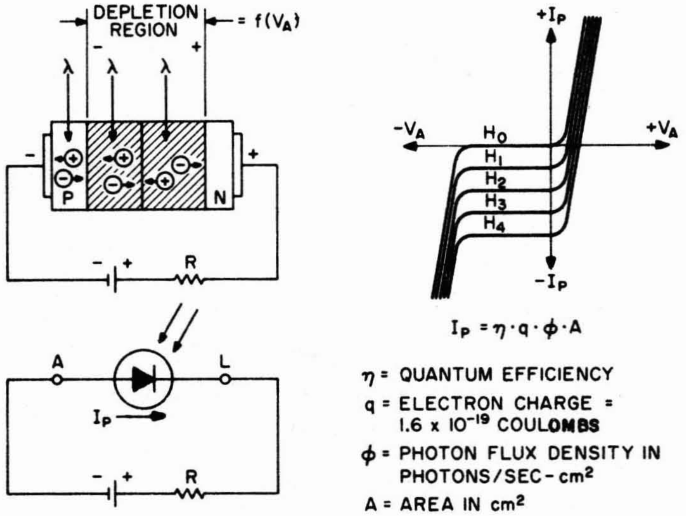
λ = WAVELENGTH OF RADIATION
h = PLANCK'S CONSTANT (eV-s)
c = SPEED OF LIGHT (μm/s)
E_ω = BAND GAP ENERGY IN ELECTRON-VOLTS

THE FORWARD BIASED LIGHT EMITTING DIODE PN JUNCTION

2. Light Detecting Devices

Having a source of light energized by electricity only provides half of the semiconductor optoelectronics picture. Light detectors, devices which convert light signals into electrical signals and based on mass produced silicon semiconductor technology, provides the other half of the modern semiconductor optoelectronics picture.

a. Photodiode – The basis of understanding silicon photosensitive devices is the reverse biased pn junction, photodiode. When light of the proper wavelength is directed toward the junction, hole electron pairs are created and swept across the junction by the field developed across the depletion region. The result is a current flow in the external circuit proportional to the effective irradiance on the device. It behaves basically as a constant current generator up to its avalanche voltage, shown graphically below. It has a low temperature coefficient and the response times are in the submicrosecond range. Spectral response and speed can be tailored by geometry and doping of the junction.



$I_P = \eta \cdot q \cdot \phi \cdot A$

η = QUANTUM EFFICIENCY
q = ELECTRON CHARGE = 1.6×10^{-19} COULOMBS
ϕ = PHOTON FLUX DENSITY IN PHOTONS/SEC-cm^2
A = AREA IN cm^2

LIGHT SENSITIVE REVERSE BIASED PN JUNCTION PHOTODIODE

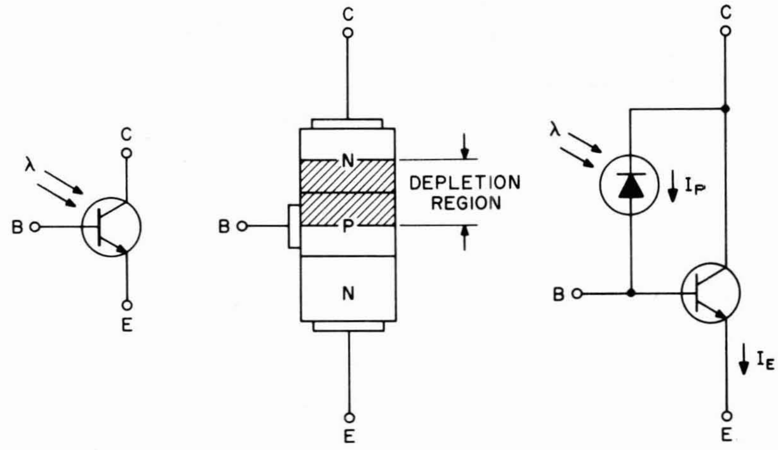
All common silicon light detectors consist of a photodiode junction and an amplifier. The photodiodes are usually made on a single chip of silicon from the same doping processes which form the amplifier section. In most commercial devices the photodiode current is in the submicroampere to tens of microamperes range, and the addition of an amplifier to the chip can be accomplished at minimal cost. Total device response to bias, temperature and switching waveforms becomes a combination of photodiode and amplifier system response.

The absorption coefficient of light in silicon decreases with increasing radiation wavelength. Therefore, as the radiation wavelength decreases, a larger percentage of the hole-electron pairs are created closer to the silicon surface. This results in the photodiode exhibiting a peak response point at some radiation wavelength. At this wavelength a maximum number of hole-electron pairs are created near the collector-base junction. The spectral response curve of the L14G phototransistor has a maximum at approximately 0.85 μm. For wavelengths longer than this, more hole-electron pairs are created deeper in the transistor beyond the photodiode (collector-base) junction. For shorter wavelengths, more of the incident radiation is absorbed closer to the device surface, and does not penetrate to the junction. Therefore, the spectral response characteristics of the photodiode are chiefly a function of the junction depth.

b. Phototransistor – The light sensitive transistor is one of the simplest photodiode-amplifier combinations. By directing light towards the reverse biased pn junction (collector-base), base current is generated and amplified by the current gain of the transistor. External biasing of base is possible, if that lead is brought out, so that the formula for emitter current is:

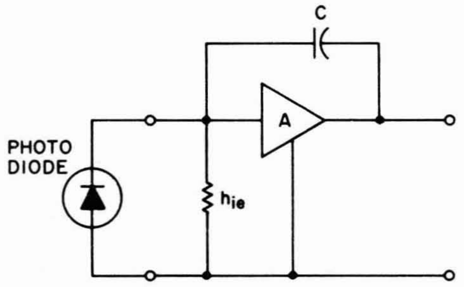
$$I_E = (I_P \pm I_B)(h_{FE} + 1)$$

where I_P = Photon generated base current
I_E = Emitter current
I_B = Base current
h_{FE} = Transistor DC current gain



LIGHT GENERATED CURRENT IN PHOTOTRANSISTOR

This shows that the sensitivity of this transistor can be influenced by different bias levels at the base. It also indicates that response of the phototransistor will vary as the h_{FE} varies with current, bias voltage, and temperature. Speed of response is affected by a greater factor than the speed of the transistor. Due to the capacitance of the photodiode, the low base currents and normally unterminated base contact causing high input impedance, and the voltage gain of the amplifier, it is found that the switching time of the combination is usually governed by the RC time constant of the base circuit, i.e., the input time constant of the amplifier. This leads to a



$t = f(A \times h_{ie} \times C)$
t = SWITCHING TIME
A = VOLTAGE GAIN
h_{ie} = INPUT IMPEDANCE
C = PHOTODIODE CAPACITANCE

PHOTOTRANSISTOR SWITCHING SPEED

generalization on photodetectors: "the higher the gain, the slower the response." Note that this generalization doesn't cover all cases, an example being the case where the voltage across the phototransistor is constant (i.e., $A = O$).

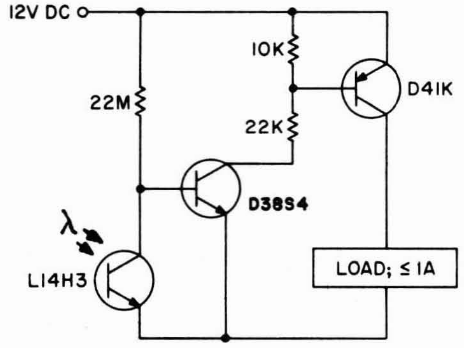
The high h_{FE} and large collector-base junction area required for high phototransistor sensitivity can also cause high dark current levels when the collector-base junction is reverse biased. The phototransistor dark current is given by

$$I_{CEO(DARK)} = h_{FE}\ I_{CBO}$$

where I_{CBO} is the collector-base junction leakage current. Careful processing of the transistor chip is required to minimize the phototransistor dark current and maintain high light sensitivity. Typical phototransistor dark currents at 10V reverse bias are on the order of 10 nanoamps at room temperature and increase by a factor of two for every 10°C rise in temperature.

Dark current effects may be minimized for low light level applications by keeping the base collector junction from being reverse biased, i.e., having a V_{CEO} of less than a silicon diode forward bias voltage drop. This technique allows light currents in the nanoampere range to be detected.

A circuit which illustrates this mode of operation follows:



USE OF PHOTOTRANSISTOR AT VERY LOW LIGHT LEVELS

This circuit will turn the load on when illumination to the L14H3 drops below approximately 0.5 foot-candle.

c. Photodarlington – Basically, this is the same as the light sensitive transistor, except for its much higher gain from two stages of transistor amplification cascaded on a single chip.

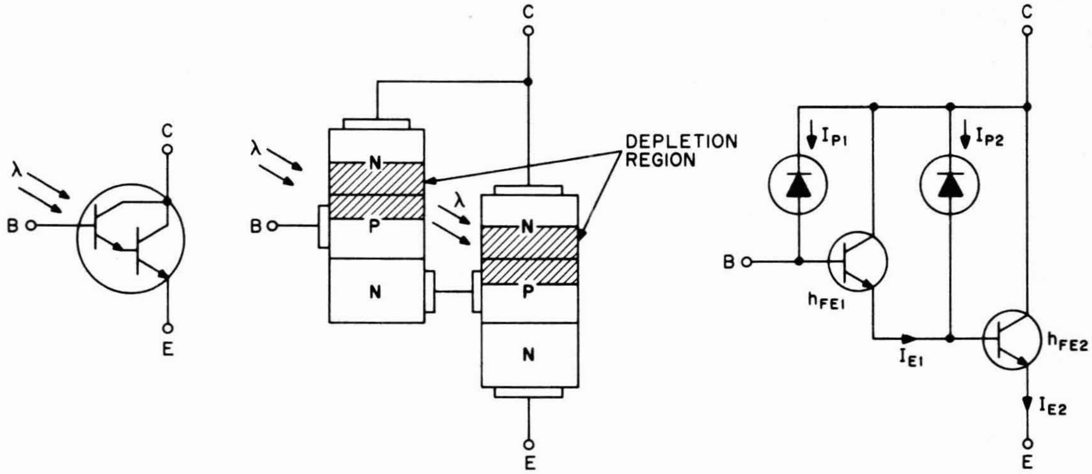


PHOTO DARLINGTON AMPLIFIER ILLUSTRATING THE EFFECTS OF PHOTON CURRENT GENERATION

$$\begin{aligned}
I_{E1} &= I_{P1}\,(h_{FE1} + 1)\\
I_{E2} &= (I_{P2} + I_{E1})\,(h_{FE2} + 1)\\
I_{E2} &= [I_{P2} + I_{P1}\,(h_{FE1} + 1)]\,(h_{FE2} + 1)\\
&\quad \text{Because } I_{E1} >> I_{P2}\\
I_{E2} &\approx I_{P1} \cdot h_{FE1} \cdot h_{FE2}
\end{aligned}$$

where I_E = Emitter Current
I_P = Photon produced current
h_{FE} = DC current gain of transistors 1 and 2
I_B = Base current

If we consider different bias levels at the base we can write:

$$I_{E2} = [I_{P2} + (I_{P1} \pm I_B)\,(h_{FE1} + 1)](h_{FE2} + 1)$$

Since $h_{FE} >> 1$, a close approximation to this equation is:

$$I_{E2} \approx (I_{P1} \pm I_B)\,h_{FE1} \circ h_{FE2}$$

This shows why the darlington connection is popular for applications where the light to be detected is of low level, with the h_{FE} product normally ranging from 10^3 to 10^5, high electrical signal levels are assured. As mentioned in the phototransistor section, speed of response does suffer, since the voltage amplification can never be brought to zero due to internal, parasitic, impedances which cannot be eliminated from the chip. Thus, photodarlington ultimate speed will always be less than phototransistor. Dark current effects, as mentioned under phototransistors, are also amplified by the increased gain of the darlington connection.

d. Photo SCR (Silicon Controlled Rectifier) – The two transistor equivalent circuit of the silicon controlled rectifier illustrates the switching mechanism of this device.

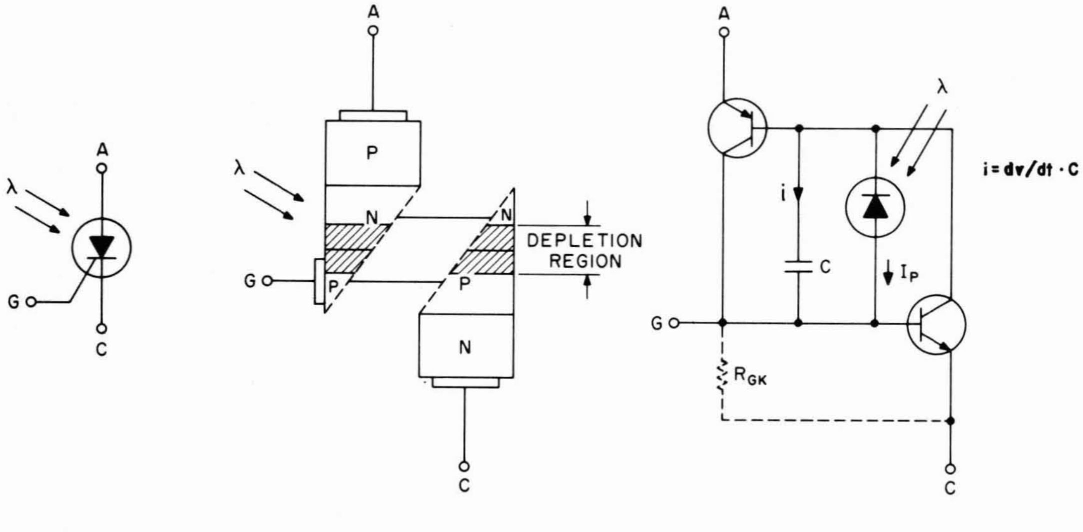


PHOTO SCR AND TWO TRANSISTOR EQUIVALENT CIRCUITS ILLUSTRATING THE EFFECTS OF PHOTON CURRENT GENERATION AND JUNCTION CAPACITANCE

Photon-current which is generated in the reverse biased pn junction reaches the gate region to forward bias the npn transistor and initiate switching. Part of this current, I_P, can be channeled around the gate-cathode terminal to decrease sensitivity. This is also expressed in the formula for I_A by the expression ($I_P \pm I_G$).

$$I_A = \frac{\alpha_2 \left[(I_P \pm I_G) + I_{CBO(1)} + I_{CBO(2)} \right]}{I - \alpha_1 - \alpha_2}$$

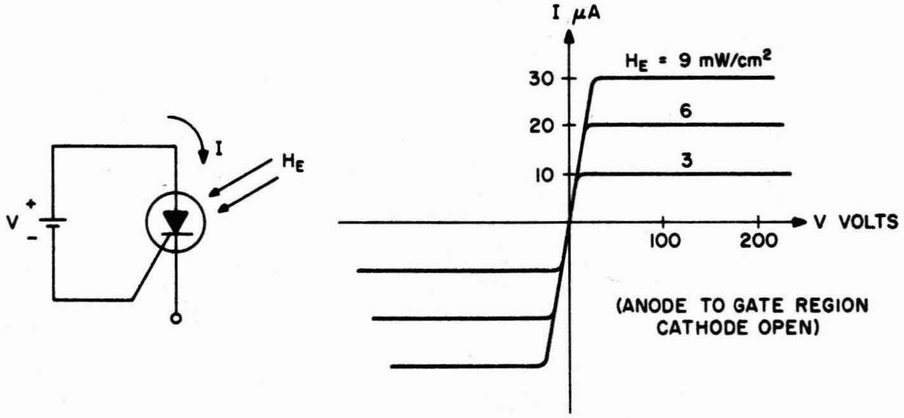
when $\alpha_1 + \alpha_2 \Rightarrow 1$ then $I_A \Rightarrow \infty$
I_A = Anode Current
I_P = Photon Current
I_G = Gate Current

$I_{CBO(1)}$ & $I_{CBO(2)}$ – Leakage Currents
α = Current Gain
α_1 – Varies with I_A and I_P
α_2 – Varies with I_A and $I_P \pm I_G$

In discrete device literature the Photo SCR is often abbreviated LASCR, i.e., Light Activated SCR. As the photodiode current is of very low level, a LASCR must be constructed so that it can be triggered with a very low gate current. The high sensitivity of the LASCR causes it to be sensitive also to any effect which will produce an internal current. As a result, the LASCR has a high sensitivity to temperature, applied voltage, rate of change of applied voltage and has a longer turn-off time than normally expected of a SCR.

All other parameters of the LASCR are similar to the regular SCR, so that the former can be triggered with a positive gate signal of conventional circuit current, as well as being compatible with the common techniques of suppressing unwanted sensitivity. All commercially available LASCR types of devices are of comparatively low current rating (<2A) and, thereby, can be desensitized to extraneous signals with small, low cost, reactive components.

Note that the schematic representation of the LASCR contains a high voltage phototransistor pnp between the anode (A) and gate (G) terminals. Due to physical construction details, this "transistor" is of low gain and behaves as a symmetrical transistor, i.e., emitter and collector regions are interchangeable. Due to the low gain, photo response is quite stable in this configuration. In fact, this connection is used with the L9UX4 which is a factory-calibrated unit used for measurement of irradiance.



TYPICAL PNP PHOTOTRANSISTOR ACTION OF L9 LASCR

Due to the high voltage junction parameters, the LASCR has unique spectral and dark current characteristics compared to the devices mentioned previously.

B. Optoelectronic Components

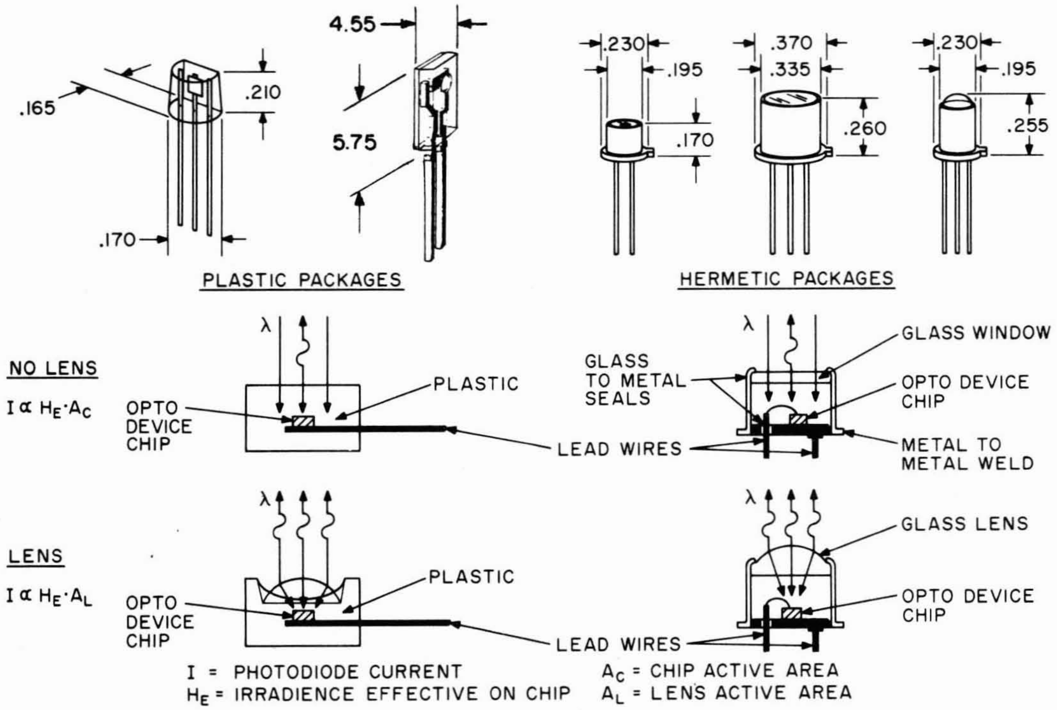
Detailing the basic device characteristics and operation provides an understanding of what can be expected from the semiconductor, but leaves unresolved the actual component characteristics, which will be affected by both device and package parameters. The basic optoelectronic devices can be packaged to provide:

- discrete detectors and emitters, which emit or detect light;
- interrupter/reflector modules, which detect objects modifying the light path;
- isolators/couplers, which transmit electrical signals without electrical connection.

The following descriptions will provide an insight into the various package characteristics and how they modify the basic devices already described.

1. Optoelectronic Detectors and Emitters

Optoelectronic components require packaging which not only protect the chip, but also allow light to pass through the package to the chip, i.e., a semiconductor package with a window. The window can be modified to provide lens action, which gives higher response on the optical axis of the lens, greater directional sensitivity and a larger aperture with less resolution. In most commercial components, the lens is also an integral part of the package, for economic reasons, so the tight control of optical tolerances are compromised somewhat to optimize chip protection via the hermetic seal. This causes lensed components to exhibit wider variations, unit to unit, than simple window components, as the optical gain variations and the basic device response variations are multiplied. Due to these factors, when high gain, highly directional optical systems are required, it is normal procedure to recommend components without integral lenses be used in conjunction with external optics of the required quality.

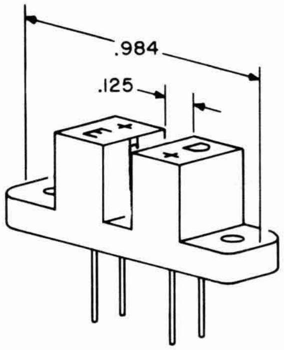


DISCRETE OPTOELECTRONIC COMPONENT PACKAGE CONCEPTS

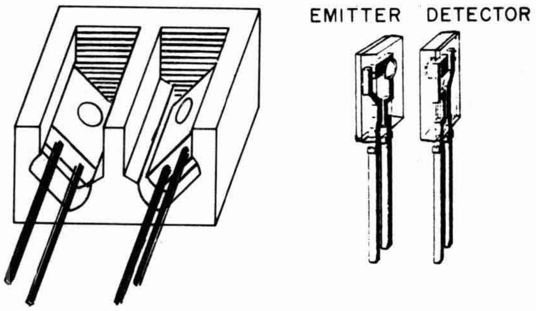
The other major factor in detector/emitter packaging is the choice of a plastic or hermetic package. Either is available with or without lens, although the plastic devices have the optical axis perpendicular to the leads, while the hermetic package optical axis is parallel to the leads. The hermetic package will operate at higher power, over a wider temperature range and is more tolerant of severe environments, but it is also relatively more expensive than the plastic. Although some components are limited to a single package type, on most the user must weigh the application's technical and economic constraints, to optimize both the device and package of the opto-electronic component used.

2. Interrupter/Reflector Modules

The use of interrupter or reflector modules eliminates most of the optical calculations, and geometric and conversion problems in mechanical position sensing applications. These modules are specified electrically at the input and output simultaneously – i.e., as a coupled pair – and have defined constraints on the mechanical input. All the designer need do is provide the input current and mechanical input (i.e., pass an infrared-opaque object through the interrupter gap) and monitor the electrical output. Other than standard tolerance, resolution, and power constraints, the only new knowledge required is the ability of the sensed object to block or reflect infrared light and an estimate of the effects of ambient light conditions providing false signals. This is true of both "off the shelf" commercial modules and limited volume "home brew" custom modules, as the mechanical and optical parameters of any given module are fixed. Once the module is characterized for minimum and maximum characteristics, it is a defined electrical and mechanical component and doesn't require optical design work for each new application. This puts these sensor modules in the same design category as mechanical precision limit switches, except that with the activating mechanism blocking or reflecting light instead of applying a force. Thus, mechanical wear and deformation effects are eliminated.



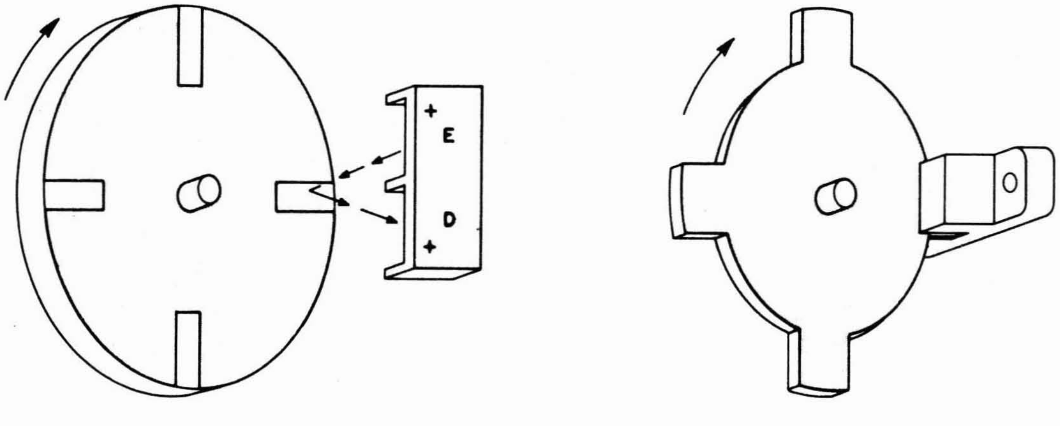
INTERRUPTER MODULE



REFLECTOR MODULE BUILT FROM H23

Most commercially available interrupter modules are built around plastic packaged emitters and detectors. Reflective modules and other custom modules are built around both plastic and hermetic parts, depending on the cost/performance trade-offs required. It should be noted that due to the longer, angle critical, and generally less efficient light transmission path in a reflector module, lensed devices are dominant in these applications. This also explains the lack of standard reflective modules, because tight spacing between the module and the mechanical actuator must

SHAFT ENCODER APPLICATION ILLUSTRATION



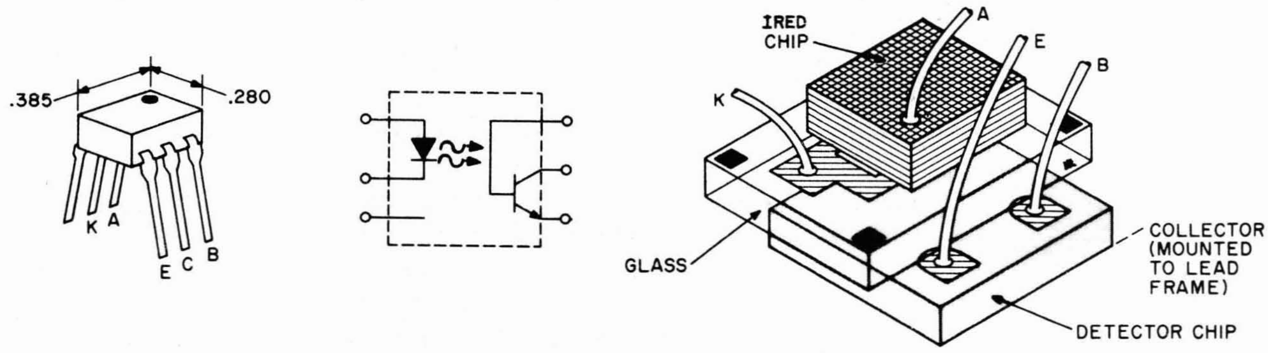
REFLECTOR MODULE

INTERRUPTER MODULE

be maintained to provide adequate optical coupling, leading to different mechanical mounting requirements for each mechanical system sensed.

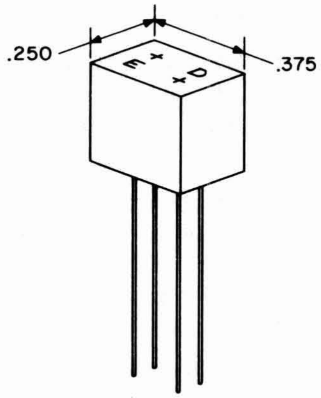
3. Optocouplers

Optocouplers, also known as optoisolators, are purely electronic components. The light path, IRED to photodetector, is totally enclosed in the component and can't be modified externally. This provides one way transfer of electrical signals, from the IRED to the photodetector, without electrical connection between the circuitry containing the devices. The degree of electrical isolation between the two devices is controlled by the material in the light path and by the physical distance between the emitter and detector. (i.e., the greater the distance, the better the isolation.) Unfortunately, the current transfer ratio (CTR), the ratio of detector current to emitter current, i.e., the effectiveness of electrical signal transfer, is inversely proportional to this separation and some type of compromise has to be made to achieve the most optimum effects. In the case of the dual in-line package, the use of optical glass has proven to be a most efficient dielectric. It allows maximum CTR and a minimum separation distance for a given isolation voltage withstand capability. Minimum (H11A5100) CTR's of 100% in combination with isolation voltages of 5000 V in phototransistor couplers result. Also, because of the glass dielectric design, yields are much more predictable, due to easier alignment of LED and detector and common side wire bonding, versus other methods of manufacture.



DUAL IN-LINE PACKAGE (DIP) OPTOCOUPLER, ILLUSTRATING GLASS ISOLATION CONSTRUCTION TECHNIQUE

Although the DIP package is the most common coupler, other packages are commercially available to provide higher isolation voltage and other special requirements. For very high isolation voltage requirements (10 to 50 kV) the H13 interrupter module can be modified by the user at very low cost by putting a suitable dielectric (glass, acrylic, silicone, etc.) in the air gap and insulating and encapsulating the lead wires. For higher isolation voltages the use of the H19 matched pair with glass or infrared transmitting fiber optics can provide a low cost isolator. Both of these approaches utilize coupler systems which are already characterized and so are easily handled from a design standpoint.



H15 OPTOCOUPLER, 4000V ISOLATION VOLTAGE

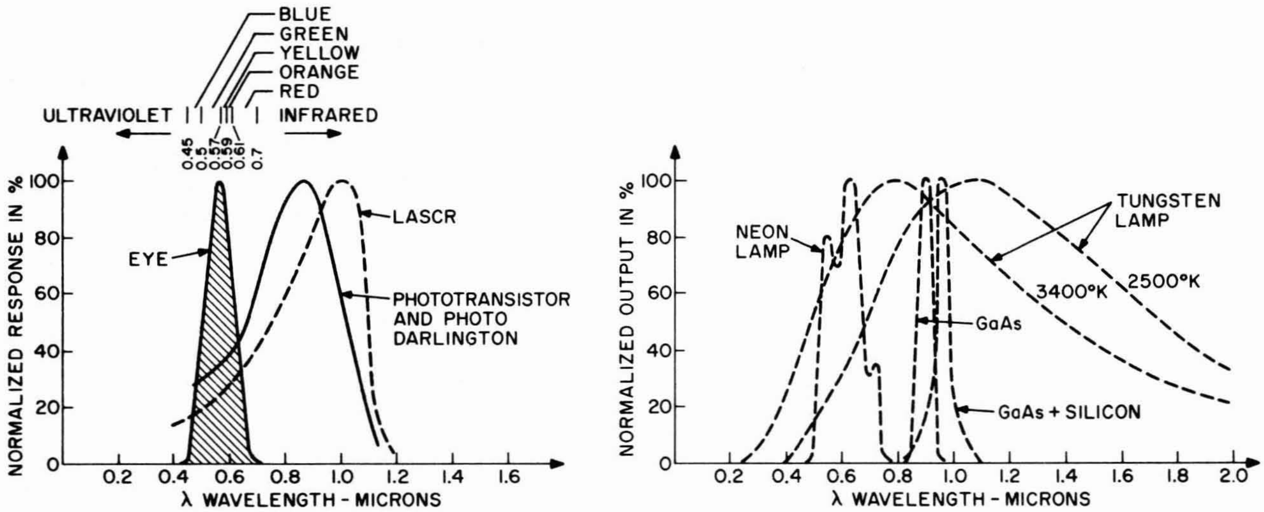
SECTION II : SYSTEMS DESIGN CONSIDERATIONS

A. Emitter and Detector Systems

1. Light, Irradiance and Effectiveness

When the word "light" is used in this discussion instead of electromagnetic radiation, it does not refer to just the visible part of the spectrum, but to the spectrum where silicon light sensitive devices have their sensitivity. Using the word "light" is obviously wrong due to the infrared component, but it has become accepted usage.

The normalized response of silicon light sensitive devices and output of sources is illustrated below. Peak spectral response is found at around 0.85 microns or 8500 Angstroms (Å) (1 Å = 10^{-10} meters) for the light activated transistors but shifts down to 1.0 micron for the LASCR. The response of the eye is shown for comparison, but it can be treated just like any other light sensitive device. When the silicon detector response and sources are compared, note the IRED GaAs and GaAs (Si) are capable of most efficient coupling.



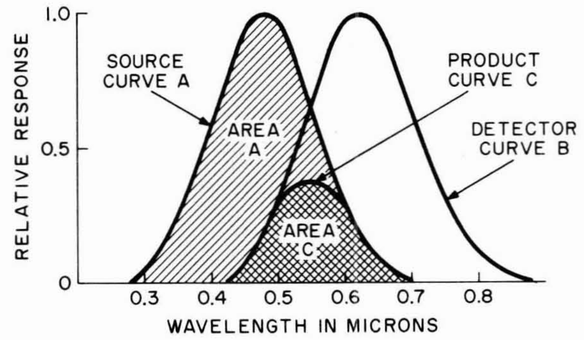
LIGHT SENSITIVE DEVICES

LIGHT EMITTING DEVICES

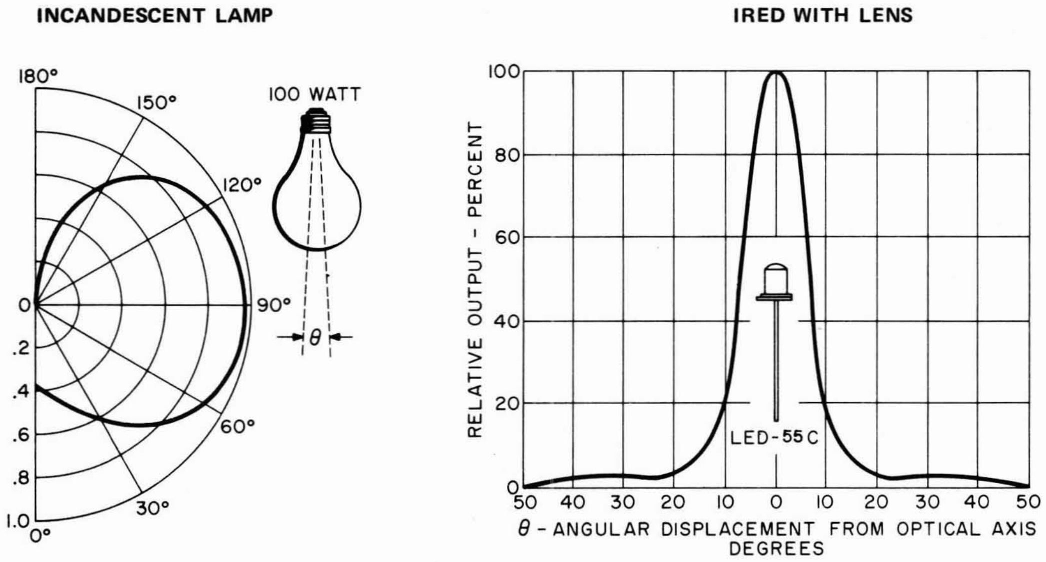
NORMALIZED SPECTRAL CHARACTERISTICS OF LIGHT SENSITIVE AND LIGHT EMITTING DIODES

Since the spectral characteristics of most sources and detectors do not match, a rigorous determination of the response of the photodetector to a given incident light level (Irradiance, H) would require determining the irradiance and spectral content of the light, then the spectral response and sensitivity of the detector, integrating the spectral response and spectral content to determine effectiveness, multiplying by the irradiance to determine the effective irradiance (H_E) and the sensitivity to determine the response. If the irradiance isn't easily measurable (the normal case) it is determined by analyzing the power into the source (P_{in}), the conversion efficiency of the source in producing light (η), the spacial distribution of the output and the transmissivity of the light path.

$$\text{EFFECTIVENESS} = \frac{\text{AREA UNDER CURVE C}}{\text{AREA UNDER CURVE A}} = \frac{\int^{\lambda} f(A) \cdot f(B)}{\int^{\lambda} f(A)}$$



EFFECTIVENESS OF SOURCE A ON DETECTOR B



SPACIAL DISTRIBUTION OF LIGHT SOURCES

In practice, it is found that there is variation in all these parameters, and for feasibility studies, approximations are used to "ball park" responses, then in the prototype stage effective irradiance is measured using calibrated detectors and "worst case" (or a distribution of) sources to analyze worst case and tolerance effects.

DETECTORS RADIATORS		HUMAN EYE	SILICON PHOTOTRANSISTORS
Tungsten Lamp	2000°K	.003	.16
	2200°K	.007	.19
	2400°K	.013	.22
	2600°K	.021	.24
	2800°K	.030	.27
	3000°K	.044	.30
Neon Lamp		.35	.7
GaAs LED 0.9μ		0	1.0
GaP LED 0.7μ		.08	.7
Fluorescent Lamp		.1	.4
Xenon Flash		.13	.5
Sun		.16	.5

APPROXIMATE EFFECTIVENESS OF VARIOUS SOURCES

To illustrate the feasibility study and approximations, consider a 10W tungsten lamp source and a silicon phototransistor of 1 mA/mW/cm² (H_E) sensitivity, 0.1 meter (4 inches) apart:

$$P_{out} = \eta \cdot P_{in} \cong .85(10) = 8.5\text{W}$$

Conversion efficiency of tungsten lamps is 80% for gas filled and 90% for evacuated lamps.

Assuming a spherical distribution of light from the lamp –

$$H_T = \frac{P_{out}}{4 \cdot \pi \cdot d^2}\ \text{mW/cm}^2 \cong \frac{8500}{12.56\ (10)^2} = 6.8\ \text{mW/cm}^2$$

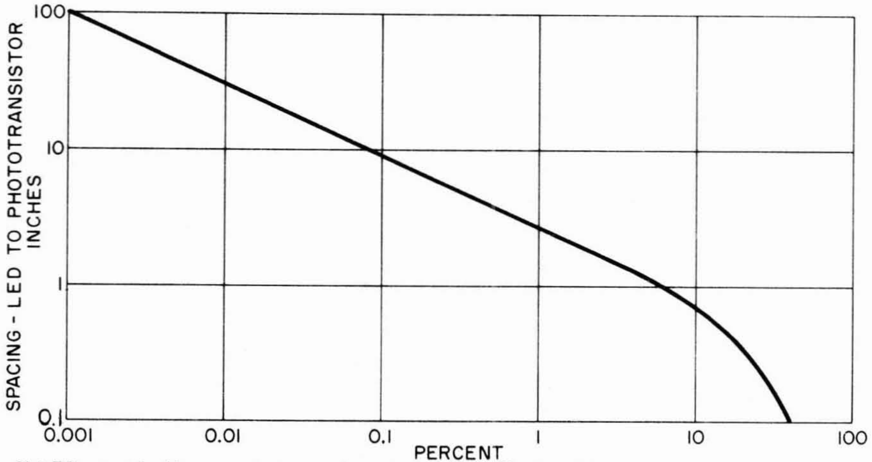
$$H_E = 0.25 \cdot H_T\ \text{mW/cm}^2 = 1.7\ \text{mW/cm}^2$$

Assuming that there are no transmission losses in the path, the phototransistor collector current is: $I_C = 1\,\text{mA/mW/cm}^2 \times 1.7\,\text{mW/cm}^2 = 1.7\,\text{mA}$,

where: P_{in} – Power input (mW)
P_{out} – Power output (mW)
d – Distance (cm)
η – Conversion efficiency of light source
H_T – Total irradiance (mW/cm²)
H_E – Effective irradiance (mW/cm²)
I_c – Transistor collector current

For the IRED, or any lensed device, the spacial distribution of energy is determined by the lens characteristics, and no simple relationship exists for general cases. For the case of the LED-55/56 series IRED, with the phototransistor on the axis of the light beam, analysis of the beam pattern in a piece-wise linear integration indicates:

$$H_E \cong 2.6\ P_o/(d + 1.1)^2 \quad (d \geqslant 1\ \text{cm})$$



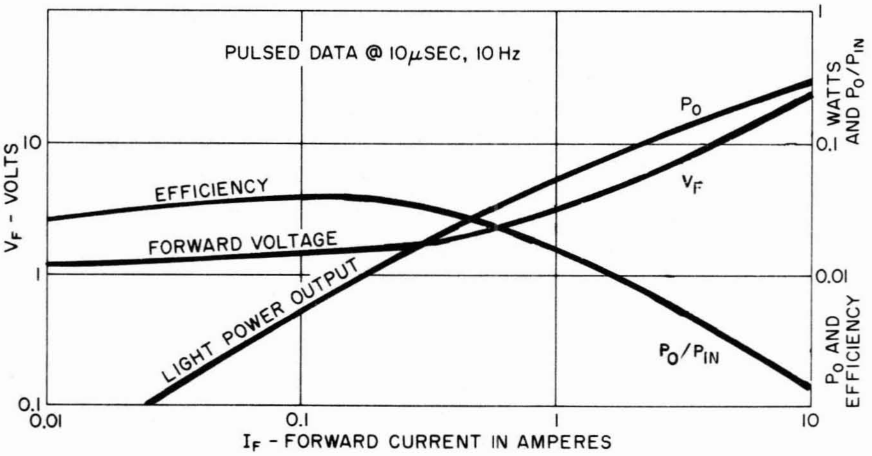
% LED output incident on phototransistor lens (0.1 cm^2) of L14G or L14F on axis, clear path transmission: To find H_{equiv} @ 2870°K (spec condition) multiply P_O of LED by 30 times this percentage.

LED TO PHOTOTRANSISTOR COUPLING CHART

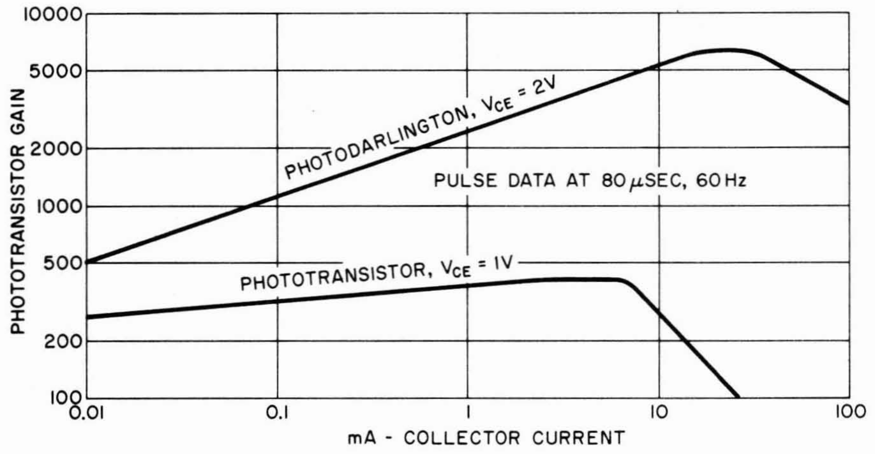
The IRED will only have efficiencies of 1% to 6%, and on a steady-state basis is limited to about 150 mW power dissipation in a normal range of ambients. For the same 10 cm spacing, using the IRED at 150 mW and 4% efficiency, the transistor collector current is:

$$
\begin{aligned}
I_c &= 2.6\ (150\,\text{mW})\ (.04)\ (1\ \text{mA/mW/cm}^2)/(11.1\ \text{cm})^2 \\
&= .13\,\text{mA}
\end{aligned}
$$

less than one-tenth the current the lamp generates, but with an input power of only 1.5% that of the lamp, the efficiency of the total system has risen by roughly a factor of 6 due to the lens and the effectiveness of the light. If the IRED is operated in a pulsed mode, P_o can be raised to 50 times the steady-state value for short times ($\sim 1\ \mu$sec) and low repetition rates (200 pps), although efficiency suffers above the 500 mA ($\approx$1W) bias point. The effects of lens misalignment, temperature, tolerances, and aging all must be evaluated before "worst case" or "Gaussian" expected performance can be determined, and this usually follows initial breadboard verification of the assumptions made above. In "tough" applications, the LED output and transistor photodiode and gain characteristics must now be evaluated to analytically determine response.



I_F, FORWARD CURRENT IN AMPERES
TYPICAL POWER OUT, FORWARD VOLTAGE AND EFFICIENCY OF LED 55 SERIES



TYPICAL PHOTO DETECTOR CURRENT GAINS IN PHOTO CONDUCTION

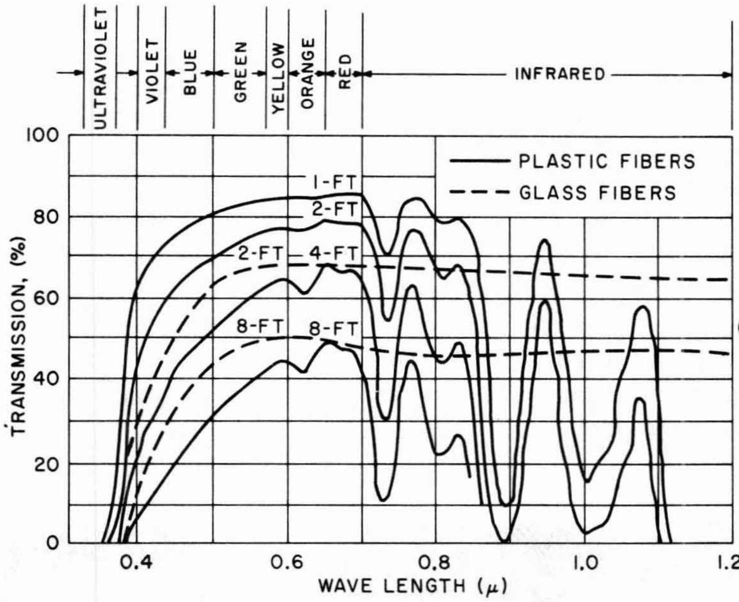
CHECK LIST	SOURCE
1. Relationship between the radiator's input electrical power and peak axial intensity of radiation	Specification Sheet
2. The radiator's relative radiation pattern	Specification Sheet
3. The radiator's relative output as a function of wavelength*	Specification Sheet
4. Distance between radiator and receiver	Design Requirements
5. Angular relationship between axis of radiator and receiver	Design Requirements
6. Relative acceptance pattern of receiver	Specification Sheet
7. Relative sensitivity of receiver as a function of wavelength*	Specification Sheet
8. Sensitivity of receiver	Specification Sheet
9. Light transmission efficiency	Path Material Properties

*Numbers 3 and 7 are not needed if the effectiveness is known.

CHECK LIST OF REQUIRED SOURCE/DETECTOR INFORMATION

The transmission of the light from source to detector is normally not a problem and can be checked visually, but not always. Some organic materials, i.e., plastics, have strong attenuation of near infrared wavelengths such that, although they look transparent and will work with incandescent light, they will not work with IRED's. Fiber optics systems are the most common area where this problem occurs, and as with all optics systems, entrance and exit light losses must also be considered.

Another criterion for selecting the proper light source is the speed at which the system has to work. As can be seen in the figure below, applying ac or unfiltered dc to light emitting devices may change their effective irradiance by as much as 30% for tungsten lamps, or as much as 100% for IRED's. Only filtered dc will yield constant effective irradiance for all light emitting devices.



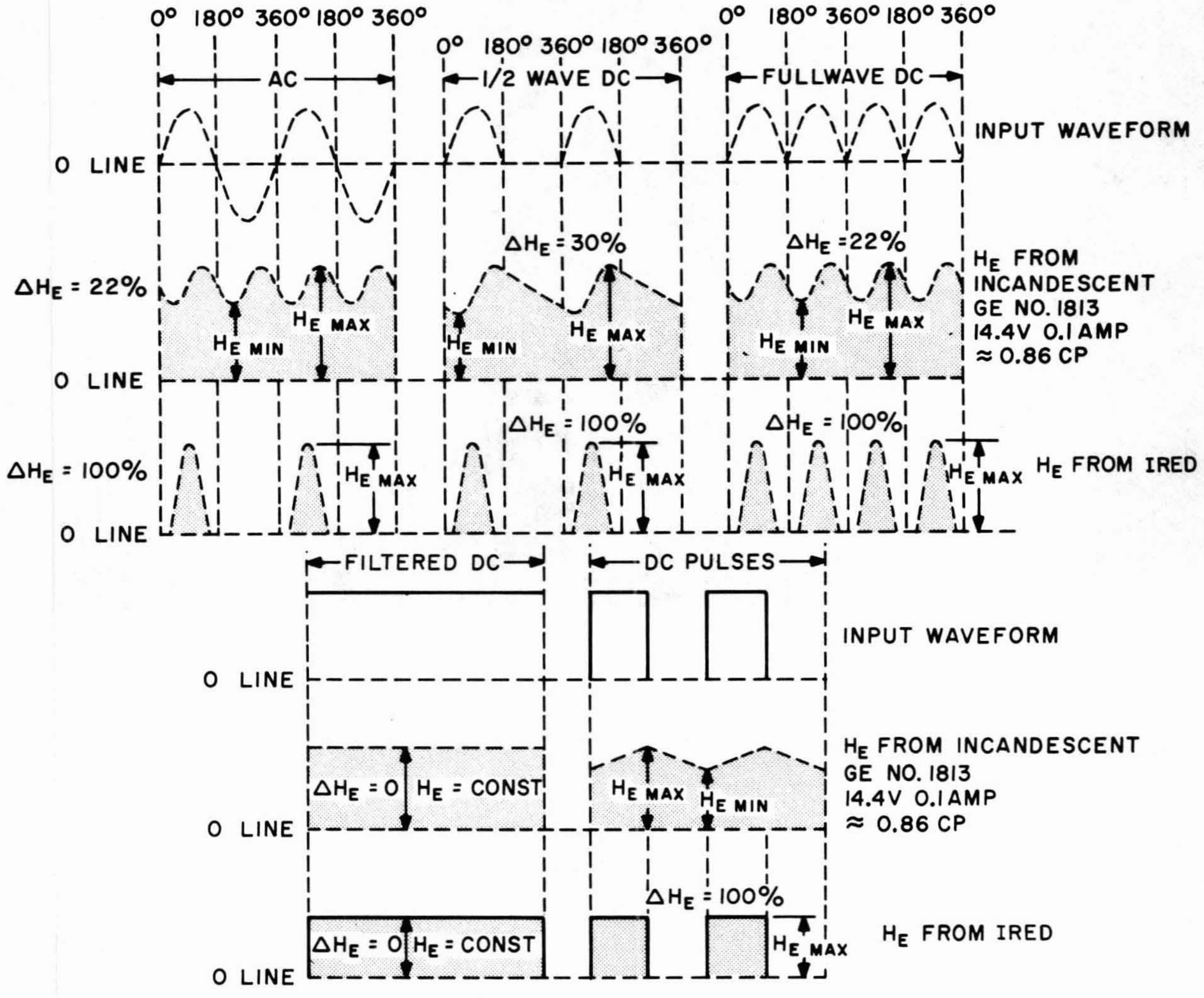
RULE OF THUMB

GLASS FIBER LOSS ≈ 30% + 10%/FOOT

$H_{OUT} = H_{IN} \cdot 0.7 \cdot (0.9)^X$

X = FEET

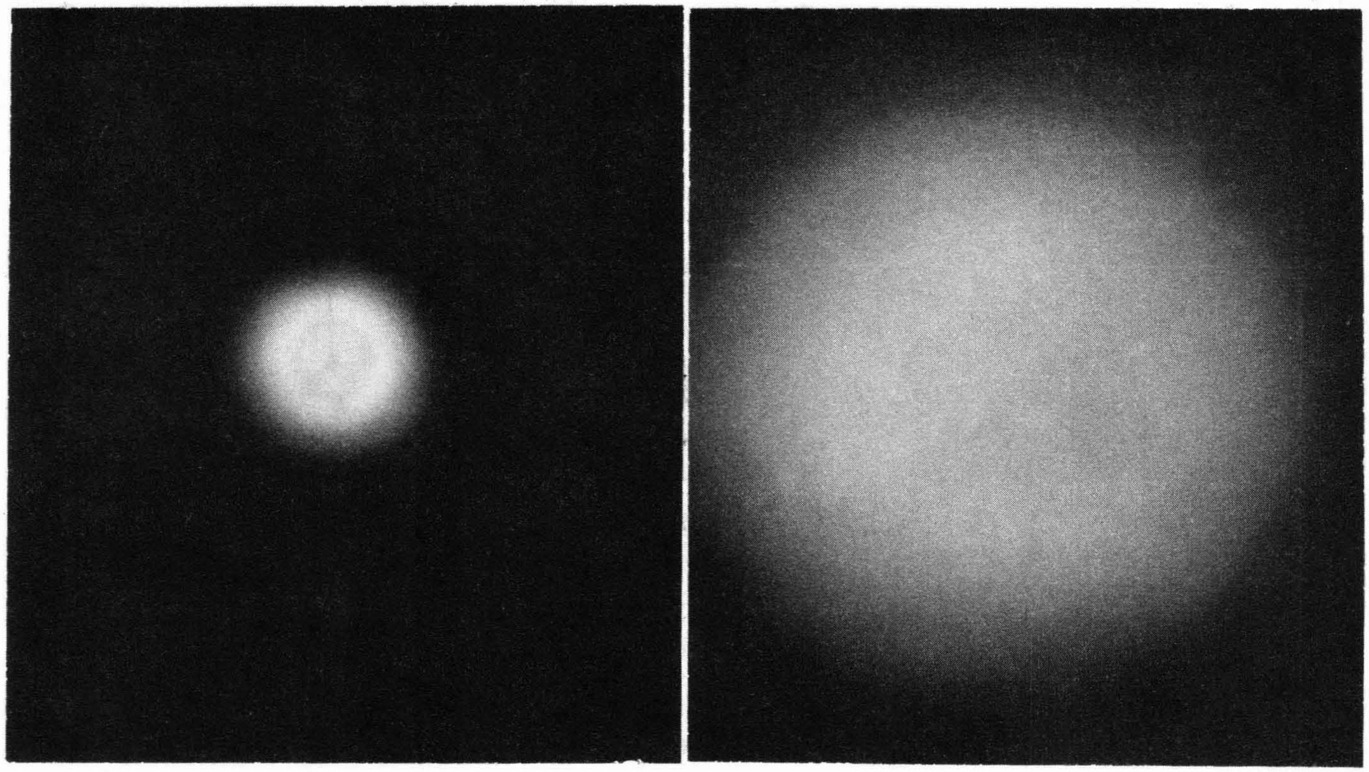
TRANSMISSION CHARACTERISTICS OF GLASS FIBER OPTICS AND PLASTIC FIBER OPTICS



TIME DEPENDANCE OF IRRADIANCE FOR VARIOUS POWER SUPPLIES

2. Lenses

Simple converging lenses are commonly used to extend the range and improve the directionality of optical systems. Improved directionality minimizes pick up or "stray" ambient light, as well as defining the volume in which an object can be sensed. In emitter-detector systems (as opposed to light level sensing) range is increased by focusing the light from the emitter into a beam and/or by focusing the received light on the detector. Focused reflectors may be used to perform the same functions, and are normally analyzed using the same techniques, although losses are generally higher. Optimum mechanical performance and optical efficiency is obtained when optoelectronic components without built-in lenses are used, although both range and directivity are also improved when using lensed devices.



LED 55C
INTEGRAL LENS

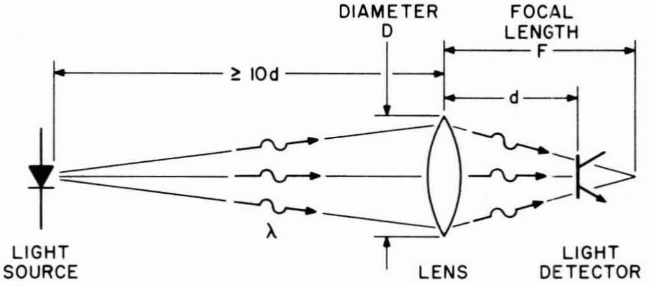
LED 55CF
NO LENSES

TYPICAL INFRARED IRRADIATION PATTERN OF IRED ON SURFACE 5 CM. AWAY
(ACTUAL SIZE)

Lenses are normally specified by the f/number, i.e., focal length divided by effective diameter, and either the effective diameter or the focal length. Normally, the effect on

$$f\ \# = \frac{\text{Focal Length}}{\text{Effective Diameter}}$$

H, irradiance, of adding a lens to the detector end of a system can be simply approximated by the ratio of the area of lens to the area illuminated in the plane of the base of the phototransistor times the irradiance incident on the lens. Note that this approximation is *only* valid for irradiance which approximates a point source, i.e., the diameter of the light source is less than 0.1, its distance from the lens and that the lens will reflect and attenuate the result by about 10%.



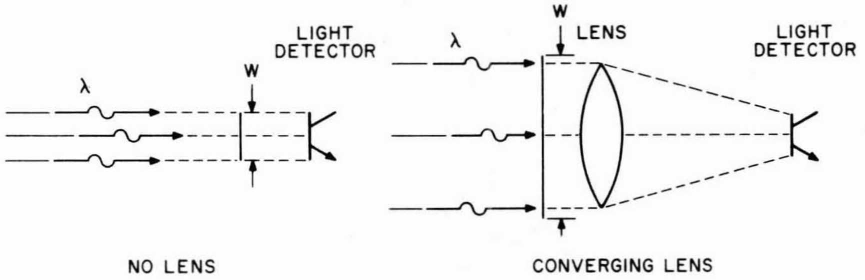
$$H_{DETECTOR} \cong 0.9\, H_{LENS} \frac{1}{(1 - D/F)^2}$$

$$\cong 0.9\, H_{LENS} \frac{1}{(1 - 1/f\#)^2}$$

WHEN IMAGE FALLS ON DETECTOR ACTIVE AREA, i.e. d ≈ F.

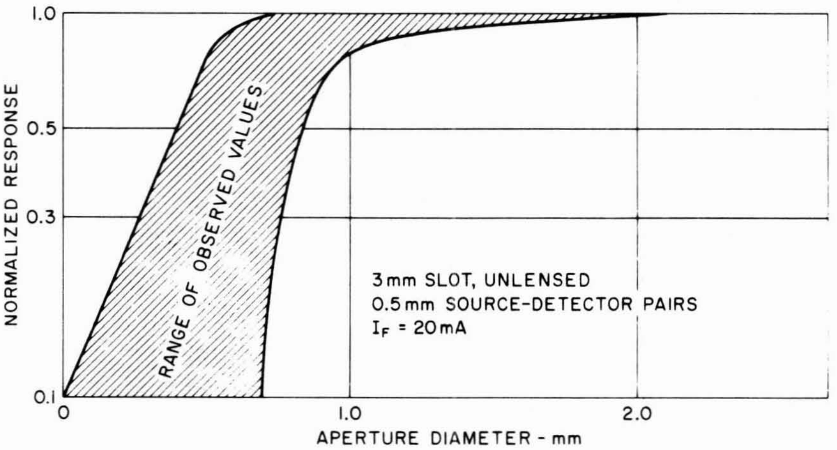
DETECTION WITH A CONVERGING LENS

Although the use of lenses does narrow the field of view of the detector and alleviate some ambient light problems, it can also widen the path of light which must be blocked to turn the detector off. Resolution is always lessened when focusing lens systems are used on the detector



W IS THE WIDTH AN OBJECT MUST HAVE TO BLOCK THE DETECTOR FROM LIGHT, i.e. FULL ON TO FULL OFF.

EFFECT OF LENS ON RESOLUTION

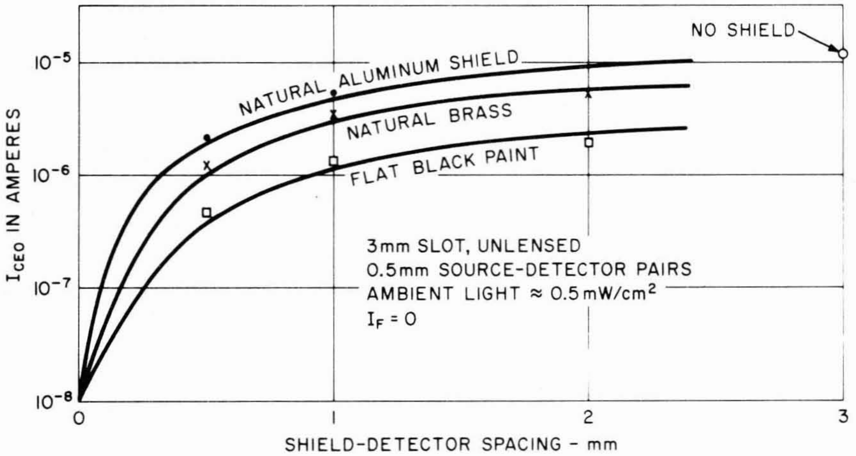


EFFECT OF APERTURE SIZE ON RESPONSE TRANSPARENT APERTURE ON OPAQUE FIELD

without light masking. With an unlensed phototransistor or photodarlington detector, the light sensitive area is about 0.5 mm (0.02 in.) square. Diffraction tolerance and edge effects will add about another 0.3 mm (0.015 in.) to the path width which must be blocked to darken the detector. When a converging lens is added in front of the detector, the field of view is lessened by, and the light path is widened by, the lens system's magnification. Adding a converging lens to the light source increases the irradiance on the detector but has insignificant effect on the light path width. Converging lenses on either device makes detector/source alignment more critical as the light path and view of the devices are now "beams." Various masking and coding techniques are used to minimize these interactions, with sensitivity or transmission efficiency usually being the parameters traded off with alignment and cost of materials.

3. Ambient Light

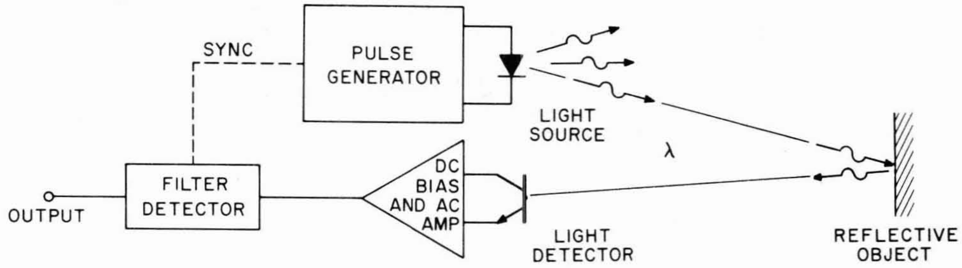
The effect of ambient light on optoelectronics is generally hard to estimate, as the ambient light is usually hard to qualify in terms of level, direction, spectral content and modulation. If the detector is not highly directional, it will normally be found that all reflecting surfaces near the system must be coated with a non-reflecting material or shielded from both ambient light and reflections of light from the light source. Note that back-lighting of the detector can cause trouble by reflecting off the object that normally blocks the light path. As a final solution, a pulse encoded and decoded light system can be used to give very high ambient light immunity, as well as vastly extending the distance over which the system will operate. High light output can be obtained by pulsing the IRED. High signal to noise ratios at the detector are obtained by AC signal processing and simple pulse decoding techniques. Such a system is illustrated in the fourth section of this handbook.



EFFECT OF AMBIENT LIGHT AND SHIELD FINISH ON OPTOELECTRONIC OBJECT DETECTOR

4. Pulsed Systems

Pulsed light systems can provide the best possible performance in detector-emitter pair applications at the expense of a more complex circuit design. The cost of a pulsed system may actually be lower than that of the high power light source and sensitive detector required to do the same job, as low cost commodity components are easily designed into a pulsed system. Performance of the pulsed system will almost always be better than a steady-state system.



TYPICAL PULSED REFLECTIVE OBJECT SENSOR

Generally, low cost systems use UJT derived current pulses from 1 to 10 μsec at a 0.1 to 1% duty cycle into an IRED, as shorter times do not provide corresponding increases in light output while requiring more sophisticated (and costly) circuits to develop the pulse. The detector is normally a phototransistor cascode biased by an ac amplifier of one to three transistors (low cost I.C. amplifiers are too slow).* Synchronous rectification of the ac amplifier output, synced by the pulse generator, allows a significant increase in performance at low cost. Xenon flash tubes and laser light sources provide highest output but cost and complexity limit these to extremely high performance systems. Normal cost/performance progressions are: dc operation, no external optics; pulsed operation, no external optics; pulsed operation with external optics; exotic (laser, etc.) systems. Occasionally, commodity plastic lenses may be found which will provide lower cost than the pulse electronics, but alignment and mechanical systems cost must be evaluated against possible savings on electronics.

B. OptoCoupler Systems

The optocoupler, also known as optoisolator, consisting of an IRED, a transparent dielectric material and a detector in a common package, has been detailed previously as to both construction and the various semiconductors which can be used in it. To utilize these devices in a circuit, we must know the characteristics of the combined component, as well as its parts. Characteristics such as coupling efficiency (the effect of IRED current on the output device), speed of response, voltage drops, current capability and characteristic V-I curves, are defined by the devices used to build the coupler and the optical efficiency. The detailed coupler specification defines these parameters such that, for these parameters, circuit design can be done in the same manner as in any other semiconductor with input, output, and transfer characteristics – except that the input is dielectrically isolated. And this is the critical difference, the definition of the isolation parameters and what they mean to the design of a circuit.

1. Isolation

The three critical isolation parameters are isolation resistance, isolation capacitance, and dielectric withstand capability. Note all three are specified with input terminals short circuited and output terminals short circuited. This prevents damage to the emitter and detector due to the capacitive charging currents that flow at the relatively high test voltages.

a. Isolation Resistance is the dc resistance from the input to output of the coupler. All G.E. couplers are specified to have a minimum of 10^{11} ohms isolation resistance, which is higher than the resistance that can be expected to be maintained between the mounting pads on many of the printed circuit boards the coupler is to be mounted on. Note that at high dielectric stress voltages, with printed circuit board leakage added, currents in the tens of nanoamps may flow.

---

*Biased in this manner, the phototransistor responds in less than a microsecond. LED current, pulse width and repetition rates, can then be determined strictly from response time, distance covered, LED thermal resistance and cost constraints.

This is the same magnitude as photodiode currents, generated at IRED currents of up to 0.5 mA in a typical dual in-line darlington coupler, and could be a problem in applications where low levels are critical. Normally, care in selection and processing of the printed circuit board will minimize any isolation resistance problems. In part, this is due to the large safety factor, to the specified limit, provided by the glass dielectric used in G.E. dual in-line (DIP) packaged couplers.

b. Isolation Capacitance is the parasitic capacitance, through the dielectric, from input to output. Typical values range between 1 pF and 2.5 pF. This can lead to noticeable effects in circuits which have the dielectric stressed by transients exceeding 500 V per microsecond. This would be in circuits sensitive to low level currents, biased to respond rapidly and subjected to the fast transients. Common circuitry which meets these criteria is found in machine tool automation, interfacing with long electrical or communication lines and in areas where large amounts of power are rapidly switched. The majority of cases where capacitive isolation problems exist are cured through one or a combination of the following:

- clean up circuit board layout – especially base (gate) lead positioning;
- use base emitter shunt resistance and/or capacitance;
- design for immunity to noise levels expected;
- electrostatically shield highly sensitive circuit portions;
- use small snubber capacitors coupling the commons on both sides of the dielectric.

This will lower the rate-of-rise of transient voltages and, thereby, lower currents into sensitive portions of the circuit.

c. Isolation Voltage is the maximum voltage which the dielectric can be expected to withstand. The accompanying table illustrates the parameters which must be defined to qualify isolation voltage capability, which depends on time, dv/dt, and waveshape, with the dependence a function of the method by which the coupler is constructed. To illustrate the effect the voltage waveform can have on the isolation capability of a coupler, a series of tests were run to qualify these effects on both a glass dielectric and a competitive dual lead frame DIP coupler.

The results of the tests were analyzed to determine the percent difference in surge isolation voltage capability that was exhibited by the couplers for the various waveforms applied, as compared to the specified test method. These percentages were then applied to a hypothetical device which just meets a 1000V peak specification and the results tabulated to determine the "real" surge voltage capability of this device for each waveform. This was done to allow the circuit designer to determine realistic surge voltage derating on each coupler type. Obviously, dual lead frame couplers with other dielectric materials and/or dielectric form factors may show different changes in capability with waveform. The glass dielectric, being very consistent in both electrical properties and form factor will show consistent performance from device to device.

WAVE FORM COUPLER	AC ZERO Φ	DC RAMP	AC RAMP	AC STEP	DC STEP
G.E. Glass	707 V*	1025 V	650 V	580 V	919 V
Dual Lead Frame	540 V	1000 V*	540 V	510 V	780 V

*Specification Sheet Test Method

SURGE ISOLATION VOLTAGE CAPABILITY OF HYPOTHETICAL 1000 V COUPLER

GENERAL ELECTRIC OPTOCOUPLER ISOLATION VOLTAGE SPECIFICATION METHOD

I. **Surge Isolation Voltage**

a. *Definition:*
This rating is used to protect against transient over-voltages generated from switching and lightning-induced surges. Device shall be capable of withstanding this stress, a minimum of 100 times during its useful life. Ratings shall apply over entire device operating temperature range.

b. *Specification Format:*
Specification, in terms of peak and/or rms, 60 Hz voltage, of specified duration (e.g., 1500V peak/1050V rms for one second).

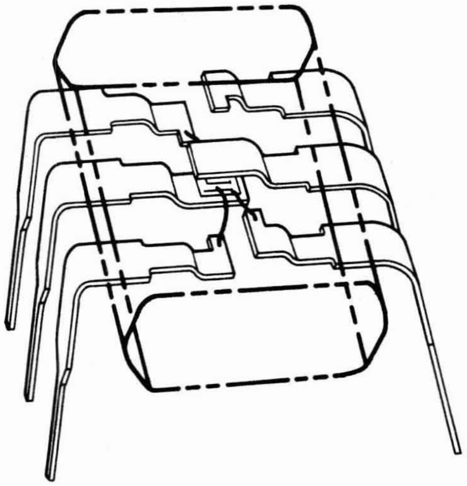
c. *Test Conditions:*
Application of full rated 60 Hz sinusoidal voltage for one second, with initial application restricted to zero voltage (i.e., zero phase), from a supply capable of sourcing 5 mA at rated voltage.

II. **Steady-State Isolation Voltage**

a. *Definition:*
This rating is used to protect against a steady-state voltage which will appear across the device isolation from an electrical power source during its useful life. Ratings shall apply over the entire device operating temperature range and shall be verified by a 1000 hour life test.

b. *Specification Format:*
Specified in terms of peak and/or rms 60 Hz sinusoidal waveform.

c. *Test Conditions:*
Application of the full rated 60 Hz sinusoidal voltage, with initial application restricted to zero voltage (i.e., zero phase), from a supply capable of sourcing 5 mA at rated voltage, for the duration of the test.



COMPETITIVE CONSTRUCTION, DUAL LEAD FRAME

The tests performed were:

1. AC – rms surge rating per G.E. definition.

*2. DC Ramp – Value at failure when potential gradually increased from zero – definition used on competitive device.

*3. AC Ramp – rms value at failure of gradually increased potential.

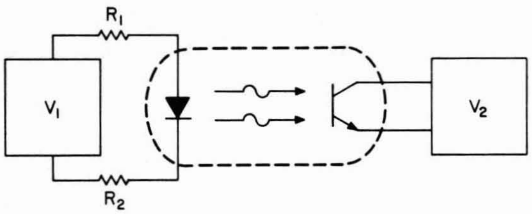
4. AC Step – rms value at failure of instantaneously applied voltage. Application of voltage synchronized to peak voltage.

5. DC Step – Value at failure of instantaneously applied potential.

*ramp slope 1000V/sec

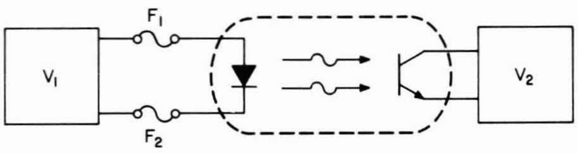
Steady-state isolation voltage ratings are usually a fraction of surge ratings and must be life test verified. The G.E. steady-state rating confirmation tests were performed on devices segmented by surge isolation voltage capabilities into groups of the lowest voltages that could be supplied to the specification tested. A destructive surge isolation voltage test was performed at specified surge rating to confirm the selection process, and then the couplers were placed on rated 60 Hz steady-state isolation stress. No failures were observed on the 160 couplers tested for 1000 hours. This consisted of 32 units, H11A types, each voltage ratio at 800/1060, 1500/2500, 1500/1770, 2200/2500 and 2500/4000 life test to surge test voltage ratios. Note that some of the tests are beyond the rated steady-state condition for a given test voltage, which again confirms the inherent properties of glass dielectric.

The mode of failure, of a coupler which has been stressed beyond its dielectric capability, is of interest in many applications. Ideally, the coupler would heal and still provide isolation, if not coupling, after breaking down. Unfortunately, no DIP coupler does this. The results of a dielectric breakdown can range from the resistive path, caused by the carbonized molding compound along the surface of the glass observed on glass dielectric couplers to a metallic short, caused by molten lead wires bridging lead frame to lead frame, noted on some dual lead frame product. In critical designs, the effects of a dielectric breakdown should be considered and, if catastrophic, protection of the circuit via current limiting, fusing, GE-MOV® Varistor, spark gap, etc. is indicated. Some techniques for protection are illustrated below. Note that film resistors will fuse open under fault currents, providing combined protection. Breakover protection, if feasible, is probably the best choice when a coupler with adequate breakover capability cannot be obtained.



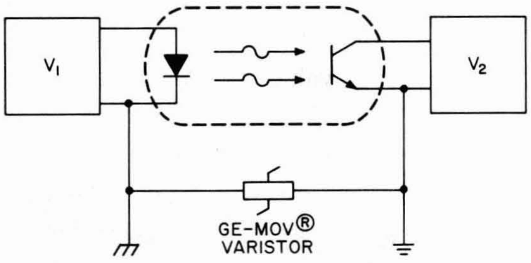
$R_1 // R_2$ LIMITS FAULT CURRENT FROM V_1 TO V_2.

Resistive Limiting



F_1 AND F_2 LIMIT MAGNITUDE AND DURATION OF FAULT CURRENT FROM V_1 TO V_2.

Fuse Limiting



Breakover Device Protection

METHODS OF LIMITING OR
ELIMINATING DIELECTRIC
BREAKOVER PROBLEMS

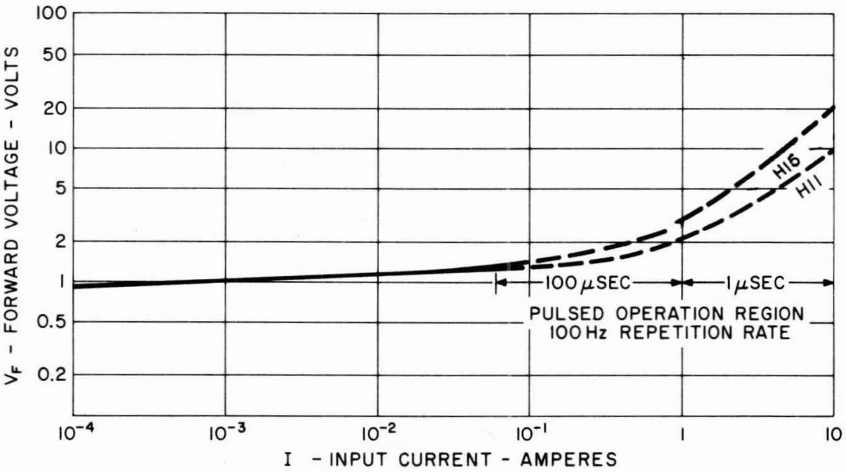
METHODS OF LIMITING OR ELIMINATING DIELECTRIC BREAKOVER PROBLEMS

Another phenomenon, which has been observed in some photocouplers when subjected to a dc dielectric stress, is a rise in the leakage current of the detector device. This rise in leakage is usually observed at high levels of dielectric voltage stress and elevated temperature, although field reports indicate the phenomena has been observed at dielectric stresses as low as 50 V dc in some brands of couplers. The phenomena seems independent from normal HTRB channelling, since it appears only under dielectric stress and not under detector blocking voltage stress. The cause is hypothesized to be mobile ions in the dielectric material which move to the detector surface under the influence of the voltage field generated by the dielectric stress. At the detector surface the field produced by these ions would cause an inversion layer, (similar to that formed in a MOS field effect transistor), to form in the collector or base region of the detector and carry the leakage current. The G.E. coupler glass dielectric has been designed to be as ion free as possible and, with the detector devices which are optimized for minimum susceptability to the formation of inversion layers, has proven to be a stable, reliable and highly reproducible coupler design. Tests performed on these devices at stresses up to 1500 V and 100°C have produced no observable change in detector leakage.

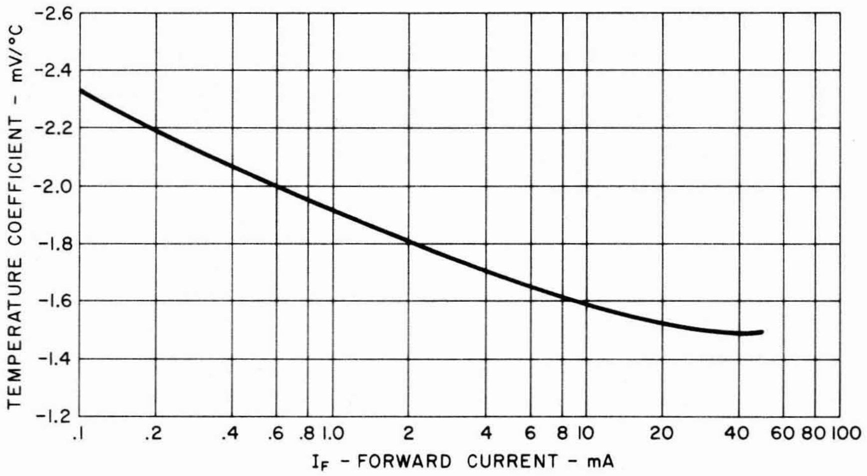
2. Input, Output and Transfer Characteristics

The complete opto coupler has the electrical characteristics of the IRED and the detector at the input and output, respectively. As the individual devices and the dielectric characteristics are known, emphasis will now be on the transfer characteristics of the coupler. Some specific device characteristics are also detailed to provide the completeness required for analytical circuit design.

a. Input The input characteristics of the coupler are the characteristics of an IRED – usually a single diode, although the H11AA has an anti-parallel connected, two IRED input. The forward voltage drop is slightly different than that of the discrete IRED previously discussed, due to differences in chip and contact details. The following curve illustrates this for both the G.E. coupler types. Note that in pulsed operation significantly higher currents can be tolerated, but close control of pulse width and duty cycle are required to keep both chip and lead bond wire from bias conditions which will cause failure. The temperature coefficient of forward voltage is related to the forward current and is of small magnitude as it varies V_F by only about ±10% over the temperature range.

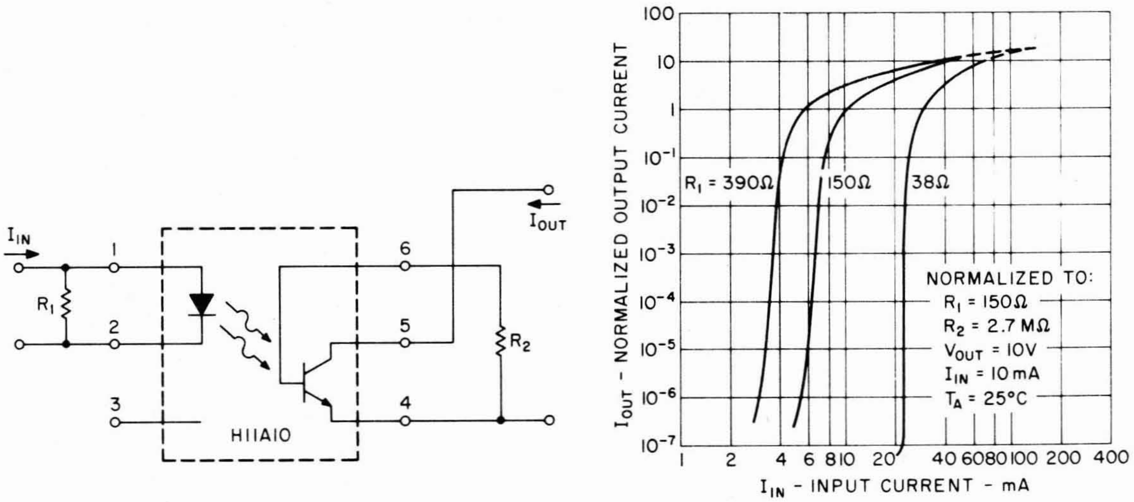


TYPICAL OPTOCOUPLER INPUT CHARACTERISTICS – V_F vs. I_F AT 25°C



IRED FORWARD VOLTAGE TEMPERATURE COEFFICIENT

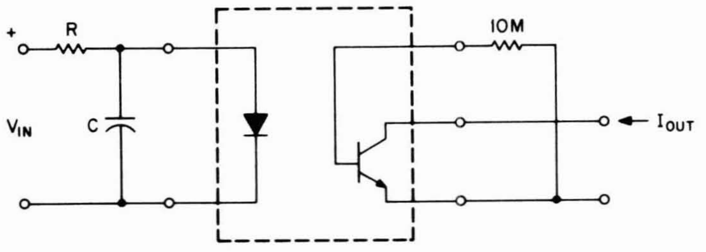
The stability and predictability of the IRED forward voltage drop lends itself to various threshold (like H11A10) and time delay applications. Threshold operation is accomplished by shunting the IRED with a resistor such that V_F isn't reached until the input current reaches the desired threshold value for turn-on. This type of application is documented in the specification of the H11A10. Time delay turn-on is accomplished by shunting the LED with a capacitor in applications where a slow turn-on and turn-off can be tolerated. In speed sensitive, time delay applications the trade-off between time delay at the input with a Schmitt trigger output vs. incorporation of the time delay in the Schmitt trigger circuit must be evaluated for cost and performance.



Threshold Circuit

Transfer Characteristics

CURRENT THRESHOLD OPERATION OF OPTO COUPLER

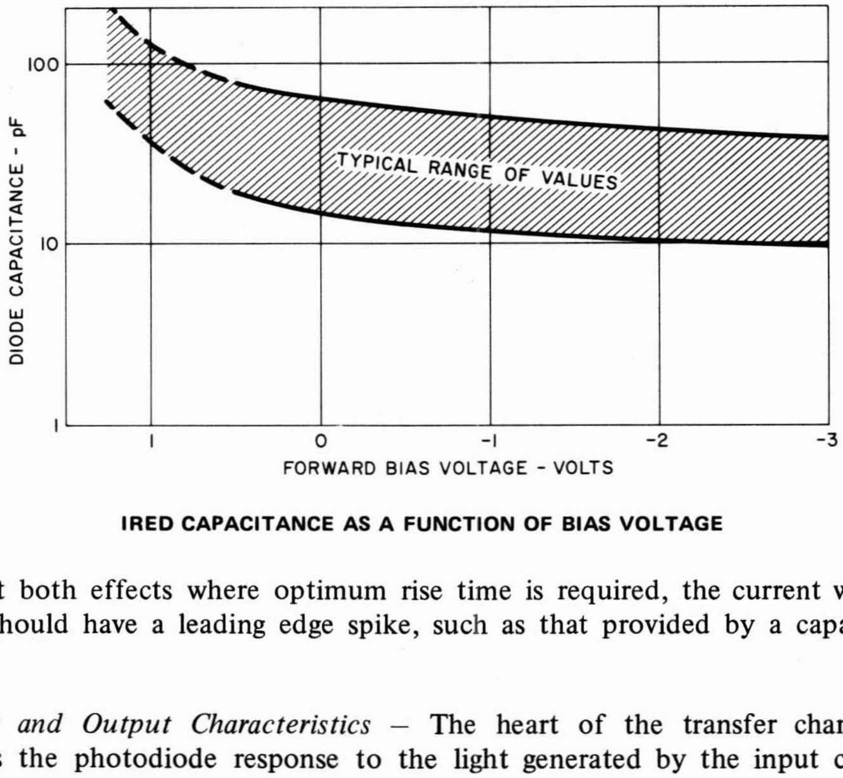


TIME DELAY FROM APPLICATION OF V_{IN} UNTIL I_{OUT} FLOWS

$$td \approx RC \ln \frac{V_{IN}}{V_{IN} - 1.1}$$

TIME DELAY OPERATION OF OPTO COUPLER

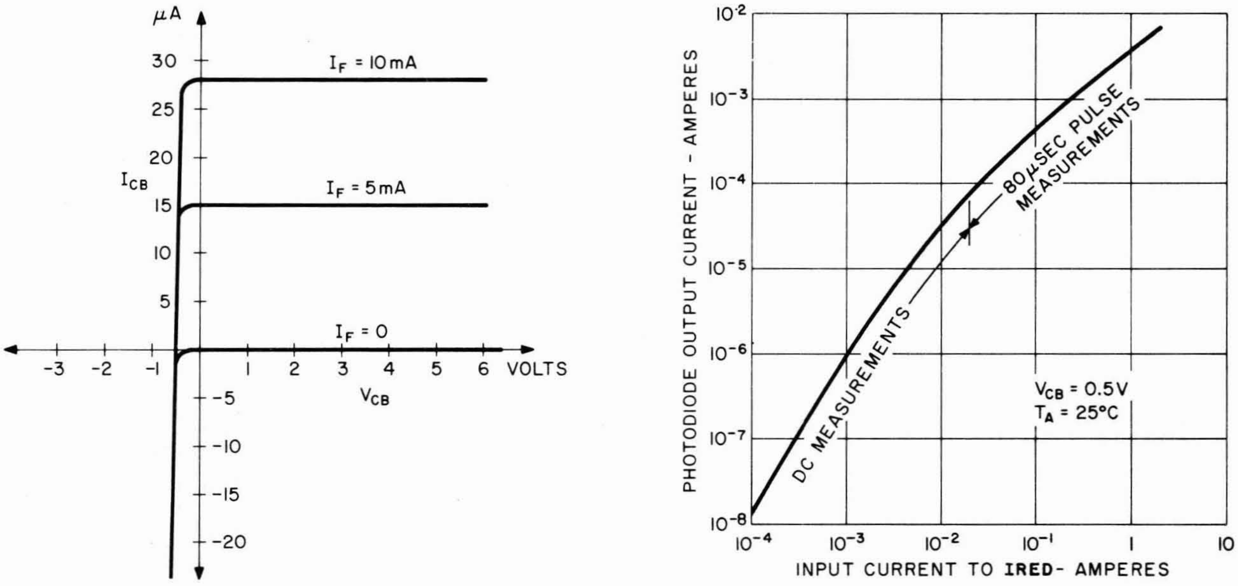
The input capacitance is a function of bias voltage and, although it is normally ignored, recent information indicates it has an effect on the turn-on time of the IRED. As the IRED is forward biased, its capacitance rises. The charging of this increasing capacitance delays the availability of current to generate light and causes a slower response than expected. In the liquid epitaxial-processed silicon-doped gallium arsenide devices, this effect is noticeable only at low drive currents, while rise time effects due to minority carrier lifetime dominates turn-on time at currents over a few milliamperes.



IRED CAPACITANCE AS A FUNCTION OF BIAS VOLTAGE

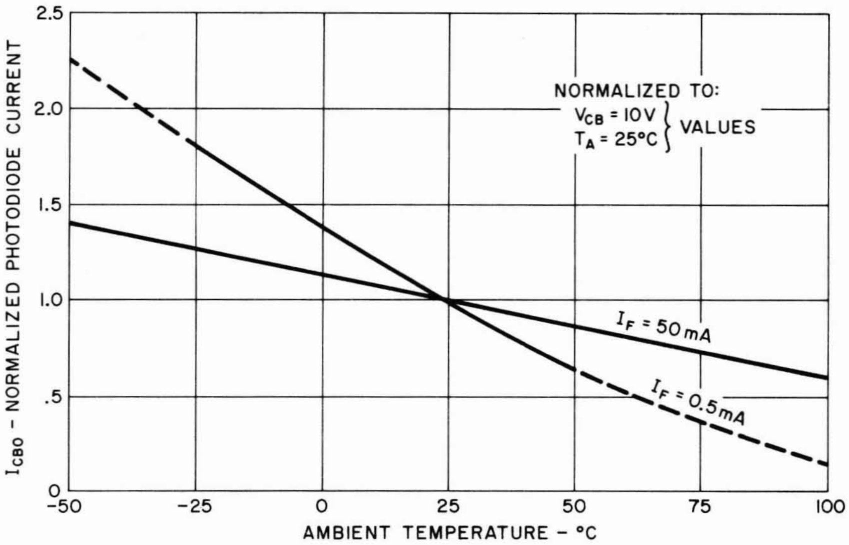
To combat both effects where optimum rise time is required, the current waveform to the coupler input should have a leading edge spike, such as that provided by a capacitive discharge circuit.

b. Transfer and Output Characteristics – The heart of the transfer characteristics of an opto coupler is the photodiode response to the light generated by the input current. In both the transistor and darlington couplers the photodiode characteristics are available in the collector-base connection and can be both measured and used easily. Note that to use the photo-darlington as a photodiode, the emitter of the output section must be open-circuited and not shorted to the base as can be done with a single phototransistor in this mode. This is because the base of the output transistor is not electrically accessible, so when the darlington is connected with a base emitter short, it acts, not as a photodiode, but as a photodiode in parallel with a low-current-transfer ratio (i.e., the ratio of output current to input current) phototransistor.



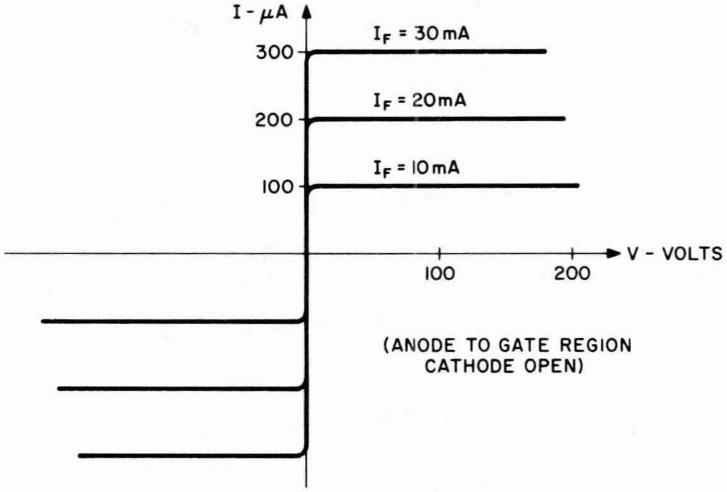
Characteristic Curves **Transfer Curves**

TYPICAL OPTOCOUPLER TRANSFER CHARACTERISTICS –
PHOTODIODE RESPONSE OF PHOTOTRANSISTOR AND PHOTODARLINGTON COUPLERS



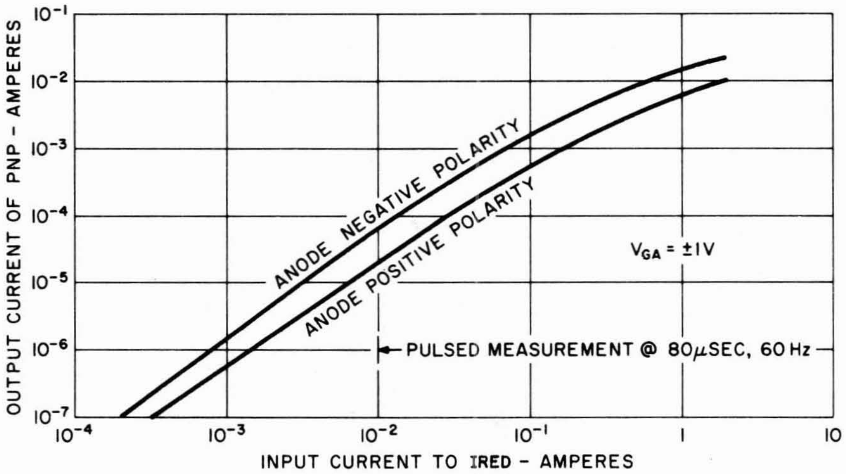
PHOTODIODE TRANSFER CHARACTERISTICS TEMPERATURE VARIATION

In the SCR coupler the pnp portion of the device from anode to gate that is activated by the photodiode can be monitored and utilized in both forward and reverse directions as a symmetrical switch, for low currents at voltages up to 400 V.



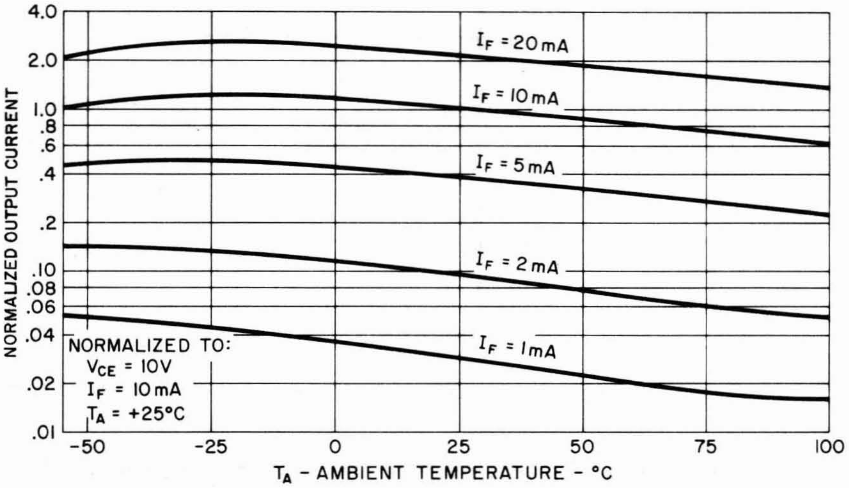
CHARACTERISTIC CURVES – PNP PHOTOTRANSISTOR ACTION OF SCR OPTOCOUPLER

Using a unijunction to pulse the IRED allows the SCR coupler biased in this mode to trigger triacs and anti-parallel SCR's without a bridge of rectifiers and its problems with commutating dv/dt. It is also useful for switching and sampling low level dc and ac signals, since offset voltage, the prime cause of distortion, is practically zero. Temperature coefficients of both the photodiode response and the pnp response will be negative, as both mainly indicate the incident light and, thereby, show the decrease in IRED efficiency as temperature rises.



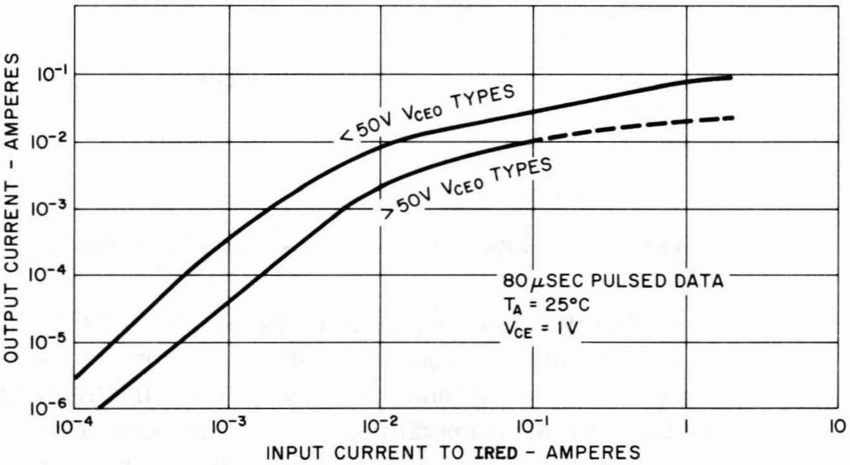
TYPICAL PNP TRANSFER CHARACTERISTICS OF PHOTO SCR OPTO COUPLER

c. Phototransistor – The phototransistor response is the product of the photodiode current and the current gain ($h_{FE,\beta}$) of the npn portion of the transistor. The photodiode current is very slightly affected by temperature, voltage and current level, while the transistor gain is affected by all of these factors. In the case of temperature, the gain variation offsets the temperature effects on IRED efficiency, giving a low temperature coefficient of current transfer ratio (CTR). Due to voltage and current effects, the temperature coefficient will vary with bias level as illustrated. As different manufacturers use different processes in both IRED and phototransistor manufacturing, considerable variation in the low current temperature coefficients is found from manufacturer to manufacturer.

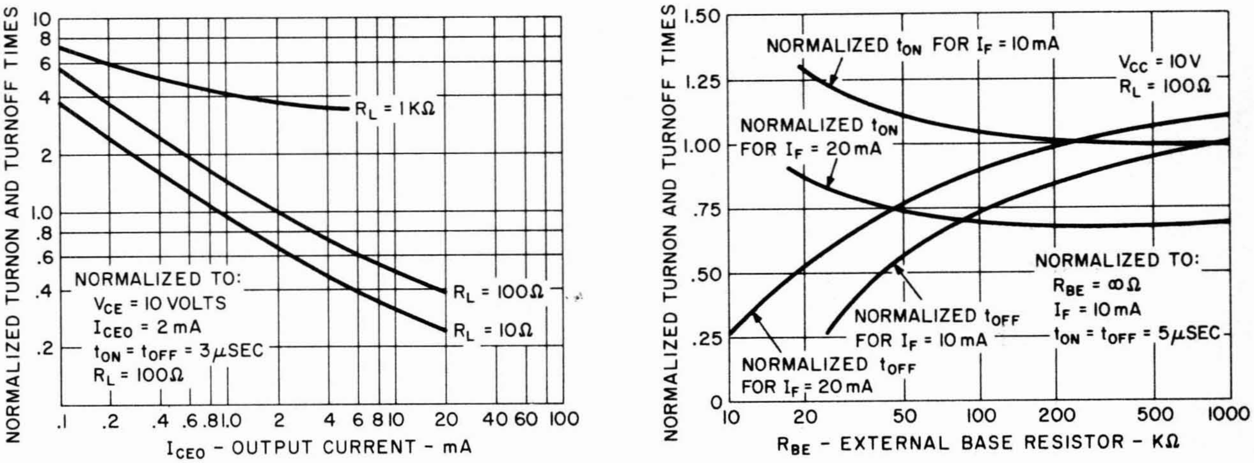


BIAS EFFECTS ON CTR TEMPERATURE COEFFICIENT

Dynamic response of the phototransistor is dominated by the capacitance of the relatively large photodiode, the input resistance of the transistor base-emitter junction, and the voltage gain of the transistor. Through Miller Effect, the R-C time constant of the phototransistor becomes input resistance times capacitance times voltage gain. Here, the penalty for a high gain phototransistor is doubled. High gain raises voltage gain and raises the input resistance, by lowering the base current. The same double penalty is extracted when a lower operating current and higher load resistor are chosen. These effects provide a trap for an unwary circuit designer as competitive pressures have driven specification sheet values of switching times to uncommon bias conditions using very low values of load resistors with fractions of a volt signal level changes. While this provides an idea of ultimate capability, it also forces the designer to evaluate each situation, and at



TYPICAL PHOTOTRANSISTOR OPTOCOUPLER TRANSFER CHARACTERISTICS



Switching Times vs. Output Current

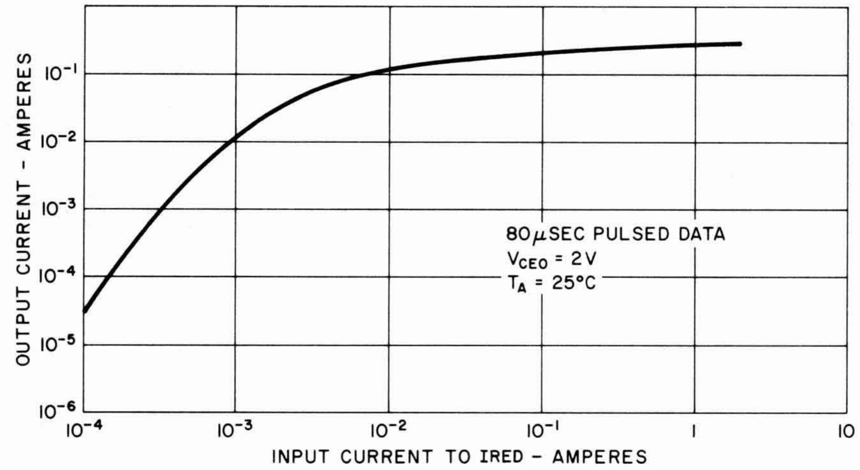
Switching Time vs. R$_{BE}$

BIAS EFFECTS ON PHOTOTRANSISTOR SWITCHING SPEED

times to resort to speed-up techniques, such as base emitter shunt impedance, cascode biasing of the phototransistor, capacitor discharge pulsing of the IRED, etc. Highest speed is obtained from the photodiode alone, biased from a stiff voltage source, with the IRED pulsed at as high a current as practical. In this mode, response is dominated by the IRED and photodiode intrinsic properties and can be under 0.2 μsec. Use of a load resistor on the photodiode requires charging the photodiodes capacitance (25 pF at OV, typically) with the associated R-C time constant.

Leakage current of the phototransistor must also be considered, especially if the base is open circuited, high temperature operation is expected and/or low current operation is desired. The photodiode leakage current (typically 200 pA at 10 V, 25°C) will be about 200 times this at 100°C. In the open base bias mode, this current is multiplied by beta, which also rises with temperature. This combination of effects raises a typical 2 nA I_{CEO} at 10 V, 25°C to 4 μA (2000 times) at 10 V, 100°C. Consider the effect on a circuit, which operates at a 100 μA phototransistor current, with a device with the specified maximum leakage limit, 100 nA at 25°C, when the ambient temperature rises. The use of a 10M base emitter resistor would allow the worst case unit to operate normally without appreciable effect on the CTR. Leakage and speed effects must be considered before the option of operating open base is taken. Higher operating voltages, especially with the high (200 to 300 V) voltage phototransistor coupler, and a time varying dielectric stress, to add capacitive current base drive, are additional factors which can cause undesired leakage effects.

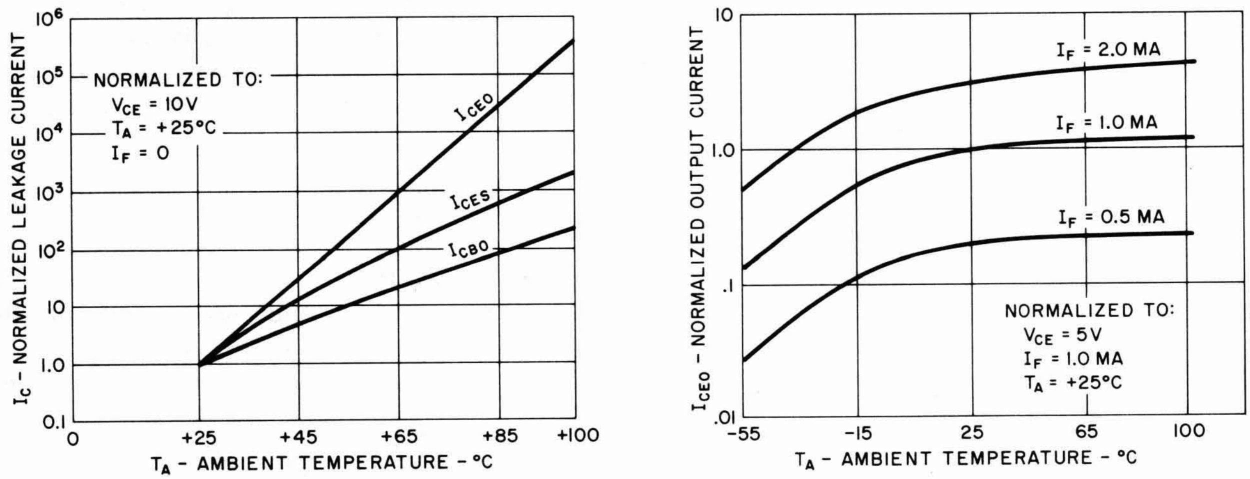
d. Photodarlington – The photodarlington adds the effects of an additional stage of transistor gain to the phototransistor coupler. The changes in CTR, its temperature coefficient, leakage currents and switching speed are extended quite obviously from the photodiode-phototransistor relationships, and will not be detailed. Instead, the two major application areas where the photodarlington opto coupler is attractive, i.e., at low input currents or at very high output currents, will be examined from the standpoint of device characteristics and their interaction with application performance.



TYPICAL PHOTODARLINGTON OPTOCOUPLER TRANSFER CHARACTERISTICS

The high gain of the darlington allows useful output currents with input currents down to 0.5 mA. Both current gain and IRED efficiency drop very rapidly with current, as was illustrated in the emitter detector systems section. These effects indicate that for very low input currents, i.e., below 100 to 500 μA, better performance, in output current to leakage current ratio, can be obtained with the phototransistor coupler (although effort is required to get even fair performance at such low input currents regardless of the output device). This then defines the low input current operation region as roughly between 0.3 mA and 3 mA input current, and the high current output region at above 3 mA input current, i.e., where the output current is in the tens and hundreds of mA.

Operation in the low input current region with a photodarlington output optocoupler provides minimum output currents in the 0.1 mA to 10 mA range at 25°C. High temperature leakage currents (I_{CEO}) can also be in this range and the rise in output current with temperature doesn't approach the rise in leakage current. This effect indicates the need for a base emitter resistor in



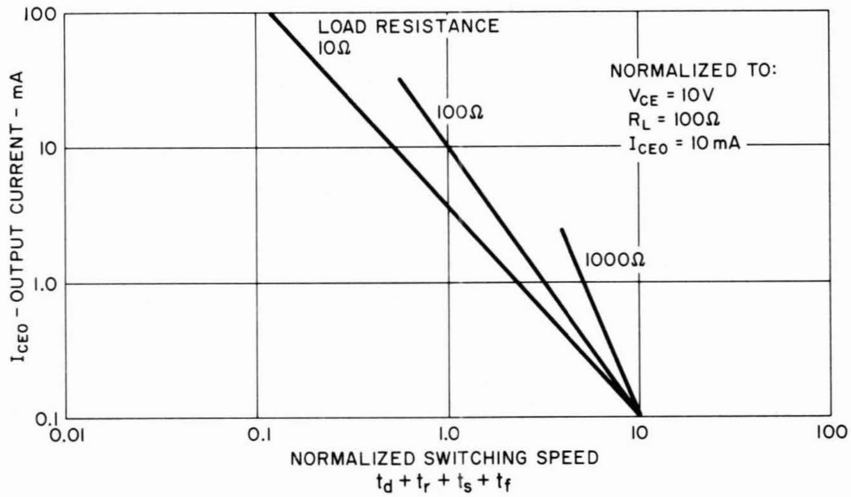
Leakage Current

Output Current

TYPICAL TEMPERATURE EFFECTS ON PHOTODARLINGTON OUTPUT

circuits which must operate at high temperature. The value selected for this resistor becomes a trade-off between minimizing the effect on output current, maximizing the effect on leakage current, and choosing a commonly available resistor. Usually, the result of the trade-off is the use of a 22M resistor with the circuit designer scraping up more drive for the IRED as an alternative to going to a non-standard or series connected resistor. Looking at the photodiode response, and noting that V_{BE} can be 1.3 V, the 22M resistor eliminates response on a typical unit for input currents less than 1/4 mA, which, in worst-case analysis, makes the reason for scraping up more input current obvious. It also illustrates another reason for using a transistor output coupler in some of the lowest input current applications. At low temperatures these phenomena make the darlington more attractive: leakage current has decreased, making a base emitter resistor unnecessary; IRED efficiency has increased and darlington gain has dropped, giving an output which is more a function of the input than of the output device characteristics.

Switching speeds in the low input current bias region are quite slow, and are decreased further by the large load resistors common for these biases. Some bias conditions have been reported where the photodarlington would not switch (full on to full off) at a 60 Hz rate. The major point is to note that dynamic effects, as illustrated, exist and must be allowed for in the early stages of circuit design and development.

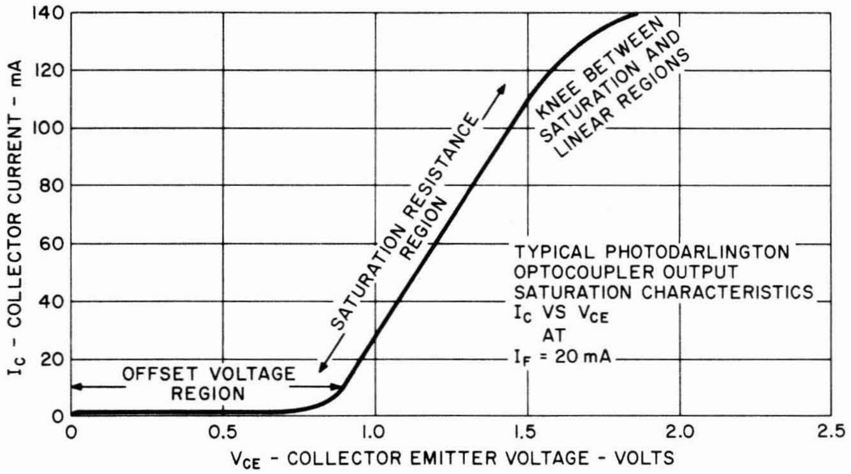


PHOTODARLINGTON SWITCHING SPEED AS A FUNCTION OF BIAS

Operation of the photodarlington optocoupler at high output currents has few pitfalls. Leakage, temperature, and dynamic effects are less, both in proportion and in action, due to normal bias choices. Currents are of such magnitude that, as in using signal transistors, power dissipation can become a concern when driving low impedance loads, such as solenoids and small lamps. Saturation resistance and offset voltage are the prime factors which govern the power dissipation in these applications. Typical values for saturation resistance, up to I_c = 100 mA, are in the 4 to 8 ohm range. Typical offset voltage can be approximated by the 10 mA collector current saturation voltage, which ranges from 0.8 V to 1.1 V. Power dissipation in the saturated photodarlington can now be approximated by:

$$P_d \approx I_c (V_{OFFSET} + I_c R_{SATURATION}).$$

For steady-state loads this corresponds to a maximum collector current of about 100 mA to stay within the 150 mW maximum rating. In pulse applications the drop in photodarlington gain with increasing current limits usefulness above 250 mA collector current. Since saturation re-

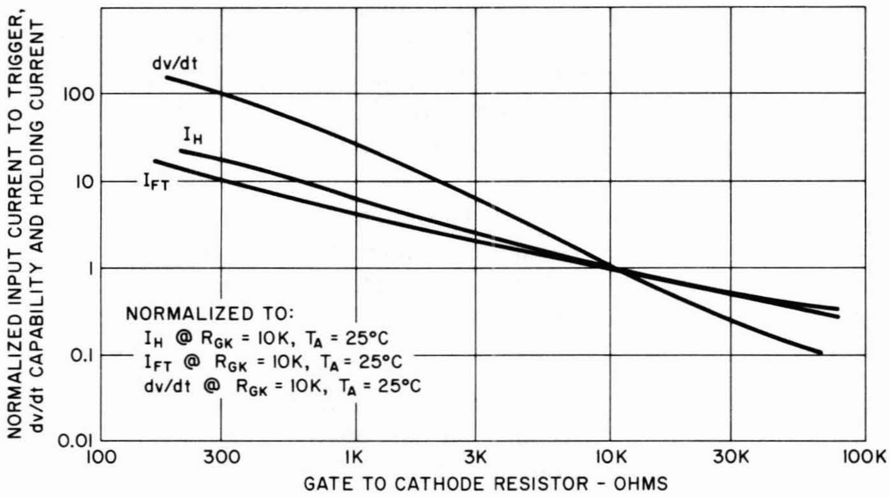


TYPICAL PHOTODARLINGTON OPTOCOUPLER SATURATION CHARACTERISTICS

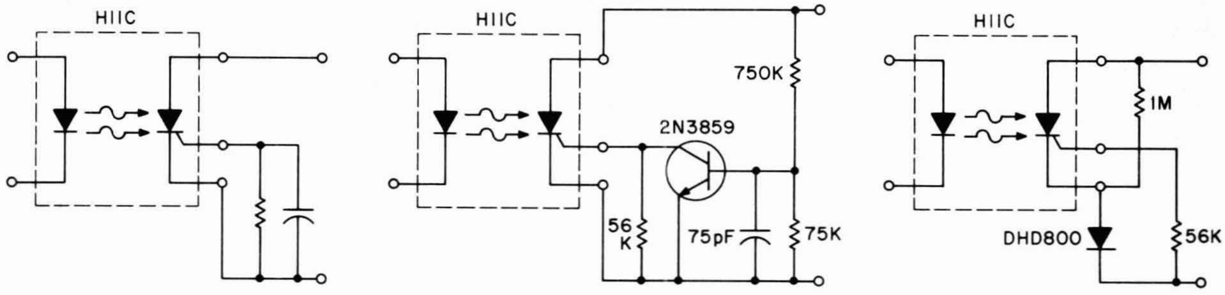
sistance and gain rise with temperature, while offset voltage decreases, the dominant effect will depend on the collector current, the input current magnitude, and the transistor junction temperature. In high current pulsed operation, self-heating effects (in the IRED by reducing its efficiency, and in the darlington by raising the saturation resistance) can cause the observed saturation voltage to rise throughout the duration of the pulse.

e. Photo SCR – The photo SCR optocoupler differs from other couplers in its detector, as was shown, and from other SCR's. The difference from other SCR's is due to the very low gate drive available from the detector. This low gate drive requires a very sensitive gate structure, while application constraints demand a SCR capable of operation on 120 and 240 V ac lines, in a full wave bridge. These needs conflict and require the SCR chip design, processing and application to be carefully controlled. The success of the H11C is a tribute to GE's superior technology in SCR's, IRED's, and optocoupler assembly being successfully combined. It also requires the circuit designer to consider the trade-off in optical sensitivity and sensitivity to dv/dt, temperature, and other undesirable effects. It also presents the circuit designer with a new effect, coupled dv/dt, where the rapid rise of voltage across the dielectric isolation capacitively supplies gate trigger current to the SCR. Due to the physical construction of the coupler, this could occur in either stress polarity, although highest sensitivity is with the IRED side positive. These effects are not as formidable as might be expected, since the low currents at which the SCR is operated make the protection techniques identical in both method and typical values, to those required in most common SCR applications. Pulse current capability of the SCR is superb, making it ideal for capacitor discharge and triggering applications. Complete isolation of input and output allow anti-parallel and series connections to be made without complicated, additional circuitry. This facilitates full wave ac control, high voltage SCR series string triggering, three-phase circuitry and isolated power supply design. The H74C series coupler is even specified to operate 120/220 V ac loads with input signals directly from TTL logic.

A knowledge of the SCR turn-on parameters allows circuit design to be done analytically. I_{FT}, the current into the IRED required to trigger (turn-on) the SCR, is the principle parameter and approximates the current required to make detector current enough to provide a diode drop of voltage across the gate-to-cathode resistor (R_{GK}). From this, the relationship of I_{FT} to R_{GK} is inferred, i.e., higher R_{GK}, lower I_{FT}. As R_{GK} also shunts currents generated by leakage, rapidly rising voltages across junction or isolation capacitance and stored charge during turn-off, it becomes obvious that a trade-off exists between optical trigger sensitivity and susceptibility to undesired triggering and ability to turn off. Turn-off is related to the holding current, I_H, the minimum anode current which will maintain the SCR in conduction. As it is normally desired to have the SCR turn-on with minimum IRED current, while being completely immune to dv/dt, and to other extraneous effects and still turn-off dependably and rapidly, the choice of a fixed R_{GK} becomes a compromise. Use of active devices in the place of, or in addition to, R_{GK} can give the best of all worlds at the price of additional circuit complexity. Circuit component cost could be lessened through these techniques by allowing the use of a less costly coupler and less fussy drive and snubbing circuitry. Three examples of this type of gate bias are illustrated here. The gate capacitor is simplest, but only affects dynamic response and is of limited use on dc or full wave rectified power. The zero voltage switching is the most effective, as it places a virtual short circuit from gate-to-cathode when the anode voltage exceeds approximately 7 volts. At low voltages the SCR is quite immune to most of the effects mentioned, and yet optical triggering sensitivity is relatively unaffected. This circuit is limited to applications where zero voltage switch-



TYPICAL EFFECT OF R_{GK} ON I_{FT}, dv/dt, AND I_H OF PHOTO SCR OPTOCOUPLER



Gate Capacitor **Zero Voltage Switching** **Reverse Gate Bias**

METHODS USED TO OPTIMIZE R_{GK} EFFECT

ing is compatible with performance requirements, of course. The reverse gate bias method is generally applicable to a wider range of circuit applications and provides somewhat better than a 2:1 performance advantage over a simple resistor. It also improves turn-off time and is of particular advantage when the SCR is used on full wave rectified power sources. When gate-to-cathode resistors of over 10K are used, the high temperature operating capability of the SCR will be compromised without the use of some circuit which will perform as these. High junction temperatures are associated with either high ambient temperature or current flow generated power dissipation, leading back to the compromise between input current magnitude and circuit simplicity. The ultimate in performance combines both techniques in one circuit – but also again limits application to zero voltage switching. If very low drive currents are available for the IRED, and precise phase control is not required, the input current can be stored on a capacitor which is then discharged through the IRED periodically. A programmable unijunction circuit, using an 0.2 μF capacitor charged to 8 V and discharged at 1 msec. intervals, draws less than 2 mA and will turn-on a H11C1 with a 1 K ohm R_{GK}. Other methods of outflanking the sensitivity compromise will undoubtedly suggest themselves to the circuit designer which may prove to be higher performance, less costly, or both. To aid the analysis of dynamic effects, typical capacitance values of 25 pF anode-to-gate and 350 pF gate-to-cathode are noted on the H11C photocoupler, and the typical gate cathode diode drop is about 0.5 V with a negative temperature coefficient of about 2 mV/°C.

Use of the photo SCR coupler on dc circuits presents no new problems. DC stability of the G.E. glassivated SCR pellet is excellent and has proven itself in both the lab and in the field at voltages up to 400 V. Commutation or other turn-off circuitry is identical to that detailed in the G.E. SCR Manual and a maximum turn-off time of 100 μsec is used to calculate the commutation circuit values. Pulse capability of the H11C photo SCR coupler output is rated at 10 A for 100 μsec. In conjunction with the 50A/μsec, di/dt capability (di/dt indicates the maximum rate of increase of current through the SCR to allow complete turn-on and, thus, avoid damaging current crowding effects) of the H11C, it is capable of excellent capacitor discharge service. For general pulse applications, the power dissipation may be calculated and used in conjunction with the pulse width, transient thermal resistance, and ambient temperature to determine maximum junction temperature, as the junction temperature is the ultimate limit on both pulse and steady-state current capability. A more complete explanation of this method of determining capability may be found in the G.E. SCR Manual and its reference material.

SECTION III. RELIABILITY OF OPTOELECTRONIC COMPONENTS

A. SUMMARY OF TEST RESULTS

The circuit designer must be aware of the expected reliability of the many different components used. This allows control of life cycle costs, such as warranty costs, repair costs and downtime costs, through proper application of these components. The manufacturer must also assess performance of the components he makes. This information is acquired by the manufacturer performing standard test sequences on periodic samples of the manufacturing line output. Most of these tests are run at, or beyond, maximum ratings to allow an accelerated reliability assessment of the product. These tests can provide the information needed by the circuit designer, but the severity of the test conditions compared to use conditions must be considered. The extrapolated results of these severe tests to normal use levels is still a challenge for the circuit designer, but the challenge is lessened by the availability of information which provides estimates of acceleration factors, i.e., the increase in rate-of-failure, caused by increasing stress levels, such as voltage, current and temperature. Application of these acceleration factors to the data can allow worse case circuit design techniques to be applied over the design life of electronic equipment. Several sources exist which document estimates of these acceleration factors, with one of the most widely available being MIL-HDBK-217 B.* The data which follows does not attempt to define failure rates as functions of stress, only to summarize observed responses. It is recommended that such information sources, as MIL-HDBK-217 B, be consulted when estimates of equipment reliability are attempted from these, or any other, summaries of reliability test data.

The following tables summarize the periodic reports issued by G.E. – SPD Quality Control on the optoelectronic products. As new products, processes and test procedures evolve, the applicability of past data to reliability prediction changes. Thus, data presented here represents a "snapshot in time" of data believed applicable to the product made now and in the immediately anticipated future. A separate section will cover the decrease in light output of the IRED with time of operation, a phenomena which is noted in all light emitting diodes, both from the viewpoint of summarizing the observed data and of predicting the response of the majority of devices to expected stress.

Each stress condition checks a different capability of the component. For the emitters and detectors, the operating life test stresses current, voltage and power activated mechanisms. It is the only test which has been found to activate the output decrease of the IRED, so performance to a degradation criteria is tabulated on tests in which current flows through the IRED. Storage life at elevated temperature tests stability and resistance to thermally activated mechanisms, such as corrosion caused by contamination. Humidity life tests the capability of the package to keep contaminants out, as well as the ability of the package to resist moisture activated corrosion and surface leakage problems. Temperature cycle causes mechanical stress on components made of materials with different coefficients of expansion, and can break or thermally fatigue parts which are thermally mismatched. This is presently a problem with optoelectronic components packaged in clear epoxies when subjected to wide, repeated temperature changes, due to the large coefficient of expansion of the clear, unfilled epoxy. Since the object of the test program is to gain the most information in the shortest time, and since thermal fatigue has a very strong temperature acceleration, these tests are run to the limits defined by activation of non-valid failure

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*MIL-HDBK-217 B, Military Standardization Handbook, Reliability Prediction of Electronic Equipment.

mechanisms or beyond common test equipment capability, without regard for maximum ratings. Note that all high efficiency IRED's have an anti-reflective coating which, unless carefully selected and controlled, can have a detrimental effect on extended temperature cycle performance. Illustrated here are temperature cycle results of the standard 100 cycle test and extended stress results to 200 and 500 cycles, without evidence of thermal fatigue. This is a tribute to the mechanical design of the GE hermetic IRED. Mechanical sequence stress was not performed on the hermetic IRED, since it contains only one flying lead bond and should exhibit half the failure rate of transistors with two flying lead bonds.

RELIABILITY TEST SUMMARY – EMITTERS AND DETECTORS

DEVICE TYPE	STRESS CONDITION	QUANTITY TESTED	TOTAL DEVICE HOURS	BEST ESTIMATE FAILURE RATE★
Hermetic IRED • **LED55 Series** • **LED56 Series** • **1N6264 - 1N6266**	Operating Life I_F = 100mA @ 25°C	267	267,000	0.26%/10^3 hrs. 0.26%/10^3 hrs.+
	Storage Life* T = 200°C	80	80,000	2.2%/10^3 hrs.
	Temperature Cycle* -65°C to +200°C	414	86,100∿	0.42%/100∿
Hermetic Detectors • **L14F Series** • **L14G Series**	Operating Life Pd = 300mW	75	75,000	0.95%/10^3 hrs.
	Storage Life T = 200°C	75	75,000	0.95%/10^3 hrs.
	Temperature Cycle -65°C to +200°C	75	7,500∿	0.95%/100∿
	Mechanical Sequence 1.5 KG Drop Shock 20 KG Centrifuge 20 G Vibration	75	N.A.	No Failures
Plastic Detectors • **2N5777 Series** • **L14D Series** • **L14H Series**	Operating Life Pd = 200mW	250	250,000	0.69%/10^3 hrs.
	Storage Life T = 100°C	249	249,000	0.69%/10^3 hrs.
	Storage Life T = 125°C*	238	238,000	0.33%/10^3 hrs.
	Humidity Storage T = 40°C, 90% R.H.	249	249,000	0.28%/10^3 hrs.

★ Catastrophic failure rate estimate to upper 50% confidence level.
+ Combined catastrophic and degradation, to $\Delta P_{OUT} \geqslant 50\%$, est. failure rate to 50% UCL.
* Stress conditions beyond device specified maximum ratings.

The optocoupler differs from familiar solid state components in that it contains two chips and a light transmission medium providing a higher potential for failure than simpler components. Each output device has some unique characteristics which require unique stress testing. Although the IRED is identical in each type of coupler, most IRED evaluation work is done on the transistor coupler due to the minimal variation of CTR with temperature and bias, and so provides an accurate monitor of IRED performance. Darlington test monitoring is done at extremely low IRED currents and, therefore, shows the highest rate of decrease when stressed at identical levels. (See next section for details.) The SCR output coupler is subject to the possibility of inversion layer formation (channelling) as are all high blocking voltage semiconductors. Stressing at high blocking voltage at high temperature (HTRB) will accelerate possible inversion layer formation, if it will occur. Test results are combined for high temperature storage life, temperature cycle, humidity and salt atmosphere stress, all of which are relatively free of effects dependent on the output device. The operating life test results again are presented to show both catastrophic and IRED output shift failure criteria. The results of these tests illustrate the superiority of the G.E. patented glass dielectric isolation, silicon doped liquid phase epitaxially grown IRED chip and total electrical and mechanical design. This is the premium optocoupler from both a reliability and a performance standpoint. From a manufacturing standpoint, it enjoys high yields and ease of assembly, providing this quality at competitive costs.

In the evaluation of these reliability tables with the acceleration factors given in the next section, both the IRED heating from power dissipated in the output device and the standard readout bias must be known. Each 5.45 mW dissipated in the output device is equivalent to raising the ambient temperature, from the IRED's standpoint, by 1°C. Standard CTR readout conditions for phototransistors are $I_F = 10\,mA$, and for photodarlingtons at $I_F = 1$ mA.

RELIABILITY TEST SUMMARY – GE DIP OPTOCOUPLER

OUTPUT TYPE	STRESS CONDITION	QUANTITY TESTED	TOTAL DEVICE HOURS	EXPECTED FAILURE RATE★
Photo Transistor • **H11A Series** • **4N35 Series** • **4N25 Series**	Operating Life, $T_A = 25°C$ $P_{TRAN} = 300mW, I_F = 20mA$	90	90,000	$0.78\%/10^3$ hrs. $0.19\%/10^3$ hrs.+
	Operating Life, $T_A = 25°C$ $P_{TRAN} = 300mW, I_F = 60mA$*	151	367,000	$0.46\%/10^3$ hrs. $<0.001\%/10^3$ hrs.+
	Operating Life, $T_A = 100°C$ $P_{TRAN} = 0, I_F = 100mA$*	325	54,600	$0.86\%/10^2$ hrs. $0.12\%/10^3$ hrs.+
Photodarlington • **H11B Series** • **4N29 Series**	Operating Life, $T_A = 25°C$ $P_{TRAN} = 300mW, I_F = 60mA$	195	195,000	$0.40\%/10^3$ hr. $0.0026\%/10^3$ hr.+
Photo SCR • **H11C Series** • **4N39 Series**	SCR D.C. Blocking Life V_D = Maximum Rating $T_A = 100°C$	104	104,000	$0.75\%/10^3$ hr.
Combined	150°C Storage	381	381,000	$0.69\%/10^3$ hr.
Combined	100°C Storage	109	109,000	$0.72\%/10^3$ hr.
Combined	Humidity Storage $T_A = 85°C$ @ 85% R.H.	333	333,000	$0.21\%/10^3$ hr.
Combined	Temperature Cycle -65°C to +150°C	709	70,900	0.15%/10∼
Combined	Salt Atmosphere MIL-S-750/1041, 35°C	25	600	0.13%/hr.

★ 50% upper confidence level best estimate failure rate.

+ Degradation only failure rate to a $\triangle$ CTR $>$ 50% criteria. This is calculated, using the acceleration factors of the next section, to equivalent time at a 55°C, $I_{FS} = I_{FM}$ stress level, at the 50% UCL.

* Accelerated test, test bias conditions in excess of device ratings.

B. RELIABILITY PREDICTION OF CIRCUITS CONTAINING IRED's

Previously the IRED phenomenon, of light output decrease, as the time current flows through it, was mentioned. This presents a dilemma to the circuit designer attempting to provide adequate margins for bias values unless he can predict what minimum value of light output, from the IRED, he can expect at the end of the design life of his equipment. Based on the results of tests performed at G.E. and at customer's facilities (who were kind enough to furnish us test data and summaries) the G.E. Application Engineering Center has developed design guidelines to allow the prediction of the approximate worst case, end of life, IRED performance. The basis of the prediction is the observed behavior of the ratio of light output after operation to the initial value of light output. It also is based on the observation that all devices do not behave identically in this ratio in time, but that a distribution with identifiable tenth, fiftieth (median) and ninetieth percentile points exists at any time the ratio is calculated. Use of this tenth percentile ratio (90% of the devices are better than this) and the distribution of light output (or CTR for couplers) above the specified minimum value allows the product of specified minimum light output and tenth percentile ratio, predicted at end of life, to be used as a reasonable approximation of minimum

SUMMARY OF TESTS USED TO OBTAIN IRED DESIGN GUIDE LINES

T_A I_{FS}	25°C	40°C	55°C	70°C	80°C	100°C
3mA	20 1000 Hr. 3mA					
5mA	20 1000 Hr. 1, 5mA					
10mA	16 1000 Hr. 1, 10mA					
20mA	27 500, 1000 Hr. 1, 5, 10, 20mA				108 1000 Hr. 10mA	
25mA	20 1500 Hr. 10mA	20 1500 Hr. 10mA	20 1500 Hr. 10mA	60 1500 Hr. 10mA		
50mA		20 1500 Hr. 10mA		40 1500 Hr. 10mA		
60mA	20 1000 Hr. 1, 5, 10, 20, 60mA				163 1000, 3000, 5000 Hr. 10mA	
75mA				20 1500 Hr. 10mA		
100mA	79 1K, 15K, 30K Hr. 1, 10, 100mA					90 168, 1500 Hr. 1, 10, 100mA

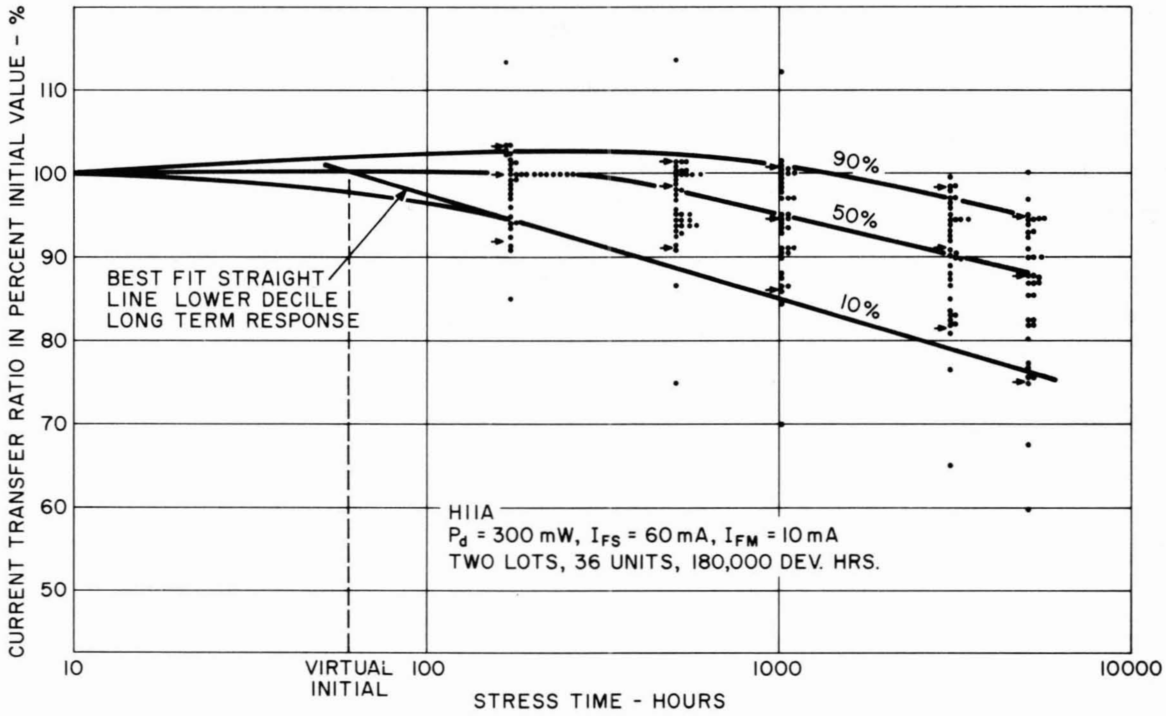
This chart represents about 2.0 million device hours of operation on 625 dual in-line optocouplers and 111 hermetic IRED's.

FORMAT OF DATA PRESENTATION:

SAMPLE SIZE
TEST DURATION
I_{FM} CURRENT

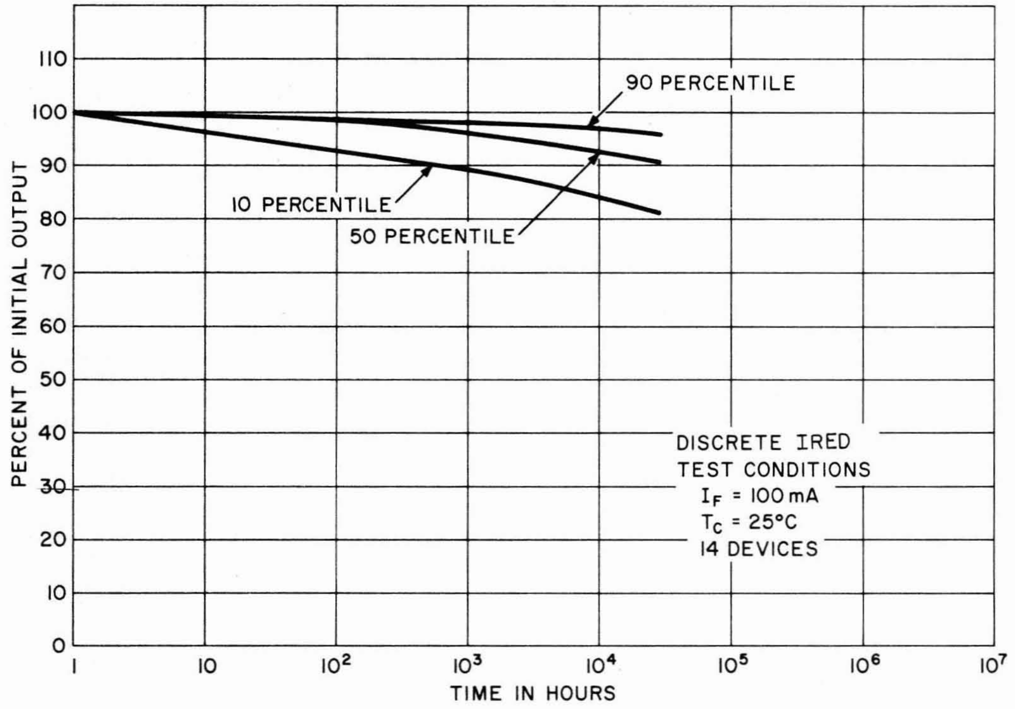
end of life value. Although this does not represent the worst possible case, no correlation can be found between initial light output and rate of decrease in light output, and so the percentage of devices expected to be less than the guideline derived number approaches zero. These guidelines, as can be noted, are based on fair sample sizes, although both larger samples than these and greater precision, higher resolution, measurements could provide better fits. To make the guideline development less obscure, the discussion will trace the steps followed in defining these design guidelines and, in the process, develop the guidelines.

When the percent of initial value of light output (or current transfer ratio in couplers) of an IRED on an operating life test, is plotted against the time the IRED has been operated, two phenomena become apparent. The long-term behavior is found to be a straight line when the ratio is plotted on a logarithmic time scale. The short-term behavior is found to have a much shallower slope, on the same plot, than the long-term behavior. This effect is illustrated by the fact that the long-term straight line can be extrapolated back towards zero and will usually intersect the initial value line at a time between 10 and 100 hours. These properties combine to allow the response to be described by a "virtual initial time" and the slope of the line passing through that time point. This had been recognized in other work. The problems with predicting response are the variety of test conditions at which both stress and measurement data have been taken, and the spread of data at the readout points. It was recognized that the fall in light output was accelerated by either stressing the IRED harder, i.e., at a higher current (I_{FS}) and/or temperature, or by monitoring the test results at lower current (I_{FM}) levels. Precise acceleration factors have yet to be determined due to lot-to-lot variability. Fortunately, circuit design purposes can be served by a less precise model, which only attempts to serve the requirements of circuit design. For this approach, as mentioned before, we pay attention to the lower decile of the distribution and its change in time.



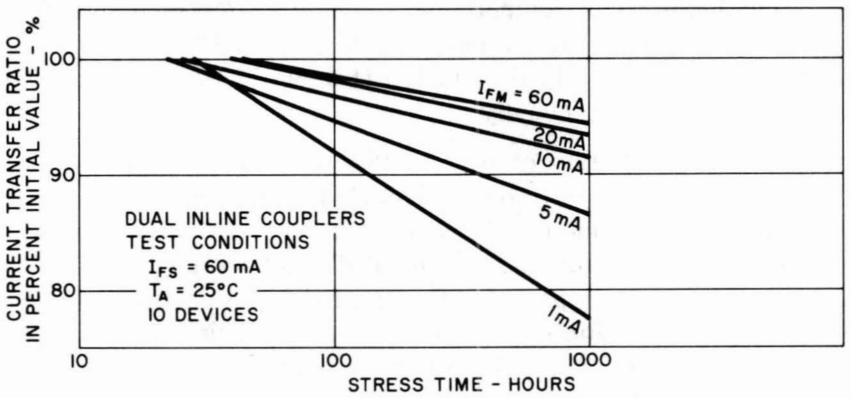
LIFE TEST RESULTS – ILLUSTRATING OBSERVED CHANGE IN IRED OUTPUT WITH OPERATING TIME

The question naturally arises of the applicability of this description to time periods beyond the one and five thousand hour times that the majority of the tests stopped at. Fortunately, tests have been completed on discrete IRED's for 30,000 hours. The results of these tests indicate that nothing unexpected happens at extremely long times, as can be seen above. This is reinforcing evidence indicating the superiority of the G.E. silicon doped, liquid phase epitaxially grown IRED.

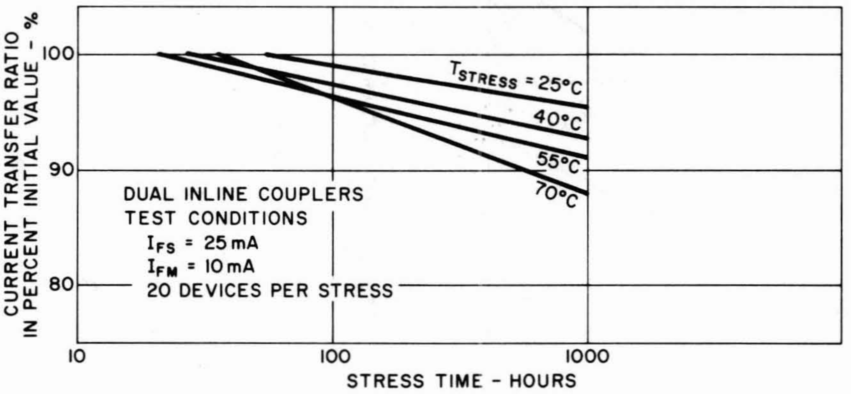


LONG-TERM IRED LIFE TEST RESULTS

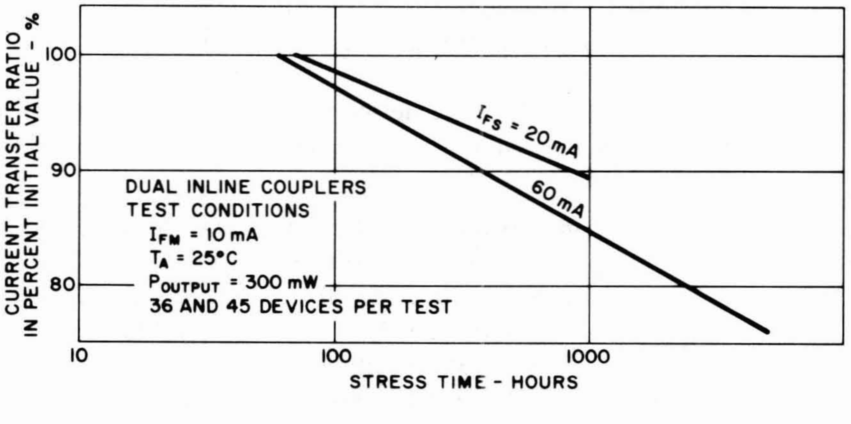
Plotting the response (best straight line) of various test conditions on a single graph, the acceleration due to raising stress current (I_{FS}) is easily seen. Higher temperatures during stress cause the same effect, and can be accomplished by raising the ambient or by self-heating (in a coupler by dissipating power in the output device). Lowering the current at which the IRED light output is monitored, (I_{FM}) also accelerates the phenomena, but in looking at many test results, it appears that the ratio of I_{FS}/I_{FM} is the key factor affecting the slope besides temperature.



EFFECT OF
MEASUREMENT CURRENT
ON SLOPE



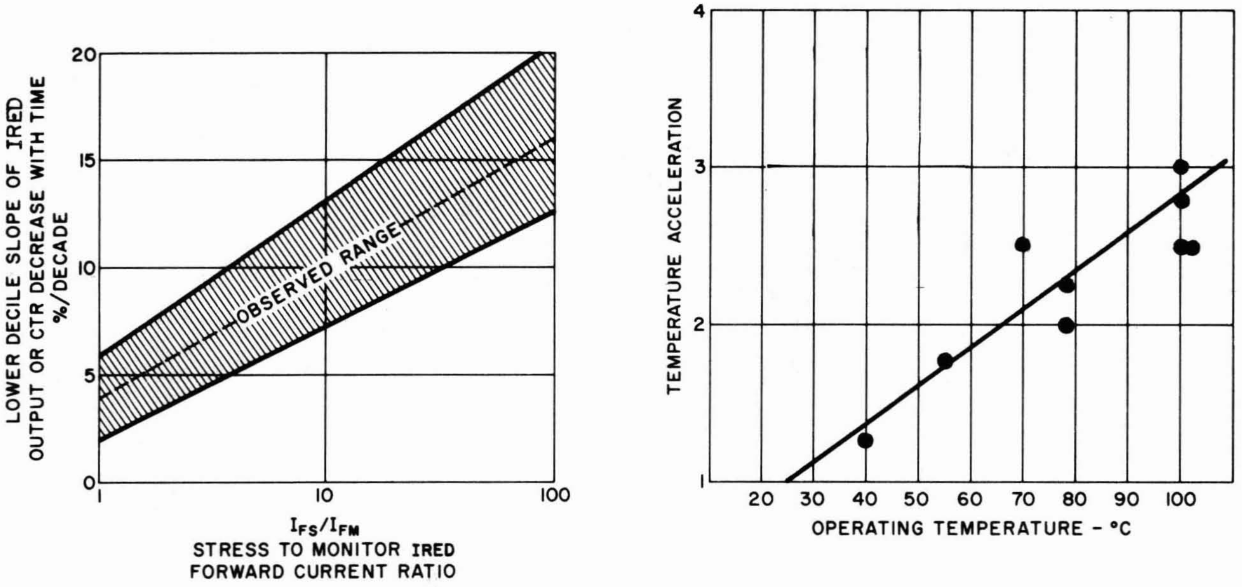
EFFECT OF
STRESS TEMPERATURE
ON SLOPE



EFFECT OF
STRESS CURRENT
ON SLOPE

When the temperature effect is plotted as an acceleration vs. temperature, a fair straight line fit is found, as illustrated below. This temperature acceleration factor represents the ratios of the slopes of the lower decile lines of various temperature stresses. The fit is not perfect, but is good enough to be useful. It contains both discrete IRED data (LED55 series) and optocoupler data (H11 series) and appears to fit both equally.

With this, and the determination of the coupled thermal resistance in the optocoupler (i.e., the heating factor for the IRED from power dissipated in the output device), it was attempted to fit the I_{FS}/I_{FM} ratio into the model. After many attempts to find models which fit various phenomena better, and the generation of additional data to try to fill holes, it was decided that two factors contributed to the inability of defining a tight fit single line. These are lot-to-lot and sampling variability and the precision (and volume) of data required to find the slope at low I_{FS}/I_{FM} ratios and low temperatures. These factors cause the best model found to enclose a band of observed values, as can be seen.



Bias Current Effect **Temperature Effect**

IRED OUTPUT VS. TIME SLOPE PREDICTION CURVES ASSUMING A VIRTUAL INITIAL TIME OF 50 HOURS

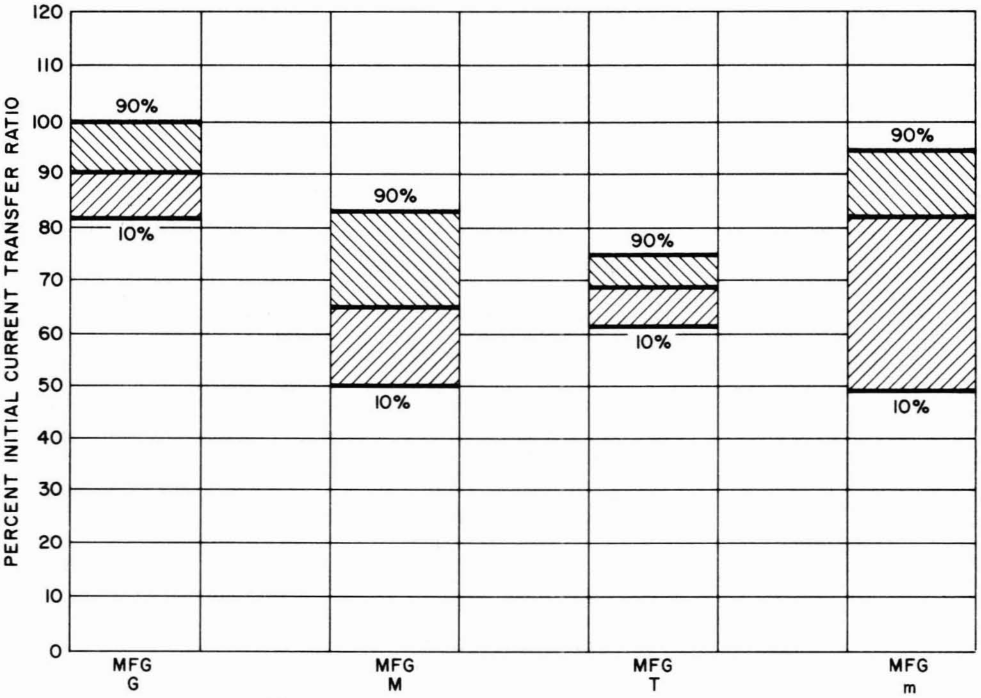
To use this data the circuit designer must define a desired lifetime, the degree of control he has on minimum and maximum values of I_F in any single socket, and the temperature environment to which the circuit is exposed.

A simple example of the design procedure illustrates its use. Assume the need for an 4N35 which will provide 10 mA of output current at 5 Volts V_{CE} after 100,000 hours of 55°C operation. To find the IRED current needed to provide this, we need the minimum specified CTR of the 4N35, the estimated slope of the lower decile of light output vs. time and the temperature acceleration of that slope at 55°C. The 4N35 specification indicates a minimum CTR of 100%, that for I_F values of up to 20 mA the CTR is relatively constant and that at 55°C the CTR will be about 0.85 times its 25°C value $\left(\frac{\Delta \text{CTR}}{\Delta \text{T}}\right)$. The center of the range of slopes vs. I_{FS}/I_{FM} is conservatively chosen at a ratio of 1.3 and found to be 5% per decade (slope). This should provide a reasonably worst case approximation of both coupler performance and possible current variation effects due to power supply and bias circuit drifts. The temperature acceleration factor curve indicates this slope will be increased by 1.75 times at 55°C (A_T), i.e., the slope will be 8.8%/decade. The difference between 50 hours and 100,000 hours (t) is 3.3 decades (log 100,000 – log 50), so the expected lower decile will provide about 29% less light at 100,000 hours than initially. To provide the 10 mA output requirement, the IRED current must be raised by about 40% to compensate for light lessening with operation [i.e., $\frac{100}{100-29}$] and this must be raised by 18% (i.e., 1/.85) to compensate temperature variation of CTR, yielding a minimum input current to the IRED of 16.6 mA, as compared to the 10 mA required initially at 25°C. The formula used in this example is:

$$I_F = \frac{100}{100 - [\text{slope} \times A_T \times \log(t/50)]} \times \frac{1}{\Delta CTR/\Delta T} \times \frac{I_C}{CTR}$$

where: A_T is the temperature acceleration for slope at the expected operating temperature,
CTR is the specified minimum current transfer ratio, adjusted for bias conditions,
$\Delta CTR/\Delta T$ is the change in CTR due to temperature,
I_C is the required output current,
I_F is the required IRED bias current,
Slope is the light output lessening per decade time, and
t is the circuit design life.

Note that for a one million hour life the required IRED current would only rise to 18.5 mA, as time has only increased by another decade! The estimate of the effect of operating time on the circuit has been almost as simple as the estimate of temperature effects.



COMPETITIVE COMPARISON, ACCELERATED LIFE TEST

The design guideline, unfortunately, is only valid for the G.E. IRED's and DIP couplers. Life tests of competitive units at both maximum rating and accelerated test conditions indicate a wide variation of performance exists in the industry. The accelerated test results were duplicated by the maximum rating test results, indicating the same type of response in both the A_T and I_{FS}/I_{FM} curves. But the magnitude of shifts observed, especially the lower decile, are much greater, indicating much greater slopes, in percent per decade, of the light output vs. operating time graphs. This is illustrated in the plots comparing the life test results given above. To life cycle design with such devices would require derivation of a different model, based on a matrix of life tests. Based on extremely limited testing and some published information, it appears that at least two other manufacturers of IRED's and optocouplers can achieve light output performance with operation similar to the G.E. performance. Neither utilizes the glass dielectric in the coupler and no tests have been performed to allow comment on other reliability factors.

Degradation failure rates, to a desired criteria of percent initial light output, may be calculated from accelerated data to use condition response by use of the design guideline. The design guideline temperature acceleration and slope per decade factors may be used to calculate an equivalent number of test hours at use condition to the accelerated test. Note that early hour slope of light output vs. time is very shallow, and accelerated test results are not valid for operating times under 168 hours. The number of devices which decrease in light output to a value less than the desired criteria on the accelerated test is then used with the equivalent unit hours to estimate failure rate. While this is not strictly accurate, due to the distribution of change in light output, the following is a useful approximation:

$$t_x = 10^{\left[\left(\log \frac{t_o}{50}\right) \times \frac{A_{T1}}{A_{T2}} \times A_I + \log 50\right]}$$

where: A_I is the slope at stress conditions ÷ slope at use conditions,
A_{T1} is the temperature acceleration at stress conditions,
A_{T2} is the temperature acceleration at use conditions,
t_o is the stress test duration, and
t_x is the equivalent time at use conditions.

The reliability test summary degradation failure rates were calculated this way and provide an example.

The 100°C, 100 mA phototransistor accelerated operating life tests run for 168 hours (t_o). The temperature acceleration curve gives a $\frac{A_{T1}}{A_{T2}}$ ratio of the slope per decade at 100°C to the 55°C value of $\frac{2.83}{1.75} = 1.62$. The middle line of the I_{FS}/I_{FM} curve gives a ratio of $\frac{10}{4} = 2.5$ for the slopes of a 10 mA/10 mA I_{FS}/I_{FM} compared to the 100 mA/10 mA I_{FS}/I_{FM} the test was run at. The equivalent hours for this test at a 55°C use condition is:

$$t_x = 10^{\left[\left(\log \frac{168}{50}\right) \times (1.62) \times (2.5) + \log 50\right]}$$

$$= 6770 \text{ hours.}$$

Two units of the 325 tested failed a light output criteria of half the initial value, giving a 2/2,200,000 device hours observed failure rate, which at the 50% UCL is the 0.12% per thousand hour failure rate shown in the summary chart. This also illustrates that for the G.E. IRED and coupler, the decrease in light output should have a minimal effect on circuit failure rate in conservatively designed circuits.

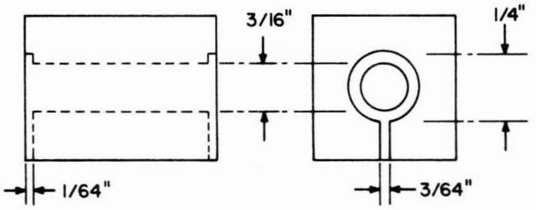
IV. MEASUREMENT OF OPTOELECTRONIC DEVICE PARAMETERS

A. IRED Parameters

Measurement of the IRED parameters is relatively straightfroward, as the electrical parameters are those of a diode. These parameters can be measured on any test equipment used to measure diode parameters, from the bench set-up of two meters and a power supply to the most automated semiconductor tester.

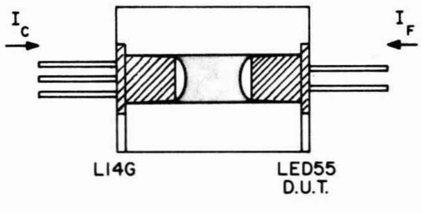
Light output measurements require the use of a spectrally calibrated photo cell or a calibrated thermo pile of at least 1/2″ (1 cm) diameter. This allows collection of all the light power output of the IRED, matching the specification method and guaranteeing correlation of measurements. If pulse measurements are desired, the calibrated silicon photo cell becomes a necessity, due to response time. This would be used in conjunction with a pulsed current source, and calibrated current probe to measure photo cell output and an oscilloscope of sufficient speed and accuracy to provide the desired result. The photo cell is the only device which is not a common electronics laboratory item, and such devices can be procured from sources such as Ealing Corp.; E.G. & G., Electro Optics Div.; Sensor Technology; and others. Spectral output determination requires use of either a wide range spectrometer or a set of precise interference filters and the photo cell. In general, spectral measurements should be performed by a laboratory specializing in optical measurements due to the cost of equipment and the specialized knowledge required for such measurements.

Simple comparison measurements of IRED output may be made using a phototransistor sensor. When this is done, spacing and alignment is critical, due to the lenses angular response and slight asymmetry, if reproducibility and correlation are to be obtained. One of the simplest means of obtaining reproducible positioning is to use a 3/16″ diameter hole through a block of material, smoke blacken the inside of the hole, put a shallow notch at each end of the hole to receive the polarity indicator tabs, and use an L14G as the detector. The collector-base photodiode, used as a photo cell, output current to a low impedance load will give the most accurate measurement of light output, while the phototransistor response, at about 0.6V V_{CE}, will provide the most reproducible measurements due to the offsetting temperature coefficients. With a rubber band holding the tabs in position, reproducibility will be near the limits of the test equipment used and environmental control.



SMOKE BLACKEN OR ANTI-REFLECTIVE PAINT ON INSIDE OF HOLE.

DETAILS



CUTAWAY

HOW USED

B. Photodetector Parameters

The measurement of electrical parameters of the photodetectors is identical to that for the non-light sensitive devices, except for the light sensitive parameters. Such techniques are described in the *General Electric Transistor Manual* and the *General Electric SCR Manual,* and will not be detailed here. The most common problem encountered is the leakage current measurement with the base open, as I_{CEO} is rarely measured on normal transistors, and understanding the need for considering dynamic effects and ambient light effects will solve the problem.* Dynamic effects must be considered, because the open base has no path but junction leakage to charge the junction capacitances. If the common high source impedance bias circuit for leakage current is used, the gain of the transistor multiplies the junction capacitance, of the collector base photodiode ($\approx$ 25 pF), and provides a long stabilization time constant. Note the "double barreled" effect of source impedance in that it is the resistance in the RC time constant and also is the load resistor that determines voltage gain ($A_v \approx 1/\text{hie} \cdot R_L \cdot \text{hFE}$). These effects indicate I_{CEO} should be measured by application of the bias voltage from a low impedance supply until junction capacitances are charged (now determined by the base emitter diode impedance), which can take up to 100 msec, (with no external capacitances, switches, sockets, coaxial, etc. connected to the base) in a darlington. After junction capacitance is charged, the current measuring resistor is introduced to the circuit by removing the short across it. The charge balance at the base can be affected by the motion of conductive objects in the area, so best reproducibility will be obtained within an electrostatic shield. The electrostatic shield can also serve the purpose of shielding the detector from ambient light, the effects of which are obvious on a leakage current measurement.

Measurement of the light parameters of a phototransistor requires a light source of known intensity and spectral characteristics. Lamps with known spectral characteristics, i.e., calibrated standards, are available and, in conjunction with a thermo pile or calibrated photo cell and a solid mechanical positioning system, can be the basis of an opto measuring system. Some relatively simple systems based on the response of a silicon photo cell are available, but the assumption that all silicon devices have identical spectral response is implicit in their use for optical measurements. As different devices have different response curves, the absolute accuracy of these devices is impaired, although excellent comparative measurements can be made. Another method which has fair accuracy is the use of a calibrated detector, L9UX4 for the photo SCR's or L14H special for the phototransistors, to adjust the light source to the desired level. This will eliminate spectral problems as the calibrated device has an identical spectral response to the devices being measured. Accuracy will then depend on basic equipment accuracies, ambient control and mechanical position reproducibility.

Spectral response measurements require use of precision filters or a precision monochromator and a calibrated photo cell or thermo pile. As in the case of the IRED, it is recommended that these measurements be done by a laboratory specializing in optical measurements.

C. Optocoupler Measurements

The measurement of the individual devices in the optocoupler is identical to the measurement of a discrete diode and a discrete device of the type of detector being considered, and is covered previously. The measurement of isolation and transfer characteristics are not as obvious, and will be illustrated.

1. Isolation Parameters are always measured with the terminals of each device of the coupler shorted. This prevents the high capacitive charging currents, caused by the high dv/dt's applied during the measurement, from damaging either device. Safety precautions must be observed in these tests due to the very high voltages present!

a). Isolation voltage is measured as illustrated below. Normally the surge voltage capability is measured, and, unless the high voltage power supply has a fast shutdown (<0.5 μsec), the device under test will be destroyed if its isolation voltage capability is less than the high voltage supply

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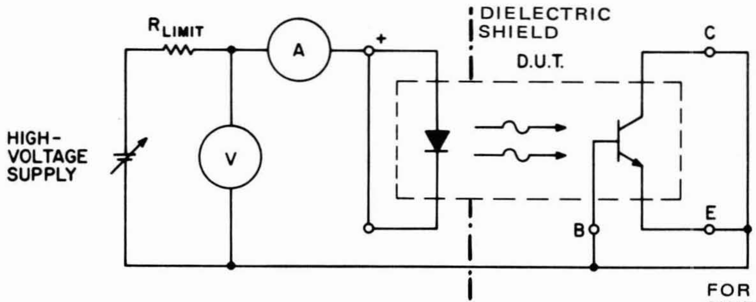
*see "Avoid I_{CEO} measurements", Hendriks.

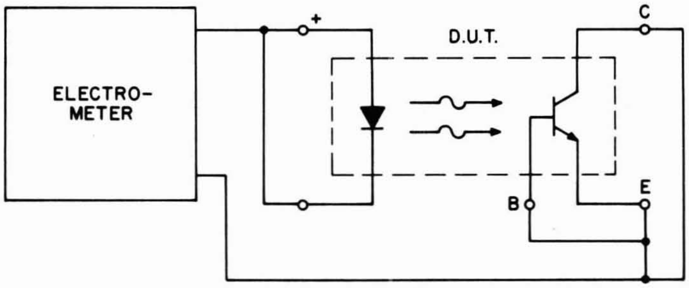


FOR VOLTAGES OVER 2500 Vrms, THE DIELECTRIC SHIELD IS RECOMMENDED TO ELIMINATE AIR GAP EFFECTS.

ISOLATION VOLTAGE TEST

is set at. Crowbar techniques may be used in lab set-ups to provide rapid turn-off and forestall the test being described as "destructive." Steady-state isolation voltage is usually specified as a fixed percentage of the measured surge capability, although limited life tests indicate this derating is not required for the G.E. glass dielectric isolation. Application Engineering believes conservative design practices are required in the use of isolation voltage ratings, due to the transients normally observed when line voltages are monitored and the catastrophic effects of a failure.

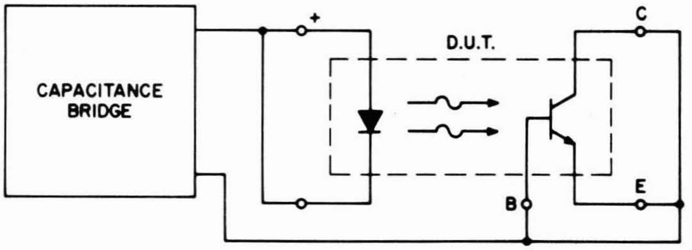
b). Isolation resistance is measured at voltages far below the surge isolation capability, and has less potential for damaging the device being tested. The test is illustrated schematically here,



MEASURING OF ISOLATION RESISTANCE

and requires the procedures normally used when measuring currents below a microampere.

c). Isolation capacitance is a straightforward capacitance measurement. The capacitance of couplers utilizing the G.E. patented glass dielectric process is quite independent of applied voltage

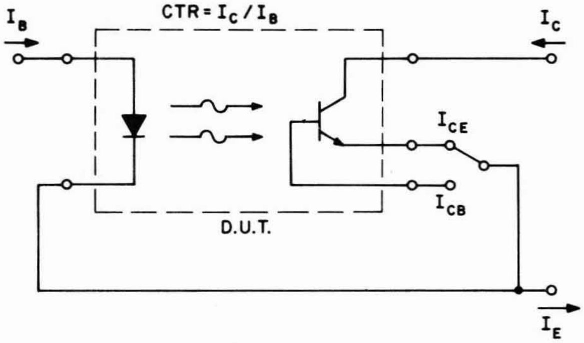


INPUT TO OUTPUT CAPACITANCE TEST CIRCUIT

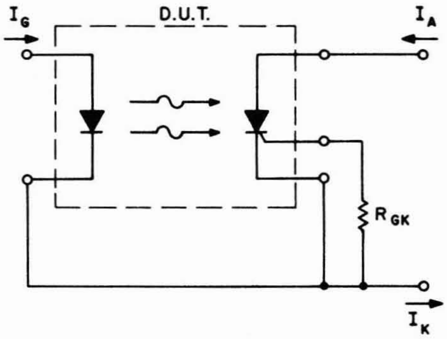
and frequency. Typical values are less than 2 pF, limiting the selection of measurement equipment.

2. *Transfer Characteristics* are normally easily measured on standard measurement equip- as the IRED can be treated as the input terminal of a discrete device.

a). *Current Transfer Ratio* (CTR) can be tested as h_{FE} of a transistor, both the phototransistor and photodiode response, and *Input Current to Trigger* (I_{FT}) can be tested as gate trigger current of an SCR. Pinout and the connection of base-emitter or gate-cathode resistors normally requires use of special test sockets.



CTR TESTED AS TRANSISTOR h_{FE}

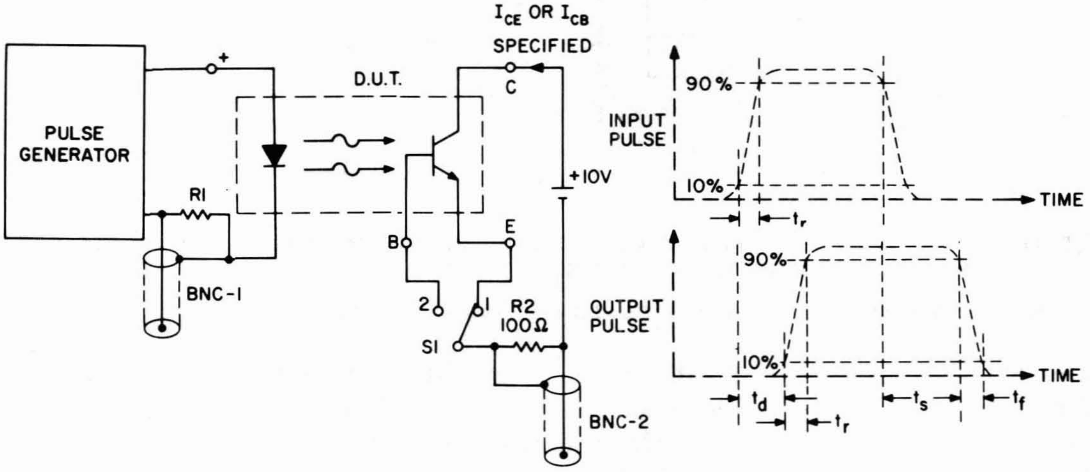


I_{FT} TESTED AS SCR I_{GT}

These sockets are illustrated above. Some commercial test equipment provides very poor resolution readings of CTR in the h_{FE} mode due to the readout system being designed for readings greater than 10. This would correspond to a CTR of 1000%, a reasonable value for a darlington, but not a transistor, output coupler. Curve tracers are well suited for use in this manner and some allow measurements to be made with the IRED pulsed at high current and low duty cycles.

b). Switching Times are measured using the technique illustrated below. Isolation of the input device from the output device allows a freedom of grounding which can simplify test set-up in some cases. The turn-on parameters are t_d – delay time and t_r – rise time. These are measured in the same manner on the phototransistor, photodarlington, and photo SCR output couplers. The turn-off parameters for transistor and darlington outputs are t_s – storage time and t_f – fall time.

t_d – delay time.	This is the time from the 10% point of the final value of the input pulse to the 10% point of the final value of the output pulse.
t_r – rise time.	The rise time is the time the leading edge of the output pulse increases from 10% of the final value to 90% of the final value.
t_s – storage time.	The time from when the input pulse decreased to 90% of its final value to the point where the output pulse decreased to 90% of its final value.
t_f – fall time.	The time where a output pulse decreased from the 90% point of its final value to the 10% point of its final value.



a. Test Set (T_1 and R_2 Non-Inductive)

b. Waveforms (Polarity Inverted for Clarity)

SWITCHING TIME TESTING

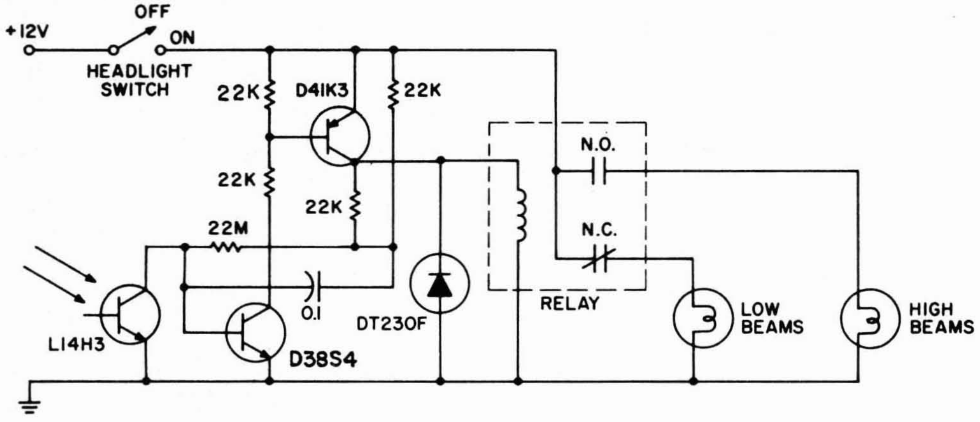
SCR turn-off times are circuit controlled, and the measurement technique is detailed in the GE SCR Manual.

SECTION V. OPTOELECTRONIC CIRCUITS

A. LIGHT DETECTING CIRCUITS

Light detecting circuits include only those circuits which cause an action based on the level of light received by the photo detector. A separate section is devoted to circuits that detect an object which breaks, or reflects, a beam of light.

Automatic Headlight Dimmer – this circuit switches the headlights, of the car equipped with it, to the low beam state when the lights of an on-coming car are sensed. The received light is very low level and highly directional, indicating the use of a lens with the detector. A relatively large amount of hysteresis is built into the circuit to prevent "flashing lights." Sensitivity is set by the 22M resistor to about 0.5 ft, candle at the transistor (0.01 at the lens), while hysteresis is determined by the two, 22K, resistor voltage divider, across the D41K3, which drives the 22M resistor, while maximum switching rate is limited by the 0.1 μF capacitor to ≈ 15/minute.

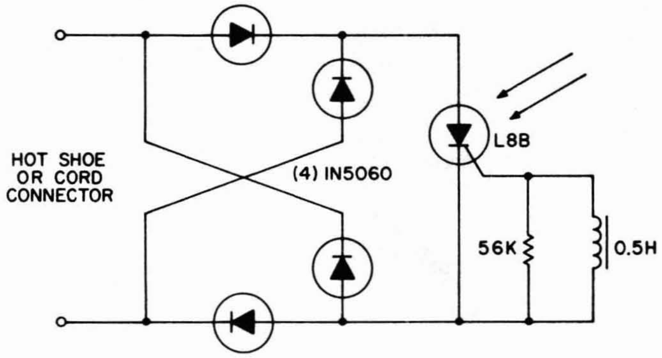


RELAY: 12V, 0.3A COIL; 20A, FORM C, CONTACTS OR SOLID-STATE SWITCHING OF 16A STEADY-STATE 150A COLD FILAMENT SURGE, RATING.

LENS: MINIMUM 1" DIAMETER, POSITIONED FOR ABOUT 10° VIEW ANGLE.

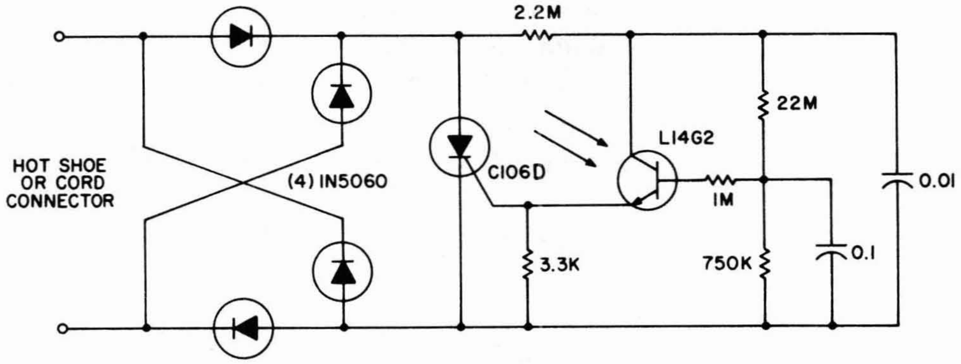
Slave Photographic Xenon Flash Trigger – often it is desirable to use a remote photographic flash unit which will flash at the same time as the flash attached to the camera. This circuit is designed to the trigger cord or "hot shoe" connection of a commercial portable flash unit and trigger the unit from the light produced by the light of the flash unit attached to the camera. This provides remote operation without need for wires or cables between the various units. The flash trigger unit should be connected to the slave flash before turning the flash on (to prevent a dV/dt triggered flash on connection) and the L8B should be pointed in the general direction of the camera flash unit. The choice of inductor value will set the sensitivity of the circuit, and no problem was noted with false triggering from fluorescent lights at 1 H , while triggering seemed adequate at the 0.1H value.

If a very sensitive (long range), more directional remote trigger unit is desired, the circuit may be modified to use a L14G2 lensed phototransistor as the sensor. The lens on this transistor provides a viewing angle of approximately 10° and gives over a 10 to 1 improvement in light sensitivity (3 to 1 range improvement). It also allows the elimination of the inductor, which may be objectionable due to its bulk or expense. Note that the phototransistor is connected in a



SLAVE PHOTOFLASH TRIGGER

self-biasing circuit which is relatively insensitive to slow changing ambient light, and yet discharges the 0.01 μF capacitor into the C106D gate when illuminated by a photo flash.



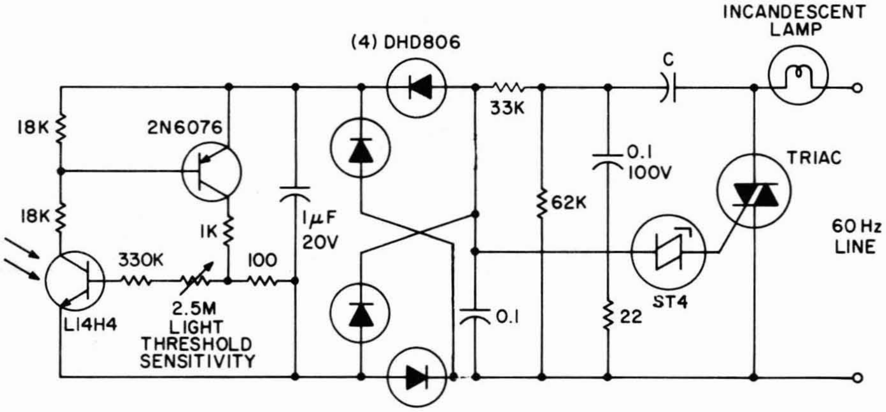
SENSITIVE, DIRECTIONAL, SLAVE PHOTO FLASH TRIGGER

Automatic Night Light Switches – these circuits are light level sensors which turn on a light when the ambient light falls below a set level. The most common of these circuits turns on street lamps and yard lights which are powered by 60 Hz lines.

Line Voltage Operated Automatic Night Light – An example of this type of circuit is illustrated here which has quite stable threshold characteristics due to its dependence on the photo diode current in the L14H4 generating a base emitter drop across the sensitivity setting register. The double phase shift network supplying voltage to the ST-4 trigger insures triac triggering at line voltage phase angles small enough to minimize RFI problems with a lamp load. This eliminates the need for a large, expensive inductor, contains the dV/dt snubber network, and utilizes lower voltage capacitors than the snubber or RFI suppression network normally would.

The addition of a programmable unijunction timer can modify this circuit to turn the lamp on for a fixed time interval each time it gets dark. Only the additions to the previous circuit are shown in the interest of simplicity. When power is applied to the lamp, the 2N6028 timer starts.

SUGGESTED TRIAC	LAMP WATTAGE MAXIMUM	
	120V	220V
SC136D	100W	200W
SC141D	400W	800W
SC146D	550W	1100W
SC151D	750W	1500W
SC260D	1200W	2500W
SC265D	2000W	4000W

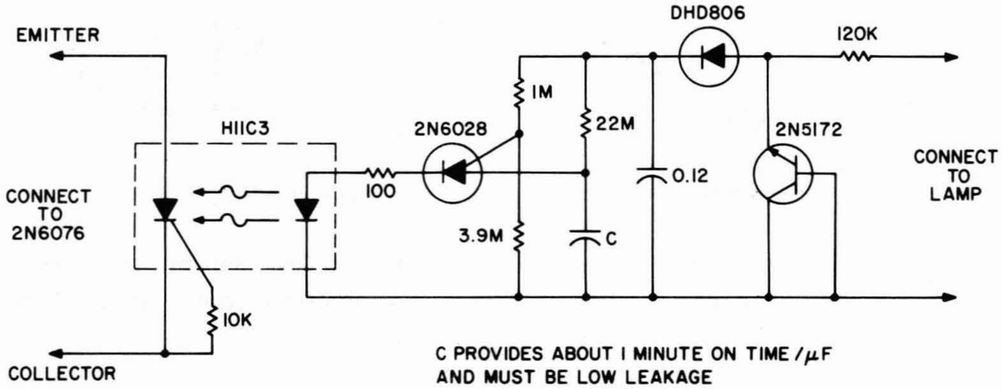


C = { 0.1µF, 100V FOR 120V LINE
0.068µF, 200V FOR 220V LINE

LINE VOLTAGE OPERATED AUTOMATIC NIGHT LIGHT

At completion of the time interval the H11C3 is triggered and turns off the lamp by preventing the ST-4 from triggering the triac. The SCR of the H11C3 will stay on until the L14H4 is illuminated and allows the 2N6076 to commutate it off. Due to capacitor leakage currents, temperature variations and component tolerances, the time delay may vary considerably from the nominal.

Another common use for night light circuits is to turn on remote illumination, warning or marker lights which operate from battery power supplies. The simplest circuit is one which provides

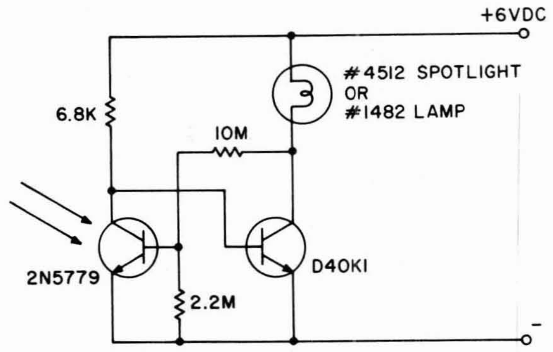


C PROVIDES ABOUT 1 MINUTE ON TIME /µF
AND MUST BE LOW LEAKAGE

AUTOMATIC TURN-OFF FOR NIGHT LIGHT

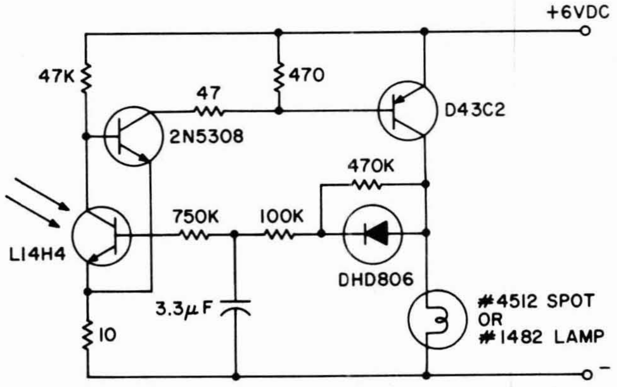
illumination when darkness comes. By using the gain available in darlington transistors, this circuit is simplified to use just a photodarlington sensor, a darlington amplifier, and three resistors. The illumination level will be slightly lower than normal, and longer bulb life can be expected, as the D40K saturation voltage lowers the lamp operating voltage slightly.

In warning and marker light applications a flashing light of high brightness and short duty cycle is often desired to provide maximum visibility and battery life. This necessitates use of an output transistor which can supply the cold filament surge current of the lamp while maintaining



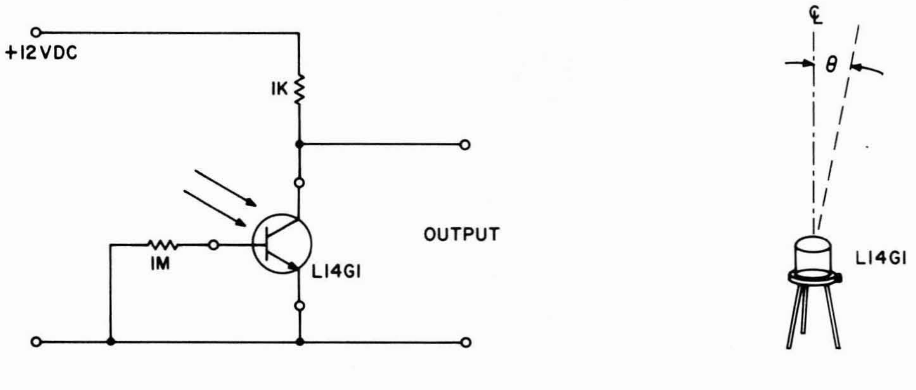
PORTABLE AUTOMATIC NIGHT LIGHT

a low saturation voltage, the addition of dynamic feedback, and the use of a phototransistor sensor to minimize sensitivity variation.



AUTOMATIC NIGHT FLASHING LIGHT

Sun Tracker – In solar cell array applications and solar instrumentation it is desired to know the position of the sun within 15° to allow efficient automatic alignment. The L14G1 lens can provide this type of accuracy in a simple level sensing circuit, and a full hemisphere can be monitored with about 150 phototransistors.



Electrical

Mechanical

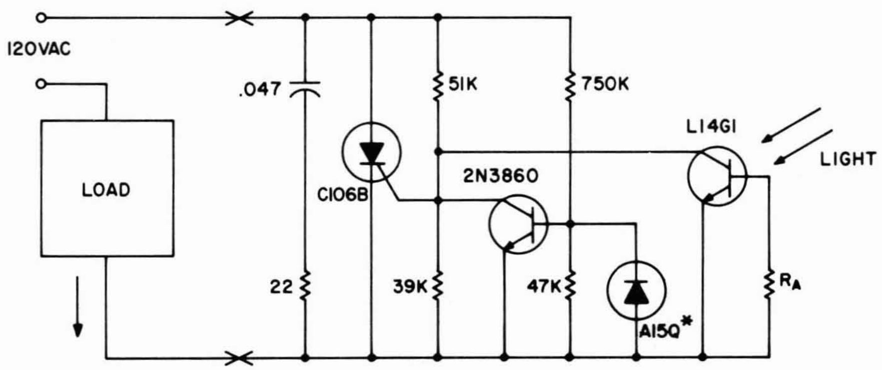
SUN TRACKING CIRCUIT

The sun provides $\approx$ 80 mW/cm^2 to the L14G1 when on the centerline. This will keep the output down at $\leqslant 0.5$V for $\Theta \leqslant 7.5^\circ$.

The sky provides $\approx$ 0.5 mW/cm^2 to the L14G1 and will keep the output above 10V when viewed. White clouds viewed from above could lower this voltage to $\approx$ 5V on some devices.

This circuit could directly drive TTL logic by clamping the output to the 5V logic supply with a signal diode. Anode-to-output line, cathode to +5V. Different bright objects can also be located with the same type of circuitry by simply adjusting the resistor values to provide the desired sensitivity.

Flame Monitor – The monitoring of a flame and direct switching of a 120V load is easily accomplished through use of the L14G1, as illustrated, for "point sources" of light.



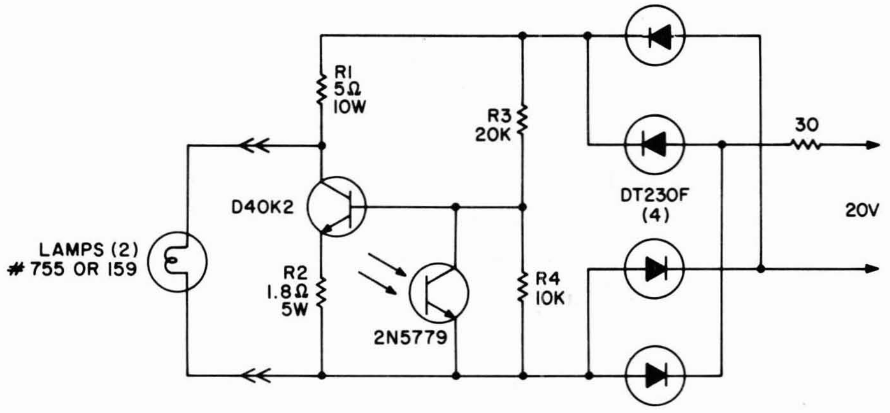
FLAME OUT MONITOR SWITCH

*The A15Q may be replaced by 100 pF shunting a DHD800.
Wire for minimum crosstalk, 120V to gate, using minimum lead lengths.
R_A is selected from the following chart for light level threshold programming.

R_A SELECTION GUIDE FOR ILLUMINATION						
HOLD OFF LIGHT LEVEL IN FOOTCANDLES	$\approx$ 20	$\approx$ 40	$\approx$ 80	$\approx$ 200	$\approx$ 400	FOOT CANDLE
R_A, Incandescent Light	N.A.	1500	270	68	33	K Ω
R_A, Flame Light	220	75	30	12	6.2	K Ω
R_A, Fluorescent Light	N.A.	N.A.	2200	180	68	K Ω

For light sources which subtend over 10° of arc, the L14H1 should be used and the illumination levels raised by a factor of 5. This circuit provides zero voltage switching to eliminate phase controlling.

Brightness Controls – The illumination level of lighted displays should ideally be lowered as the room ambient light drops to avoid undesirable or unpleasant visual effects. This circuit provides a very low cost method of controlling the light level from the relatively high source impedance transformers and motor windings normally used to drive the low voltage lamps used in these functions. It should be noted that the bias resistors are optimized for the 20V, 30 Ω

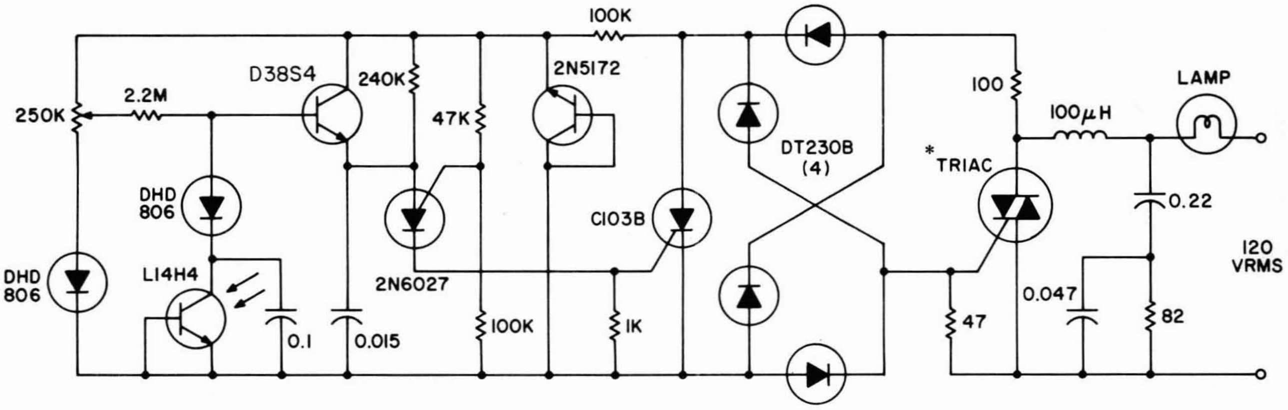


AMBIENT SENSITIVE DISPLAY ILLUMINATION

source, and must be recalculated for other sources. The 2N5779 is placed to receive the same ambient illumination as the display and be shielded from the light of the display lamps.

Another form of automatic brightness control maintains a lamp at a constant brightness over a wide range of supply voltages. This circuit utilizes the consistency of photo diode response to control the phase angle of power line voltage applied to the lamp and can vary the power applied to the lamp between that available and ≈ 30% of available. This provides a candlepower range from 100% to less than 10% of nominal lamp output. The 100 μH, 2 capacitor filter network is used to eliminate conducted RFI problems.

Many other light sensitive circuits are feasible with these versatile devices, and those included here are chosen to illustrate a range of practical cost effective designs.



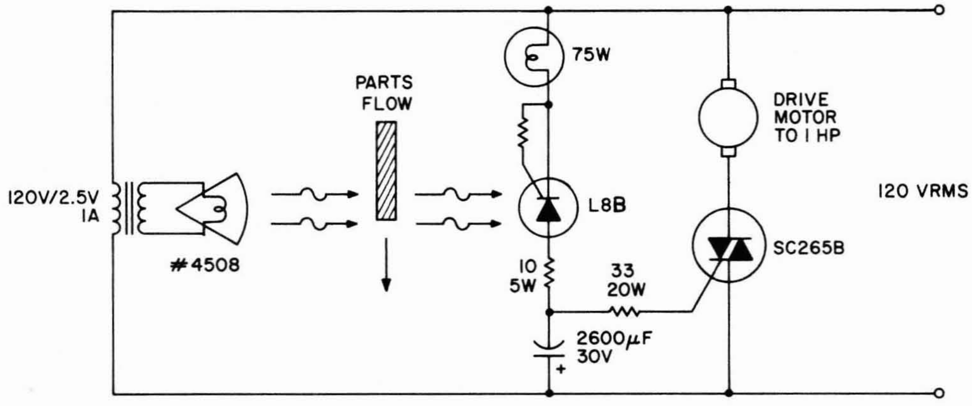
*The triac is matched to the lamp per chart at top of Page 54.

CONSTANT BRIGHTNESS CONTROL

B. DETECTING OBJECTS WITH LIGHT

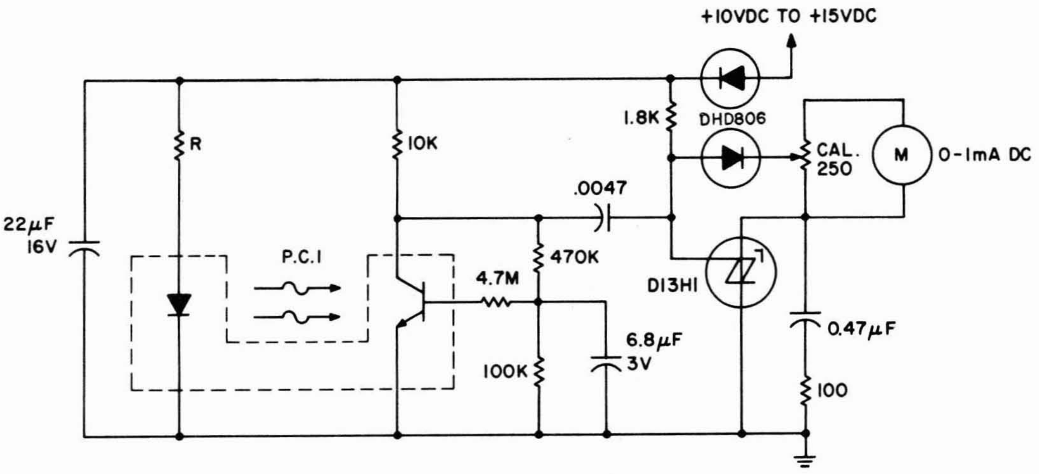
This section is devoted to circuits which use a light source and a light sensor, or arrays of either or both, to sense objects by affecting the light path between the source and detector. Normally, the light is blocked or reflected by the object to be sensed, although modulation of the transmission medium is also common.

Production Line "Log Jam" Control – In many production lines the flow of parts is controlled by a drive motor, which should be turned off if a "log jam" occurs and parts are no longer being removed from the output of the driven conveyance. This simple circuit provides direct control of the drive with a lamp providing visual indication of normal flow. Snubber networks have not been illustrated to simplify the schematic. The #4508 sealed beam lamp and 75W indicator lamp are run at about two-thirds rated voltage to provide long service and reliable operation. Light blockages of up to ¼ second are ignored by this circuit (except for the indicator blinking off) and, if the blockage time extends, the drive motor is turned off. When the light blockage is removed, the drive motor will automatically turn on again.



NORMAL FLOW

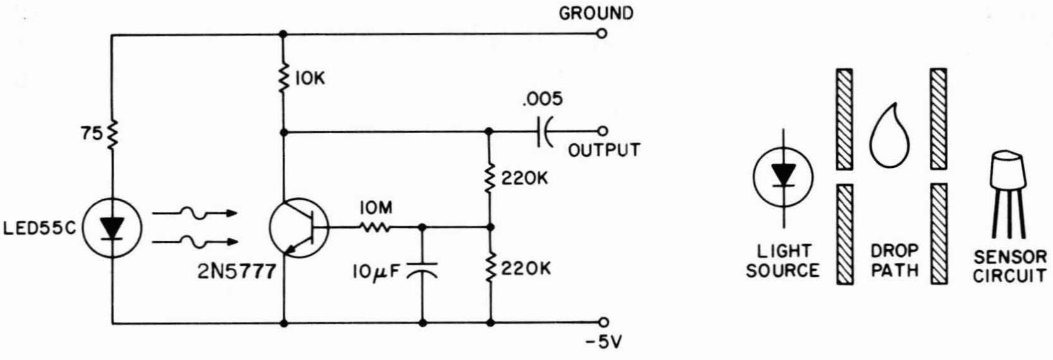
Optical Pick Up Tachometer – Remote, non-contact, measurement of the speed of rotating objects is the purpose of this simple circuit. Linearity and accuracy are extremely good and



PC-1 AND R { H13B1 FOR TRANSMISSIVE SENSING, R = 1K
LED55C AND L14G3 FOR REFLECTIVE SENSING, R = 150Ω

normally limited by the milliammeter used and the initial calibration. This circuit is configured to count the leading edge of light pulses and to ignore normal ambient light levels. It is designed for portable operation as accuracy is not supply voltage sensitive within supply voltage tolerances. As illustrated, full scale at maximum sensitivity of the calibration resistance is read at about 300 light pulses per second. Longer range reflective operation may be obtained by using a focused incandescent lamp, operating straight from supply voltage (filament time constant replaces filtering), to replace the IRED. A digital volt meter may be used, on the 100 mV full scale range, in place of the milliammeter, by shunting its input with a 100 Ω resistor in parallel with a 100 μF capacitor. This R-C network replaces the filtering supplied by the analog meter.

Drop Detector – The self-biasing configuration used for the light detector in the tachometer is useful any time small changes in light level must be detected, as when monitoring very low flow rates by counting drops of fluid. In this bias method, the photodarlington is DC bias stabilized by feedback from the collector, compensating for different photodarlington gains and light emitting diode outputs. The 10 μF capacitor integrates the collector voltage feedback, and the 10M resistor provides a high base source impedance to give minimal effect on optical performance.



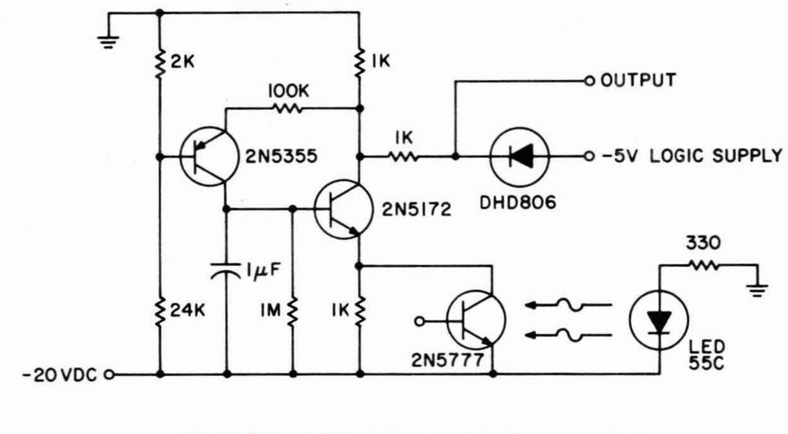
Electrical Schematic

Mechanical Schematic

LOW LIGHT LEVEL DROP DETECTOR

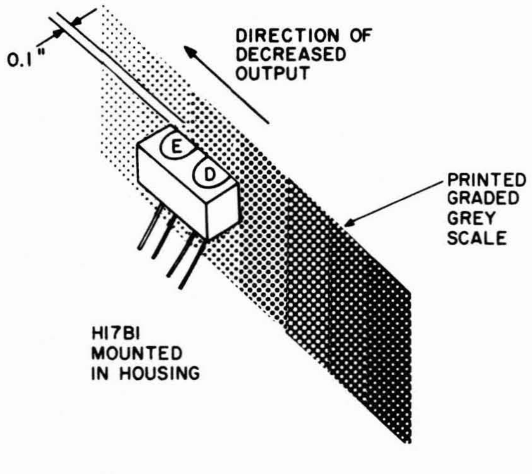
The detector drop causes a momentary drop in light reaching the chip, which causes collector voltage to momentarily rise, generating an output signal. The initial light bias is small due to output power constraints on the light emitting diode and mechanical spacing system constraints. The change in light level is a fraction of this initial bias due to stray light paths and drop translucence. The high sensitivity of the photodarlington allows acceptable output signal levels when biased in this manner. This compares with unacceptable signal levels and bias point stability when biased conventionally, i.e., base open and signal output across the collector bias resistor.

Paper Tape Reader – When computer peripheral equipment is interfaced, it is convenient to work with logic signal levels. With a nominal – 1V at the output dropping to 0.6 V below the logic supply, this circuit reflects the requirements of a high-speed, paper tape optical reader system. The circuit operates at rates of up to 1000 bits per second. It also must operate at tape translucency such that 50% of the incident light is transmitted to the sensor, and provide a fixed threshold signal to the logic circuit. All at low cost. Several circuit tricks are required. Photodarlington speed is enhanced by cadcode constant voltage biasing. The output threshold and tape translucency requirements are provided for by sensing the output voltage and providing negative feedback to adjust the cascode transistor bias point. Circuit tests confirmed operating to 2000 bits per second at ambient light levels equal to signal levels.

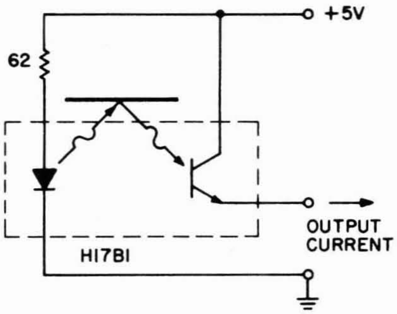


HIGH SPEED PAPER TAPE READER CIRCUIT

Frictionless Potentiometer – This circuit provides not a potentiometer output, but a current source that varies with the position of an object. At first glance, this might appear a trivial problem, but the small physical sizes of optoelectronic components combined with mechanical tolerances on assembling the parts virtually eliminates transmissive sensing of the leading edge of a light shield, while the manufacturing of a shield which will provide smooth current changes with smooth motion is a challenge in providing a transmissive "graded grey scale." At this time, it appears the most practical way of providing the optical potentiometer function is to reflect light from a printed "graded grey scale." Tests on an H17B pair, placed next to each other in a non-transmissive, non-reflective, housing with a thin light shield separating the pair, indicate a current transfer ratio of about 5% of the test condition value when viewing a sheet of white paper at ≈ 0.1″ (¼ cm). Viewing a black printed field, the CTR dropped to zero (leakage current level). This indicates the minimum signal change expected, at 25°C in the above circuit, would be from about 1 μA leakage (allowing for some ambient light) at black to about 150 μA with a white field.



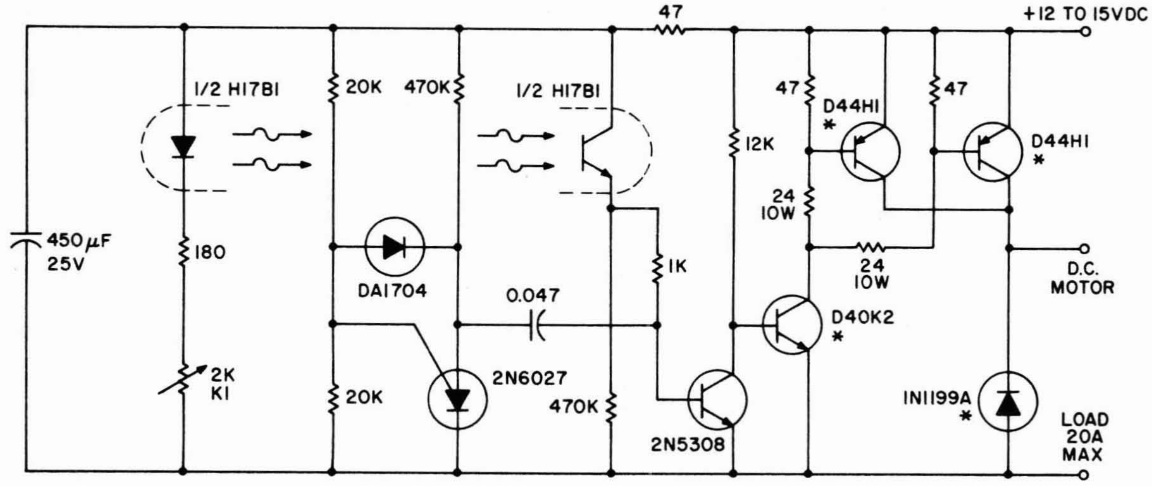
MECHANICAL SCHEMATIC



ELECTRICAL SCHEMATIC

Motor Speed Control Circuits – These controls may be of the open loop type, where light just provides a no contact, non-wearing, circuit input from a person or machine which monitors the output of the motor, or a closed loop type, where the light monitors motor speed as a tachometer and maintains a fixed, selected, speed-over a range of load and line conditions.

The open loop circuits are nicely suited to use with the frictionless potentiometer circuit previously presented. The following circuit illustrates the concept used to control a low voltage, battery operated 200 W motor. Temperature, etc., effects can be compensated for by regulating the IRED bias current via a 2N5777 directly illuminated by the IRED, although this precision is not generally needed in a human input system.



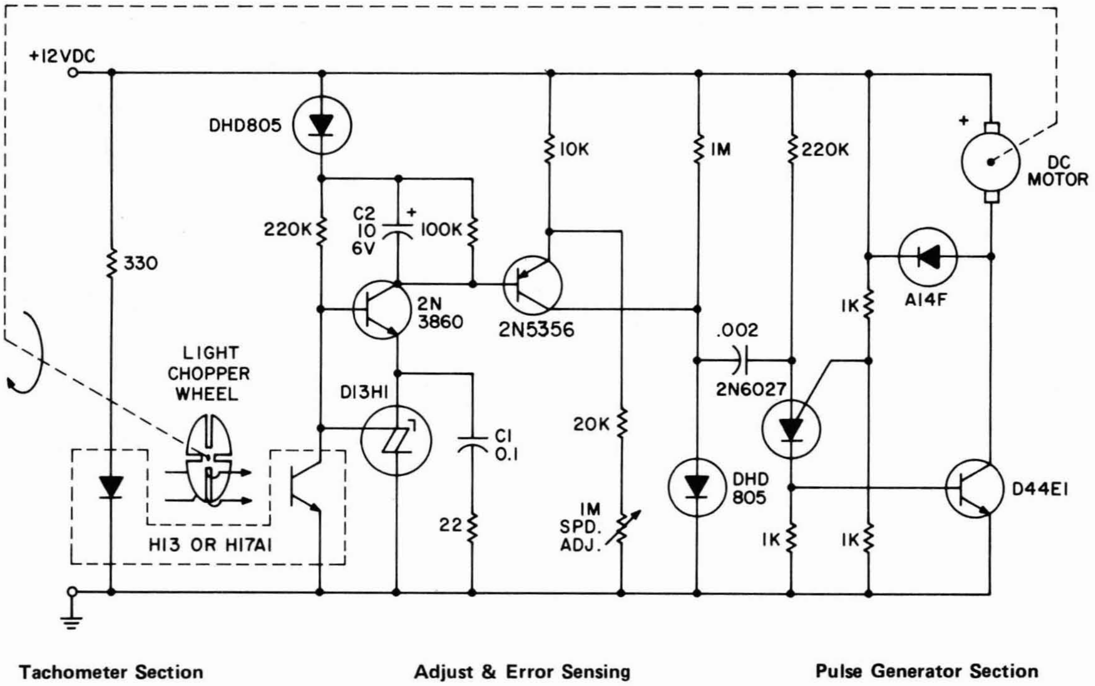
*heat sink as required

Pulse Generator/Modulator **Amplifier**

PULSE WIDTH MODULATED SPEED CONTROL

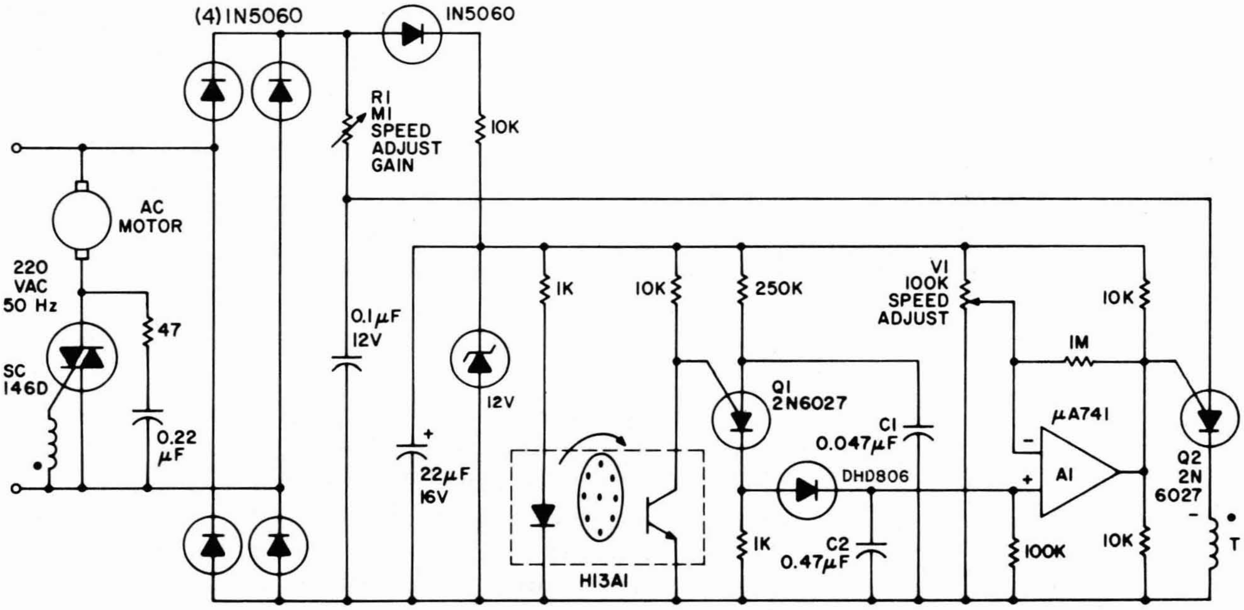
Open loop phase control of an A.C. motor can be accomplished using the "Constant Brightness Control" circuit previously documented with an H17A1, in the "Frictionless Potentiometer" configuration, replacing the L14H4 and the motor replacing the lamp as a load. Using this or other phase control circuits for motor speed control, it must be noted that many A.C. motors are not compatible with this method of speed control, and some of those that are phase controllable can only be controlled over a fraction of the speed range. Universal (A.C. – D.C.) motors are easily phase controlled over wide speed ranges, although some bearing designs have lubrication problems at low speed.

Closed loop, tachometer feedback control systems utilizing the H13A and a chopper disc, provide superior speed regulation when the dynamic characteristics of the motor system and the feedback system are matched to provide stability. The tachometer feedback systems illustrated on the next page were designed around specific motor/load combinations and may require modification to prevent hunting or oscillation with other combinations. This D.C. motor control utilizes the opto tachometer circuit previously shown to control a P.U.T. pulse generator which drives the D44E1 darlington switch which powers the motor.



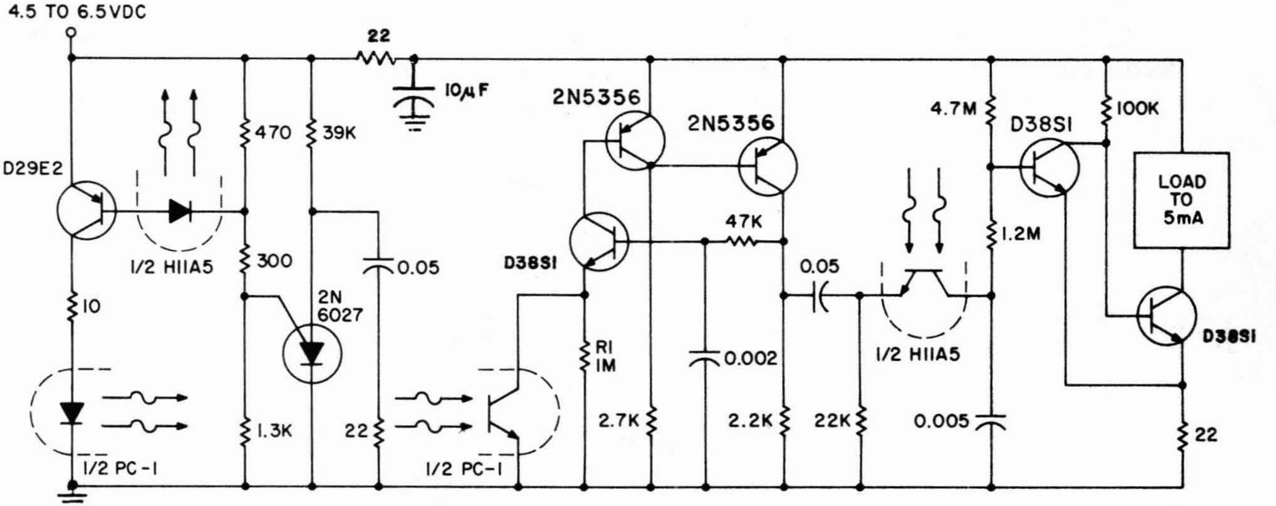
D.C. MOTOR, TACHOMETER FEEDBACK, PWM, SPEED CONTROL

The A.C. motor control below illustrates feedback speed regulation of a standard A.C. induction motor, a function difficult to accomplish otherwise than with a costly, generator type, precision tachometer. When the apertured disc attached to the motor shaft interrupts the light beam across



CLOSED LOOP A.C. MOTOR SPEED CONTROL WITH OPTICAL TACHOMETER the coupler module, the programmable unijunction transistor, Q_1, discharges capacitor, C_1, into the much larger storage capacitor, C_2. The voltage on C_2 consequently is a direct function of the rotational speed of the motor. Subsequently, this speed-related potential is compared against an adjustable reference voltage, V_1, through the monolithic operational amplifier, A_1, whose output, in turn, establishes a D.C. control input to the second P.U.T., Q_2. This latter device is synchronized to the A.C. mains and furnishes trigger pulses in conventional manner to the triac at a phase angle determined by the speed control, R_1, and by the actual speed of the motor.

Long Range Object Detector – When long ranges must be worked with IRED light sources, as when high system reliability is required, pulsed mode operation of the IRED is required. Additional reliability of operation is attained by synchronously detecting the photodetector current, as this circuit does. PC-1 is an IRED and phototransistor pair which detect the presence of an object blocking the transmission of light from the IRED to the phototransistor. Relatively long distance transmission is obtained by pulsing the IRED, at about 10 μsec. per 2 msec., to 350 mA via the 2N6027 oscillator. The phototransistor current is amplified by the D38S1 and 2N5356 amplifier to further increase distance and allows use of the H11A5, also pulsed by the 2N6027, to be used as a synchronous detector, providing a fail safe, noise immune signal to the D38S1 switches.



PC-1 SELECTION	TRANSMISSION RANGE	REFLECTIVE RANGE
H17A1	1-1/2″	3/8″
LED56 and L14H3	12″	3″
LED56 and L14G1	18″	4-1/2″
LED55C and L14G1	32″	8″
1N6266 and L14G3	48″	12″

LONG RANGE OBJECT DETECTOR

This design was built for battery operation with long battery life a prime consideration. Note that another stage of amplification driving the IRED can boost the range by 5 to 10 times, limited by the IRED V_F, and a higher supply voltage for the IRED can double this!

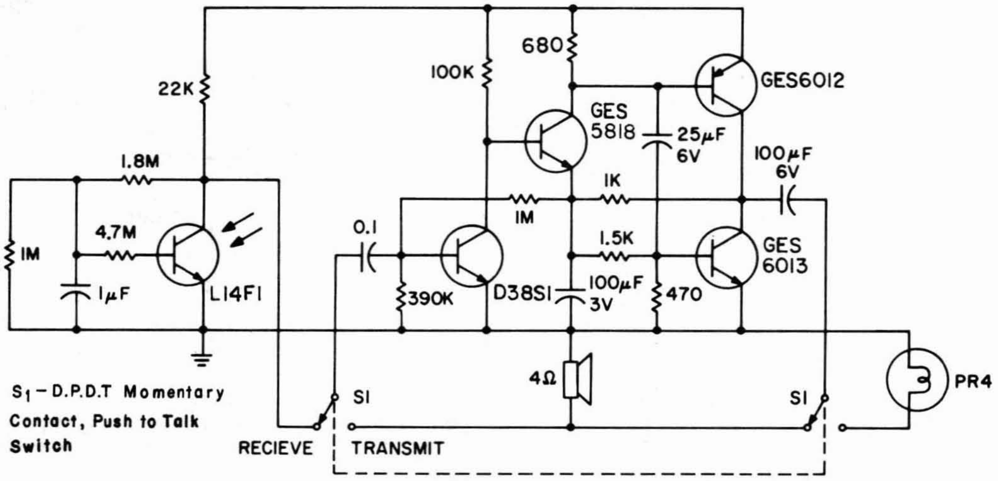
C. Transmitting Information With Light

Transmission of electronic information over a light beam is the major use of optoelectronics today. These applications range from the use of optocouplers transmitting information between IC logic circuits and other circuits, between power lines and signal circuits, between telephone lines and control circuitry, to the pulse modulated systems which transmit information through air or fiber optics over relatively great distances.

1. Analog Information

The circuits illustrated here are designed to transmit analog, i.e., linear signals, optoelectronically. In this section the trade-offs of communication distance, fidelity, noise immunity and other design constraints are illustrated by example in an attempt to provide a feeling for this technology.

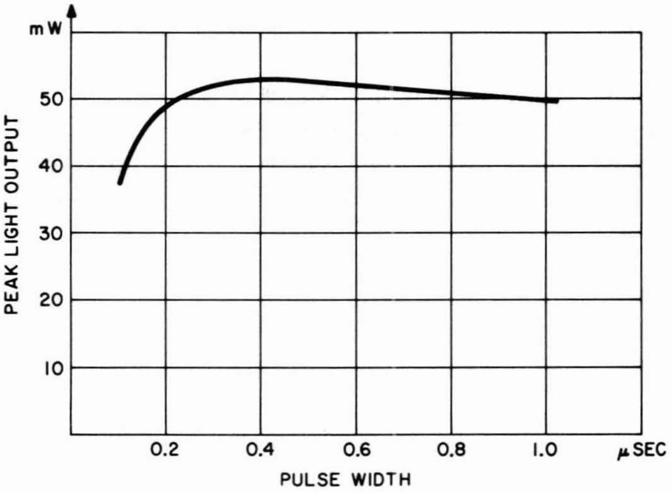
Light Coupled Transceivers – A very simple, portable, visually-aligned transceiver system has been designed around 6V flashlights. The lamp current is modulated at an audio rate, which modulates the light beam. The light beam is detected by a photodarlington, AC amplified, and drives a small speaker for audio output. Note that driving the lamp with an AC signal cuts the RMS voltage to about one-third the 6V, indicating the use of the 2V PR4 bulb in the 6V circuit. The L14F can be mounted on the axis of the beam, or for possibly improved sensitivity, facing the reflector of the flashlight just above the bulb (the bulb filament is at the focal point of the reflector. Fidelity is not high, due to the low pass characteristics of the lamp filament, but intelligible conversation at distances up to 100 feet have been reported.



S₁ – D.P.D.T Momentary Contact, Push to Talk Switch

FLASHLIGHT COMMUNICATOR

Using an IRED for the light source eliminates the response time of the light source as a limit to fidelity, but requires the design of a pulse source and amplitude or frequency modulation techniques to allow the IRED to generate enough light power to transmit appreciable distances. Power dissipation in the IRED limits the ultimate capability of this type of system for distance and modulation frequency, due to the trade-off of power dissipation, pulse width and pulse frequency. In applications where transmission of information without electromagnetic interference is imperative, a relatively low cost system can be built around an IRED, a phototransistor, and low cost glass fiber optics, which can provide transmission over distances greater than 100 feet, or at rates over 100 KHz using low cost driving circuitry. Higher frequency systems for long distance operation require pulse generators capable of generating short (<200 nsec), high current pulses with leading edge overshoot, adding considerably to system expense, and heat sinking of the IRED. Frequency modulation and pulse data transmission are compatible with both low and high frequency systems. The General Electric LED55 Series IRED is very efficient and has excellent stability due to the liquid epitaxial processing, which also defines its switching parameters and speed of response. This response time varies from about 100 to 500 nsec, depending on bias level, and indicates that, for a given IRED power dissipation, and frequency of operation, there is an optimum input pulse width which will maximize pulse power output and, thereby, range of transmission. For the system illustrated in the next application, this was determined to be about 500 nsec, although power output was within 10% of the maximized value for widths from 170 nsec to over 1 μsec. This was determined by monitoring the power output with a photo cell connected phototransistor (the photo response with a low value load resistor is about an order of magnitude faster than the IRED) as the pulse width to the IRED is changed, maintaining other system parameters constant. Peak power input for the desired maximum power dissipation can be calculated for each pulse width and multiplied by the normalized peak power out and efficiency, at that pulse width and input power, respectively, to obtain a set of values of peak available power out, as a function of pulse width, at the frequency, waveshape and average power dissipation desired. Plotting the set of values gave the curve, which allowed analytical system optimization. It should be noted that peak light output occurred 50 to 100 nsec after peak input current was reached, and that the IRED continued to emit light for 1 μsec after the input current pulse had gone to negligible levels, which places a peak repetition rate and peak envelope power optimization constraint on designs over 500 KHz.* This is why most high frequency systems are designed around the expensive, short lived, GaAs laser diode.



PEAK LIGHT OUTPUT EXPECTED FOR P_{AVE} = .25W, f = 80 KHz OPERATION

A relatively simple FM (PRM) optical transmitter was designed around a programmable unijunction transistor (PUT) pulse generator using these techniques. The basic circuit can be operated at 80 KHz and is limited by the PUT-capacitor combination, as higher frequency demands smaller capacitance, which provides less peak output. As illustrated, 60 KHz is maximum modulation. Pulse repetition rate is relatively insensitive to temperature and power supply voltage and and is a linear function of V_{IN}, the modulating voltage. Tested with the receiver illustrated below, useful information transfer was obtained in at free air ranges of 12 feet (≈ 4m). Lenses at the light emitter and detector, or transmitting the signal through low cost glass fiber optics greatly increases range and minimizes stray light noise effects. Greater output can be obtained by using a larger capacitor, which also gives lower operating frequency, or using the higher output LED55C. Average power consumption of the transmitter circuit is less than 3 watts.

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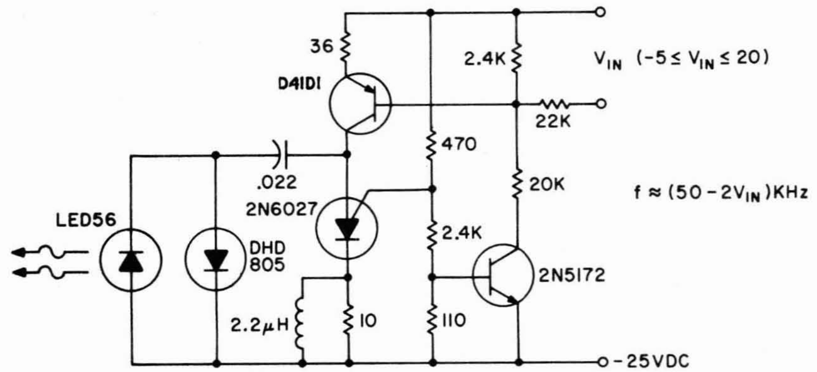
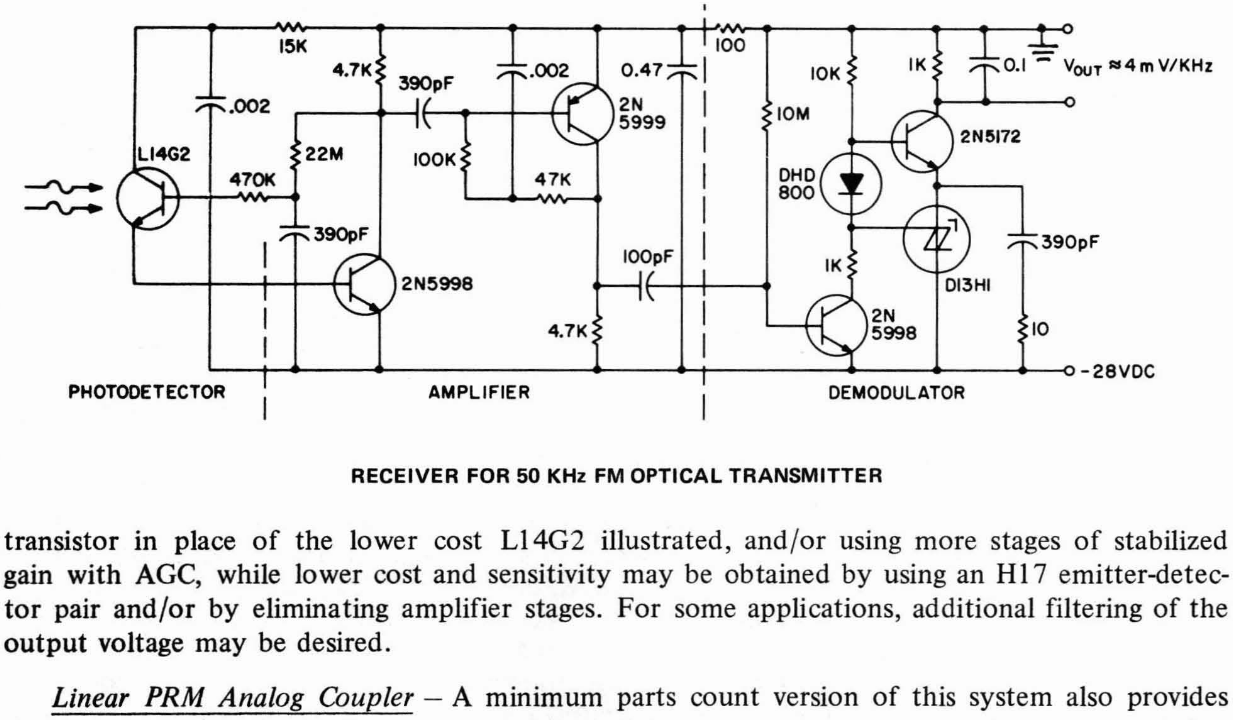
*See 1 MHz Telecommunications Data Isolator pg. 73, for further information.



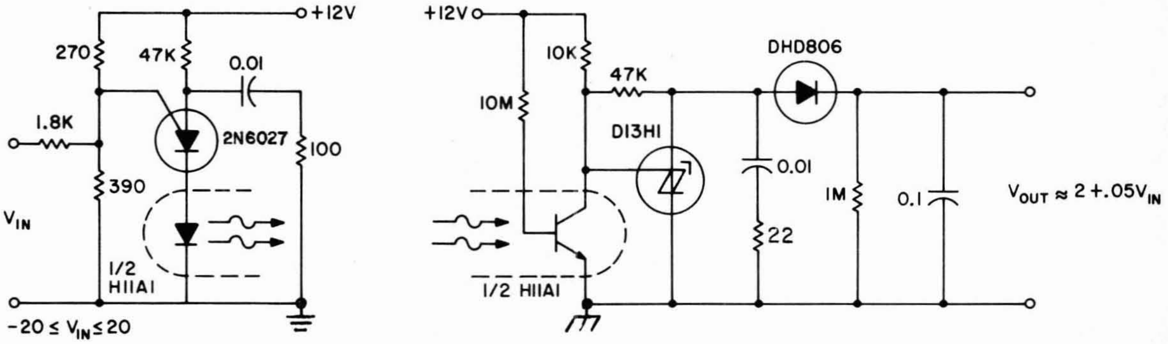
50 KHz CENTER FREQUENCY FM OPTICAL TRANSMITTER

For maximum range, the receiver must be designed in the same manner as a radio receiver front end, as the received signals will be similar in both frequency component and in amplitude of the photodiode current. The major constraint on the receiver performance is signal to noise ratio, and e.m. shielding, stability, bias points, parts layout, etc. become significant details in the final performance. This receiver circuit consists of a L14G2 detector, two stages of gain, and a FM demodulator (which is the tachometer circuit, previously illustrated, modified to operate over 100 KHz). Note that better sensitivity can be obtained by using the L14G3 high gain phototransistor in place of the lower cost L14G2 illustrated, and/or using more stages of stabilized gain with AGC, while lower cost and sensitivity may be obtained by using an H17 emitter-detector pair and/or by eliminating amplifier stages. For some applications, additional filtering of the output voltage may be desired.



RECEIVER FOR 50 KHz FM OPTICAL TRANSMITTER

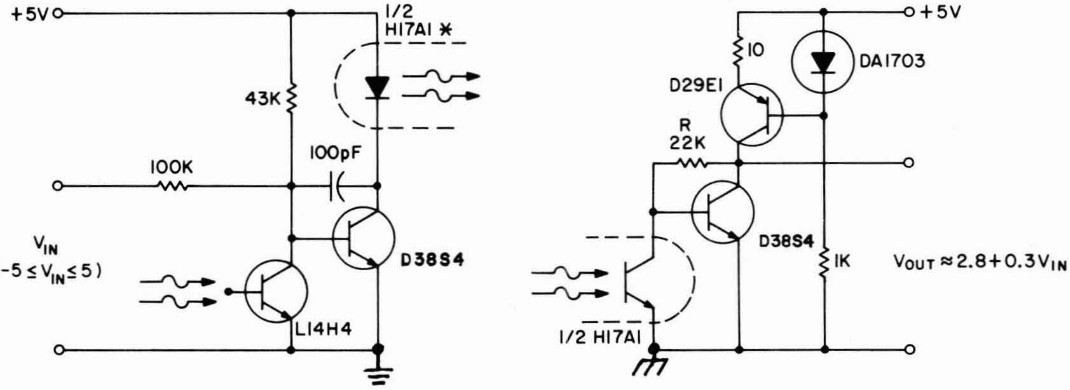
Linear PRM Analog Coupler – A minimum parts count version of this system also provides isolated, linear signal transfer useful at shorter distances or with an optocoupler for linear information transfer. Although the output is low level and cannot be loaded significantly without harming accuracy, a single I.C. operational or instrumentation amplifier can supply both the linear gain and buffering to allow use with a wide variety of loads.



Transmitter Receiver

MINIMUM PARTS COUNT LINEAR PRM ISOLATION CIRCUIT

DC Linear Coupler – Direct linear coupling of analog current signals via an optocoupler puts circuit performance at the mercy of coupler linearity and temperature coefficient. Use of an additional coupler for feedback can only provide linearity if the two couplers are perfectly matched and identically biased. These are not practical constraints in most equipment designs and indicate need for a different design approach. One of the most successful solutions to this problem can be implemented using a H17 emitter-detector pair and a L14H4, as illustrated below. The H17 detector and L14H are placed so both are illuminated by the H17 IRED emitter. Ideally, the circuit is mechanically designed such that the H17 emitter may be positioned to provide V_{OUT} = 2.8V when V_{IN} = 0, thereby insuring collector current match in the detectors, and then all three devices are locked in position relative to each other. Otherwise, R may be adjusted to provide the proper null level, although temperature tracking should prove worse when R is adjusted. Note that the input bias is dependent on power supply voltage, although the output is quite independent of supply variations. Testing indicated linearity was better than could be resolved due to alignment motion using plastic tape to lock positions.



Input Output

LINEAR OPTICAL COUPLER CIRCUIT

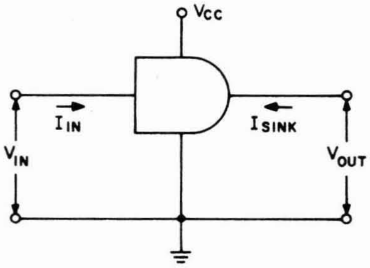
*Closely positioned to illuminate L14H4 and H17A1 Detector, such that $V_{OUT} \cong 2.8V$ at $V_{IN} = 0$.

2. Digital Information

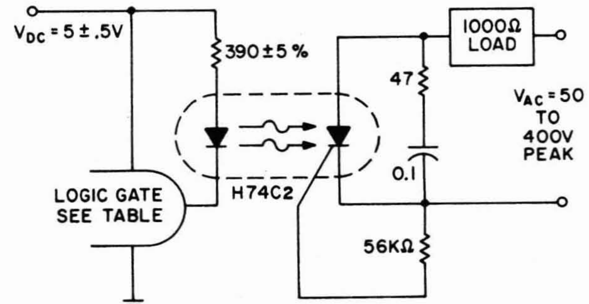
The circuits illustrated here are used to transmit information in the form of switch states, i.e., on and off or zero and one states. Most of these circuits are designed to interface with commercial integrated circuit logic by receiving and/or providing signal for the logic circuit. Due to switching speeds, of both emitters and detectors, no optocoupler can provide true speed compatibility with any but the slowest logic families at state-of-the-art speeds. For this reason, the logic compatibility of these circuits is level compatibility at worst case conditions, i.e., zeros and ones will meet the I.C. specified levels over the ranges of conditions specified.

TTL – This is the most common logic family, has the most functions available, and is the basis for the IEEE digital interface standard for programmable instruments. There are also a wide variety of standard types of TTL (i.e., high speed, Schottky, LSI, etc.) each of which has different logic level or logic level conditions (source and sink currents, mainly) each of which can place different requirements on an optocoupler required to interface with it. To simplify some problems of interfacing TTL logic with optocouplers, GE surveyed the specifications of SSI devices (single function devices, i.e., "or" gates, flip-flops, etc.) and has specified a series of couplers to be level compatible with the common 7400, 74H00 and 74S00 series TTL over the range of gate parameters, power supply and temperature variations specified. These couplers are designated the H74 series, and are specified with specific values of 5% tolerance bias resistors in a defined configuration. This eliminates any chance of misapplication or circuit malfunction. The circuits and logic truth table below illustrates application of this series of coupler. Noise margin considerations are minimized with these couplers as the slow switching speeds of the optocoupler do not allow reaction to the high speed hash that are provided for by noise margins.

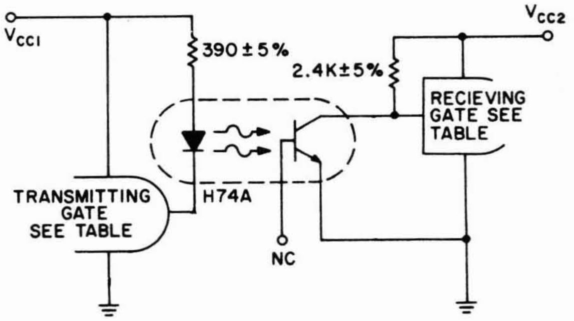
PARAMETER	TEST CONDITIONS						LIMITS		
	V_{CC}		I_{IN}		I_{SINK}		Min.	Max.	Units
	Min.	Max.	Min.	Max.	Min.	Max.			
V_{OUT} (1)	4.5V					-0.4mA	2.4		Volts
V_{OUT} (0)	4.5V				12.0mA			0.4	Volts
V_{IN} (1)		5.5V		1.0mA			2.0		Volts
V_{IN} (0)		5.5V	-1.6mA					0.8	Volts



CHARACTERISTICS REQUIRED OF TTL GATES WHICH ARE TO BE INTERFACED BY H74 SERIES



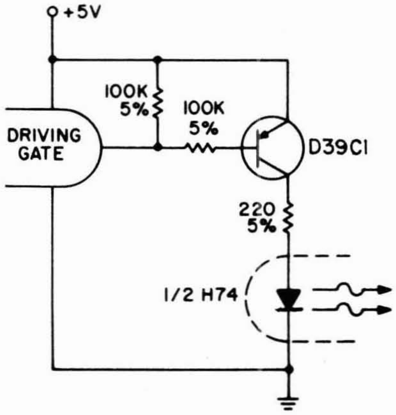
LOGIC TO POWER COUPLING H74 BIAS CIRCUIT



LOGIC TO LOGIC COUPLERS H74A1 BIAS CIRCUIT

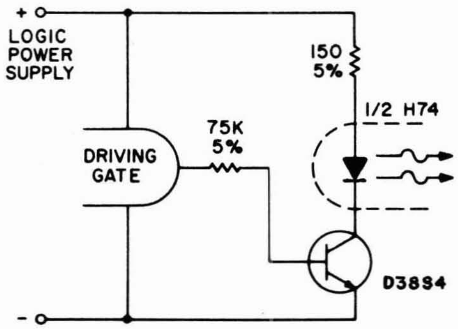
H74 SERIES TTL LOGIC COUPLING

Low power TTL, low power Schottky clamped TTL, MSI TTL and LSI TTL circuits will not in general, provide the current sinking capability indicated in the H74 bias chart. The H74 series optocoupler still can provide the means of using a general purpose circuit which will interface with all these types and between all the types. A simple stage of transistor amplification as an output buffer allows the low current sink capability (down to 100 μA) to drive the IRED. The logic sense is not changed, logic zero out provides current to the IRED which activates the output of the optocoupler. High threshold versions of TTL (HNIL, etc.) can normally be used without buffering by raising the bias resistors to keep worst case currents within the TTL range at the higher supply voltages used with these logic circuits.



H74 SERIES OPERATION FROM LOW POWER, MSI AND LSI TTL

CMOS – Like all low power (bipolar and MOS) logic, CMOS inputs are easily driven by optocoupler outputs. Although some couplers are advertised as CMOS output compatible, careful examination reveals the CMOS gate must be capable of sinking/sourcing several hundred microamps to drive the light source. As standard CMOS logic operates down to 3V supply and is specified as low as 30 μA maximum current sinking/sourcing capability, it is again necessary to use a buffer transistor to provide the required current to the IRED if CMOS is to drive the optocoupler. As in the case of the low output TTL families, the H74A output can drive a multiplicity of CMOS gate inputs or a standard TTL input given the proper bias of the IRED. The optocoupler driving circuit is illustrated below.



GENERAL PURPOSE CMOS H74 BIAS CIRCUIT

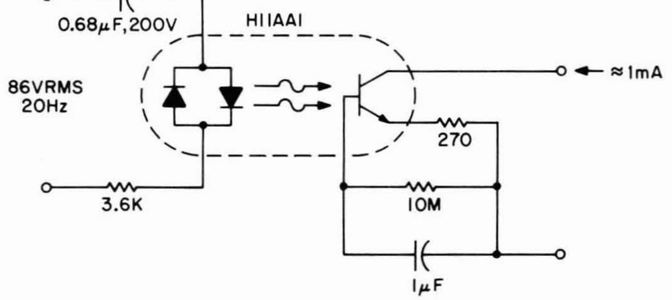
Note the logic sense is changed, i.e., a one logic state drives the IRED on. This circuit will provide worst case drive criteria to the IRED for logic supply voltages from 3V to 10V, although lower power dissipation can be obtained by using higher value resistors for high supply voltages. If this is desired, remember the worst case drive must be supplied to the IRED with minimum supply voltage, minimum temperature and maximum resistor tolerances, gate saturation resistance and transistor saturation voltages applied. For the H74 devices, minimum IRED current at worst case conditions (zero logic state output of the driving gate) is 6.5 mA.

P MOS and N MOS – These logic families have current source and sink capabilities similar to the previously mentioned CMOS worst case. Normal logic supply voltages range from 6V to 30V at these drive levels and bias circuitry design must account for this. N MOS provides higher current sinking than sourcing capability, while P MOS is normally the opposite. As these logic families are found in a wide variety of custom and standard configurations (from calculators to micro computers to music synthesizers, etc.) a general optocoupler bias circuit is impossible to define. The form of the circuit will be similar to the low output TTL circuit for N MOS and similar to the CMOS circuit for P MOS. Bias resistor constraints are as previously mentioned.

3. Telecommunications Circuits

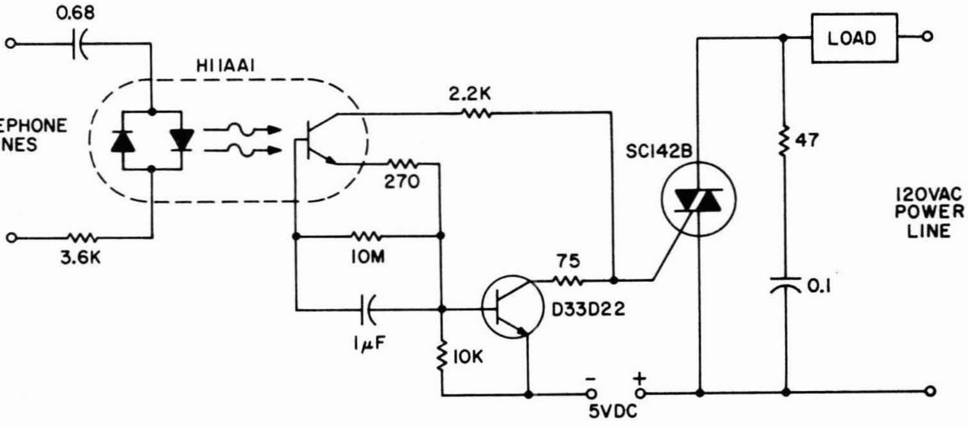
The largest information transmitting system is the telephone system of the United States. In this system many functions exist which could benefit from the applications of an optocoupler. This section will document a few of these applications, although it should be noted that very detailed knowledge of the particular telephone system and its interaction with the optocoupler circuit is required to insure proper circuit operation and prevent damage to the phone system.

Ring Detectors – These circuits are designed to detect the 20 Hz, ≈ 86V rms ring signal on telephone lines and initiate action in an electrically isolated circuit. Typical applications would include automatic answering equipment, interconnect/interface and key systems. The circuits illustrated below are "bare bones" circuits designed to illustrate concepts and do not eliminate the ac/dc ring differentiation, 60 Hz noise rejection, dial tap rejection, etc. effects which must be considered in field application. The first ring detector is the simplest and provides about 1 mA signal for a 7 mA line loading about 1/10 sec. after the start of the ring signal. The time delay capacitor provides a degree of dial tap and click suppression, as well as filtering out the zero crossing of the 20 Hz wave.



SIMPLE RING DETECTOR CIRCUIT

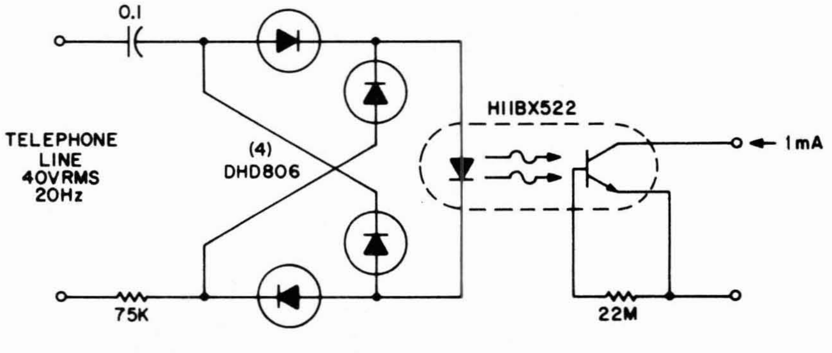
This circuit provides the basis for a simple example, a ring extender which will operate lamps and buzzers from the 120V, 60 Hz power line while maintaining positive isolation between the telephone line and the power line. Use of the isolated tab triac simplifies heat sinking by removing the constraint of isolating the triac heat sink from the chassis.



Maximum Load: 500 W Lamp or 800 W Inductive or Resistive

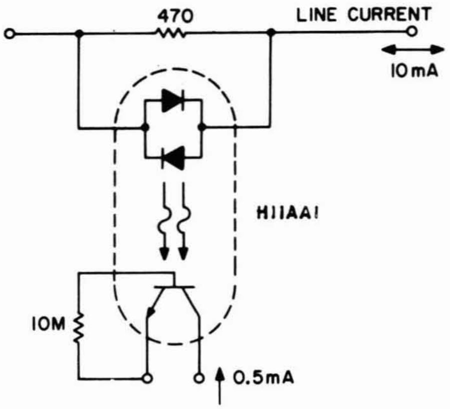
REMOTE RING EXTENDER SWITCH

Lower line current loading is required in many ring detector applications. This can be provided by using the H11BX522 photodarlington optocoupler, which is specified to provide a 1 mA output from a 0.5 mA input throughout the -25°C to +50°C temperature range. The following circuit allows ring detection down to 40V RMS ring signal while providing 60 Hz rejection to about 20V RMS. Zero crossing filtering may be accomplished either at the input bridge rectifier or at the output, similar to the method employed with the H11AA1 illustrated earlier.



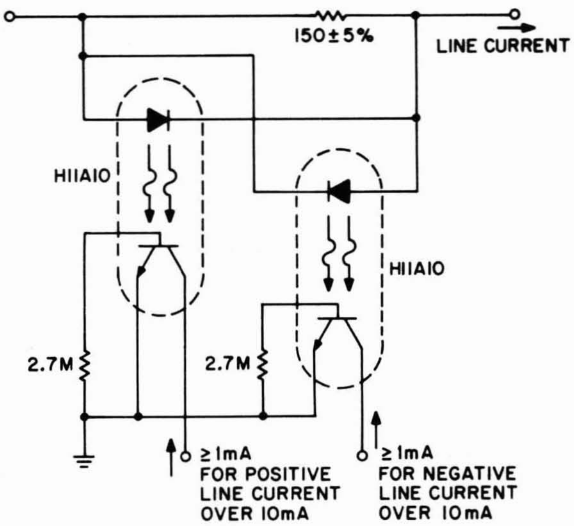
LOW LINE LOADING RING DETECTOR

Line Current Detection – Detection of line current flow and indicating the flow to an electrically remote point is required in line status monitoring at a variety of points in the telephone system and auxiliary systems. The line should be minimally unbalanced or loaded by the monitor circuit, and relatively high levels of 60 Hz induced voltages must be ignored. The H11AA1 allows line currents of either polarity to be sensed without discrimination and will ignore noise up to approximately 2.5 mA.



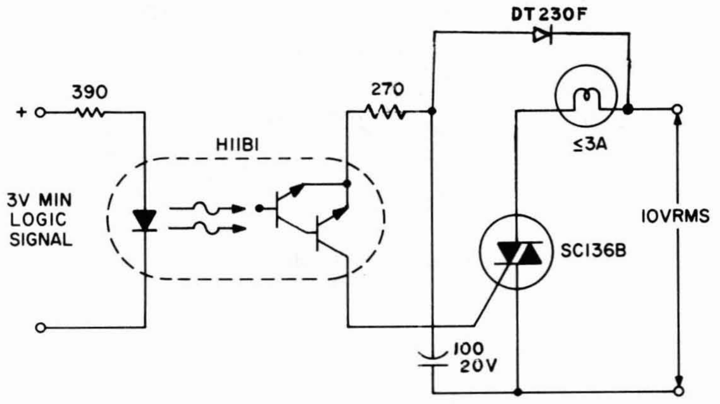
POLARITY INSENSITIVE LINE CURRENT DETECTOR

In applications where greater noise immunity or a polarity sensitive line current detection is required, the H11A10 threshold coupler may be used. This phototransistor coupler is specified to provide a minimum 10% current transfer ratio at a defined input current while having less than 50 μA leakage at half that input current – over the full -55°C to +100°C temperature range. The input current at which the coupler is on is programmable by a single resistor from 5 mA to 100 mA. The following circuit illustrates a line current detector which indicates the polarity of line currents over 10 mA while ignoring line currents of less than 5 mA. This circuit will maintain these margins over a -55°C to +100°C temperature range.



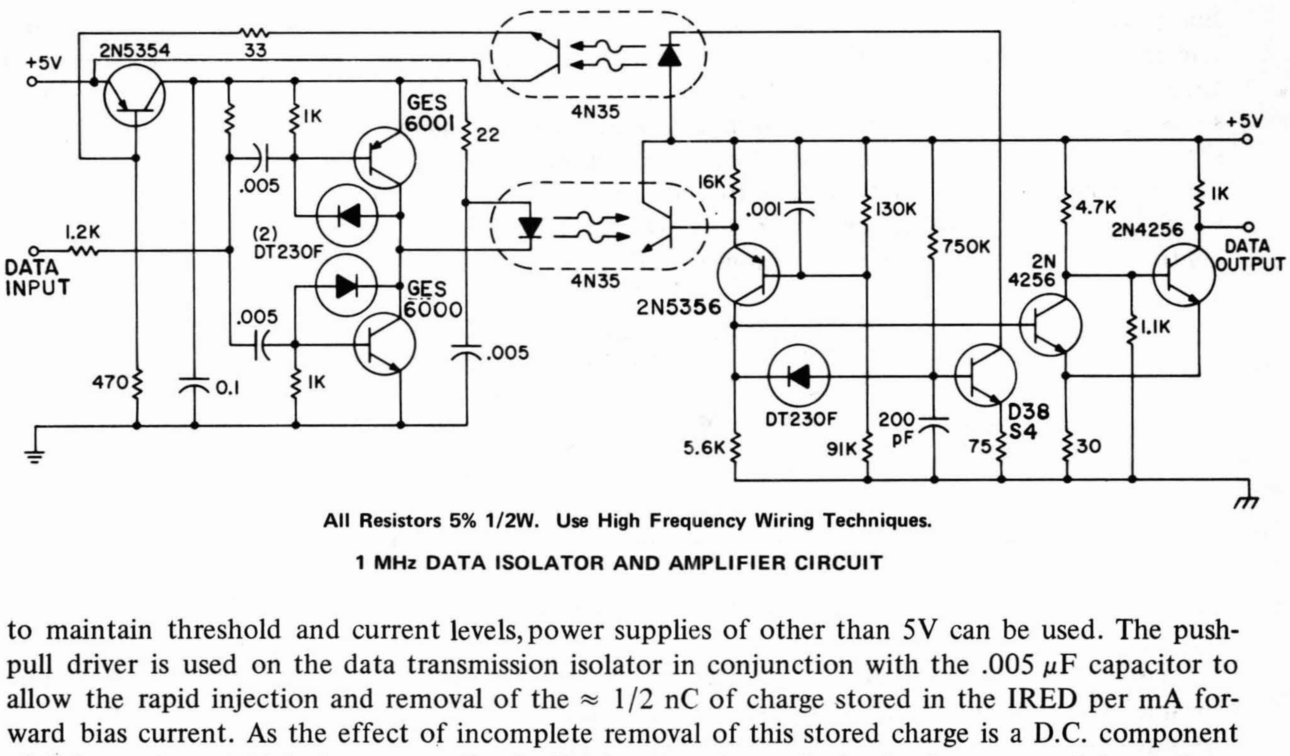
POLARITY INDICATING LINE CURRENT DETECTOR

Indicator Lamp Driver – A simple "solid state relay" circuit provides a simple method of driving the 10V ac telephone indicator lamps from logic circuitry while maintaining complete isolation between the 10V line and the logic circuit.



ISOLATED, LOGIC CONTROLLED, INDICATOR LAMP SWITCH

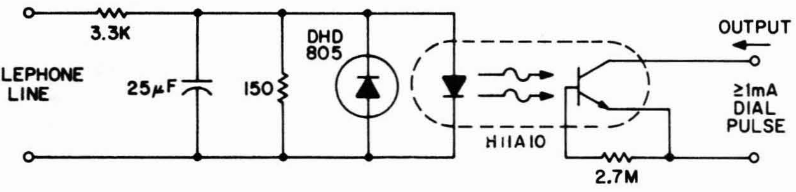
Data Isolator – A high speed data transmission isolator/amplifier can be constructed at reasonable cost using the 4N35 as the isolated data link. The following circuits provide the data transmission amplifier, the data transmission link, the data receiver amplifier, and bias current feedback which allows very high speed operation of the coupler. Note that by changing bias resistor values to maintain threshold and current levels, power supplies of other than 5V can be used. The push-pull driver is used on the data transmission isolator in conjunction with the .005 μF capacitor to allow the rapid injection and removal of the ≈ 1/2 nC of charge stored in the IRED per mA forward bias current. As the effect of incomplete removal of this stored charge is a D.C. component of light output at high frequency, the feedback network sets I_F in the data transmitting isolator to minimize this D.C. component. Hysteresis in the output amplifier sharpens the rise and fall times of the output while maintaining pulse width relationships.



All Resistors 5% 1/2W. Use High Frequency Wiring Techniques.

1 MHz DATA ISOLATOR AND AMPLIFIER CIRCUIT

Dial Pulse Indicator – A dial pulse indicator senses the switching on and off of the 48V DC line voltage and transmits the pulses to logic circuitry. A H11A10 threshold coupler, with capacitor filtering, gives a simple circuit which can provide dial pulse indication and yet reject high levels of induced 60 Hz noise. The DHD805 provides reverse bias protection for the LED during transient over-voltage situations. The capacitive filtering removes less than 10 msec. of the leading edge of a 40V dial pulse, while providing rejection of up to 25V RMS at 60 Hz.



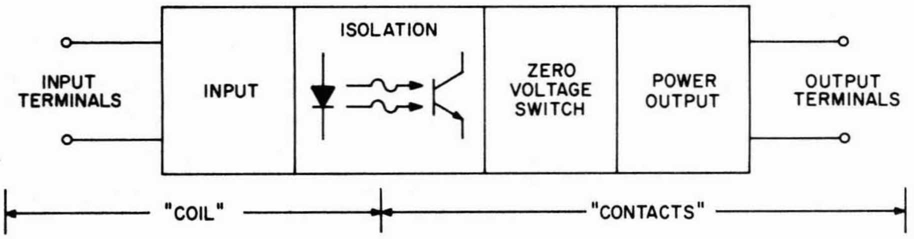
DIAL PULSE INDICATOR

D. Power Control Circuits

The evolution of the optoelectronic coupler has made it feasible to design a completely solid state relay. A solid state relay can perform not only the same functions as the original electromechanical relay, but can also provide solid state reliability, zero voltage switching and, most importantly, a direct interface between integrated circuit logic and the power line.

1. A.C. Solid State Relays

A zero voltage switching designs AC solid state relay meeting all the above criteria is a combination of four individual functions. It consists first of an input circuit. The input terminals of this portion of the relay are analogous to the coil of an EMR (electromechanical relay). It is effectively a resistive network and can be designed to accept a large range of input values. Circuits are designed to accept either digital or analog signals and to limit input current requirements so as to provide direct interfacing to logic circuits. The second portion of a solid state relay consists of an isolation function performed by an optocoupler. A coupler provides, by means of a dielectric medium, an isolation path to transfer the input signal information to a third function; which is the zero voltage switching network. The ZVS network monitors the line voltage and controls the fourth (or power) function, selecting the "on" state or "off" state.



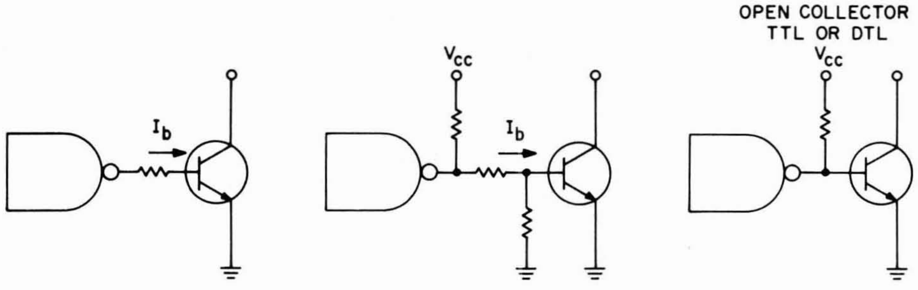
SOLID STATE RELAY BLOCK DIAGRAM

A reliable solid state relay design incorporates the correct choice of components and a careful consideration of the system to be interfaced. There are a variety of circuit configurations which are possible, each with its own advantages and disadvantages.

Input (Coil) Circuits – The first design consideration is to the relay's input (or coil) characteristics. It can be a simple current limiting resistor (≅330 Ω for TTL) in series with a light emitting diode, or it can be as complex as a Schmitt trigger circuit exhibiting hysteresis characteristics.

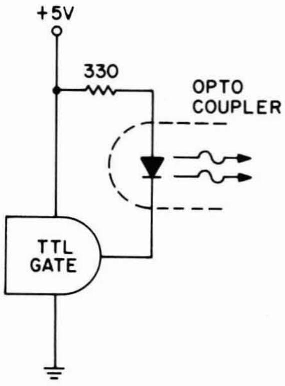
The input circuit should be designed around the available input signal. When working with logic signals, consider the complete capabilities of the gate output. A logic gate can operate in both the sinking or sourcing mode. Some MOS (or CMOS) circuits supply only about 20 μa, while TTL gates can offer up to 50 ma in the sink mode and -1.6 ma in the source mode. These currents are the input available to drive the solid state relay. In most circuits, the relays IRED may require

0.5 mA to 20 mA of drive current at a minimum voltage of 1.5V (the drop across the diode) in order to achieve workable output currents in the detector device. The low MOS signals normally indicate the need to use transistor buffer (or signal amplification) stages in the input circuit.

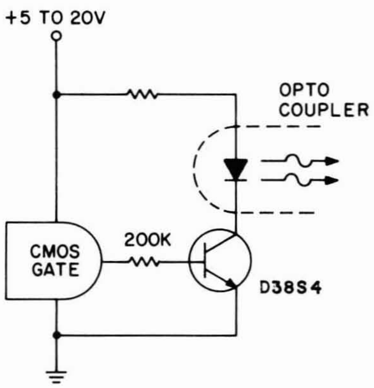


CONNECTION OF TRANSISTOR BUFFERS TO LOGIC CIRCUITS

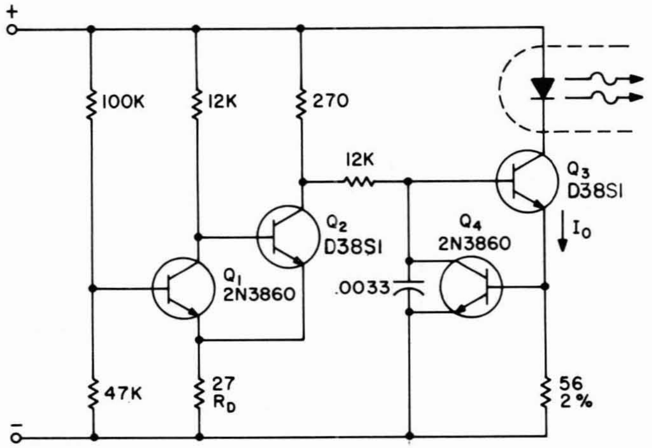
In general, direct TTL connection to the optocoupler using SSI gates of the 54/74, 54H/74H and 54S/74S logic families, which guarantee V_O (0) (maximum) of 0.4V sinking $\geqslant$ 12 mA, is made with the IRED "on" for a logic zero. For CMOS circuits the logic "1" output is the best means of operation, using an NPN transistor buffer. The buffer circuit below illustrates the advantage of the low saturation voltage, high gain, GE transistor D38S.



DIRECT CONNECTION OT TTL $I_o \geqslant 7$ mA



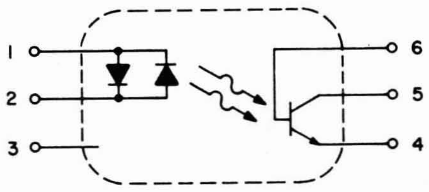
NPN BUFFERED CMOS CONNECTION $I_o \geqslant 7$ mA



HYSTERESIS INPUT CIRCUIT, $I_o \geqslant 10$ mA

In the case where analog signals are being used as the logic control, hysteresis, via a Schmitt trigger input, similar to the one illustrated below, can be used to prevent "chatter" or half wave. power output. Circuit operation is straightforward at low input voltages Q_1 is biased in the off state. Q_2 conducts and biases Q_3 and, thereby, the IRED, off. When the base of Q_1 reaches the biasing voltage of 0.6V-plus the drop across R_D, Q_1 turns on. Q_3 is then supplied base drive, and the solid state relay input will be activated. The combination of Q_3 and Q_4 act as a constant current source to the IRED. In order to turn-off Q_3 base drive must be reduced to pull it out of saturation. Because Q_2 is in the off-state as signal is reduced, Q_1 will now stay "on" to a base bias voltage lower by the change in drop across R_D. With these values, highest turn-off voltage is 1.0V, while turn "on" will be at less than 4.1V supplied to the circuit.

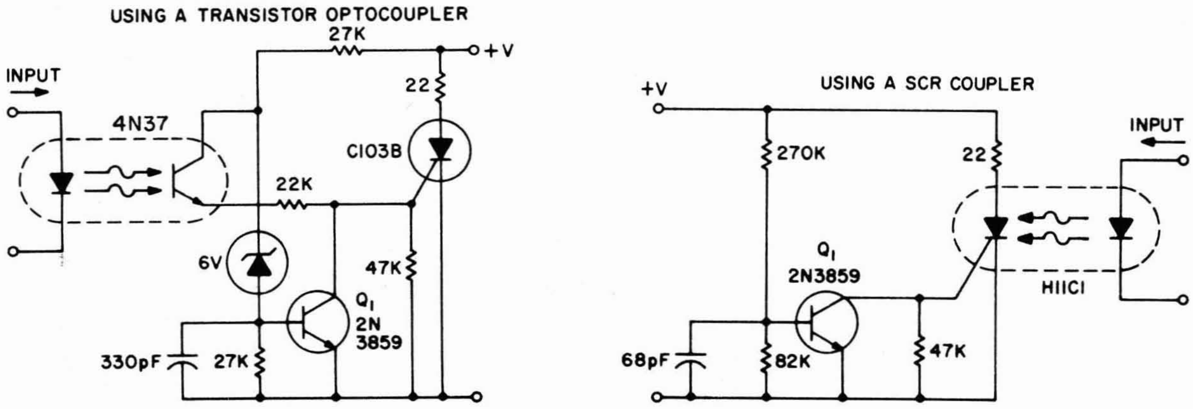
For AC or bi-polar input signals there are several possible connections. If only positive signals are to activate the relay, a reverse diode (such as the A14) can be connected in parallel to protect the IRED from reverse bias damage, since, in general, its specified peak reverse voltage capability is on the order of 3 volts. If AC signals are being used, or activation is to be polarity insensitive, a H11AA coupler which contains two LED's in antiparallel connection can be used.



H11AA1 AC INPUT PHOTON COUPLED ISOLATOR

For higher input voltage designs or for an easy means of converting a DC input relay to AC a full wave diode bridge can be used to bias the IRED.

Illustrated are two simple circuits providing zero voltage switching. These circuits can be used with full wave bridges or in antiparallel to provide full wave control and are normally used to trigger power thyristors. If an input signal is present during the time the AC voltage is between 0 to 7V, the SCR will turn-on. But, if the AC voltage has risen above 5V (7.5V) and the input signal is then applied, the transistor, Q_1, will be biased to the "on" state and will hold the SCR and, consequently, the relay "off."

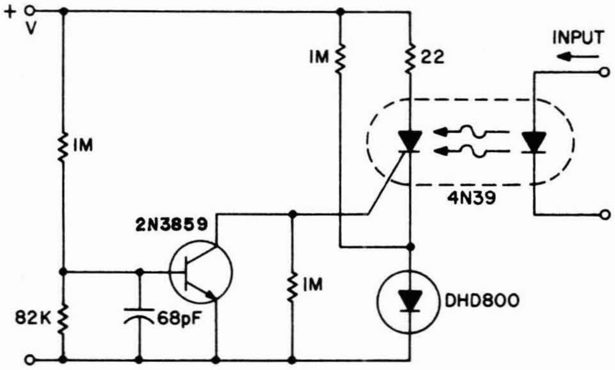


Using A Transistor Optocoupler

Using A SCR Coupler

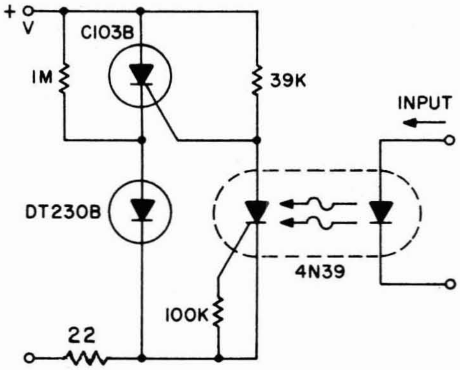
NORMALLY OPEN, TWO TERMINAL, ZERO VOLTAGE SWITCHING HALF WAVE CONTACT CIRCUITS

The SCR coupler circuit can be modified to provide higher sensitivity to input signals as illustrated below. This allows the lower cost 4N39 (H11C3) to be used with the ⩾ 7 mA drive currents supplied by the illustrated input circuits.



HIGH SENSITIVITY, NORMALLY OPEN, TWO TERMINAL, ZERO VOLTAGE SWITCHING, HALF WAVE CONTACT CIRCUIT

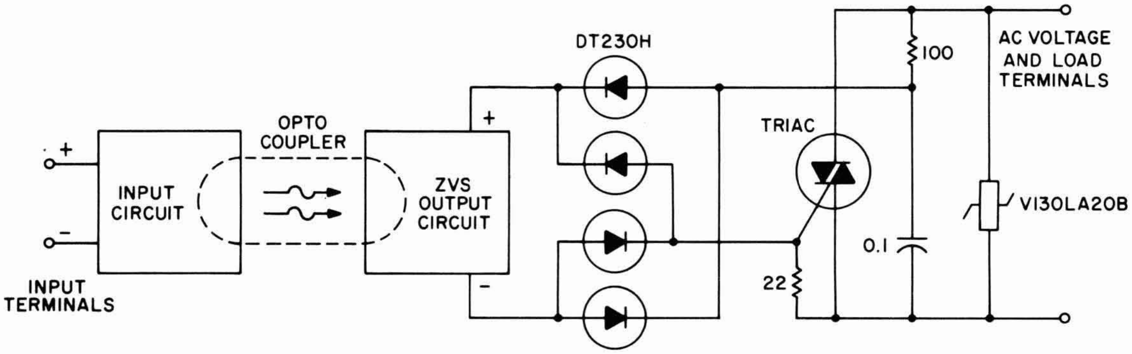
A normally closed contact circuit which provides zero voltage switching can also be designed around the 4N39 SCR opto coupler. The following circuit illustrates the method of modifying the normally open contact circuit by using the photo SCR to hold off the trigger SCR.



NORMAL CLOSED, HALF WAVE ZVS CONTACT CIRCUIT

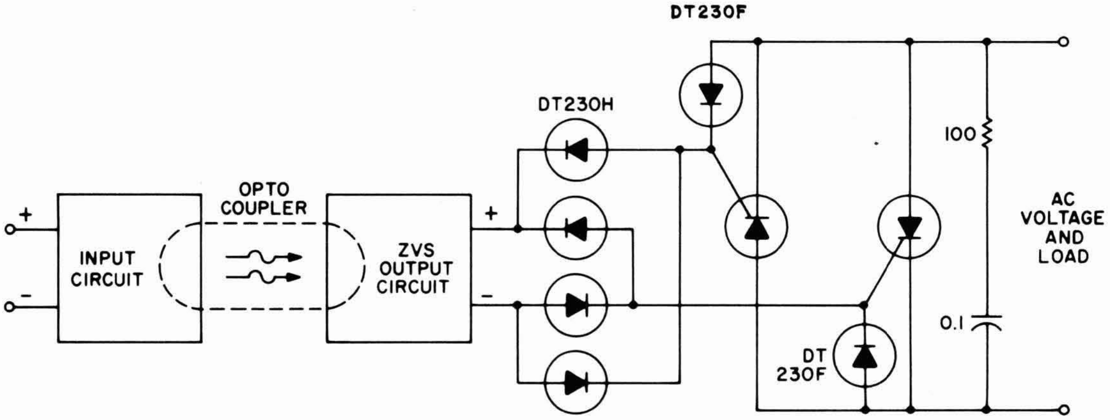
Integrated Solid State Relay Designs

A completed zero-voltage switch, solid state relay contains an input circuit, an output circuit, and the power thyristor. The choice of specific circuits will depend, of course, on the designer's immediate needs. The illustrated circuit can incorporate any of the previously described input and output circuits. It illustrates a triac power thyristor with snubber circuit and GE-MOV® Varistor transient over-voltage protection. The 22 Ω resistor shunts dv/dt currents, passing through the bridge diode capacitances, from the triac gate, while the 100 Ω resistor limits surge and gate currents to safe levels.



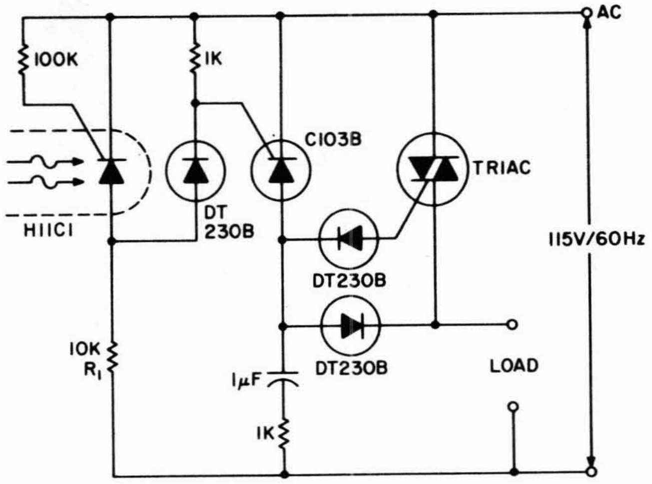
ZERO VOLTAGE SWITCHING SOLID STATE RELAY

Higher line voltages may be used if the diode, varistor, ZVS and power thyristor ratings are compatible levels. For applications beyond triac current ratings, antiparallel SCR's may be triggered by the ZVS network, as illustrated below.



ZERO VOLTAGE SWITCHING, SOLID STATE RELAY WITH ANTI-PARALLEL SCR OUTPUT

In some circuits driving reactive loads, it is required to have integral cycle, zero voltage switching, i.e., an identical number of positive and negative half cycles of voltage are applied to the load during a powered period. The following circuit, although not strictly a relay due to the three terminal power connection, performs the integral cycle, ZVS, function when interfaced with the previous coil circuits.



NORMALLY CLOSED INTEGRAL CYCLE, ZERO-VOLTAGE SWITCHING, CONTACT CIRCUIT

As an aid in determining the applicability of triacs to various jobs and in selection of the proper triac, a chart has been prepared giving the characteristics of common incandescent lamp and motor loads. Both of these loads have high surge currents associated with them, which could complicate thyristor selection without this chart.

TABLE I – TYPICAL INCANDESCENT IN-RUSH CURRENT RATINGS

WATTAGE	RATED VOLTS	TYPE	AMPS. STEADY STATE RATED VOLTS	HOT/COLD RESIST. RATIO	THEORETICAL PEAK IN-RUSH (170V pk) (Amps)	RATED (LUMENS /WATT)	HEATING TIME TO 90% LUMENS (Sec.)	LIFE RATED HOURS AVERG.	GENERAL ELECTRIC TRIAC SELECTION
6	120	Vacuum	0.050	12.4	0.88	7.4	.04	1500	SC136
25	120	Vacuum	0.21	13.5	4.05	10.6	.10	1000	SC136
60	120	Gas Filled	0.50	13.0	9.70	14.0	.10	1000	SC141/240
100	120	Gas Filled	0.83	14.3	17.3	17.5	.13	750	SC141/240
100(proj)	120	Gas Filled	0.87	15.5	19.4	19.5	.16	50	SC141/240
200	120	Gas Filled	1.67	16.0	40.5	18.4	.22	750	SC146/245
300	120	Gas Filled	2.50	15.8	55.0	19.2	.27	1000	SC146/245
500	120	Gas Filled	4.17	16.4	97.0	21.0	.38	1000	SC250/260
1000	120	Gas Filled	8.3	16.9	198.0	23.3	.67	1000	SC250/260
1000(proj)	120	Gas Filled	8.7	18.0	221.0	28.0	.85	50	SC250/260

For 240 volt lamps, wattage may be doubled.

TABLE II – FULL-LOAD MOTOR-RUNNING AND LOCKED ROTOR CURRENTS IN AMPERES CORRESPONDING TO VARIOUS AC HORSEPOWER RATINGS

HORSE-POWER	110 – 120 VOLTS			220 – 240 VOLTS			MTR. LOCK-RTR. CURRENT AMPS.				G.E. TRIAC* SELECTION	
	Single-Phase	Two-Phase	Three-Phase	Single-Phase	Two-Phase	Three-Phase	Single-Phase		Two or Three Phase		120V	240V
							110-120	220-240	110-120	220-240		
1/10	3.0	–	–	1.5	–	–	18.0	9.0	–	–	SC141/240	SC141/240
1/8	3.8	–	–	1.9	–	–	22.8	11.4	–	–	SC146/245	SC141/240
1/6	4.4	–	–	2.2	–	–	26.4	13.2	–	–	SC146/245	SC141/240
1/4	5.8	–	–	2.9	–	–	31.8	17.4	–	–	SC250	SC141/240
1/3	7.2	–	–	3.6	–	–	43.2	21.6	–	–	SC260	SC146/245
1/2	9.8	4.0	4.0	4.9	2.0	2.0	58.8	29.4	24	12	SC265	SC260

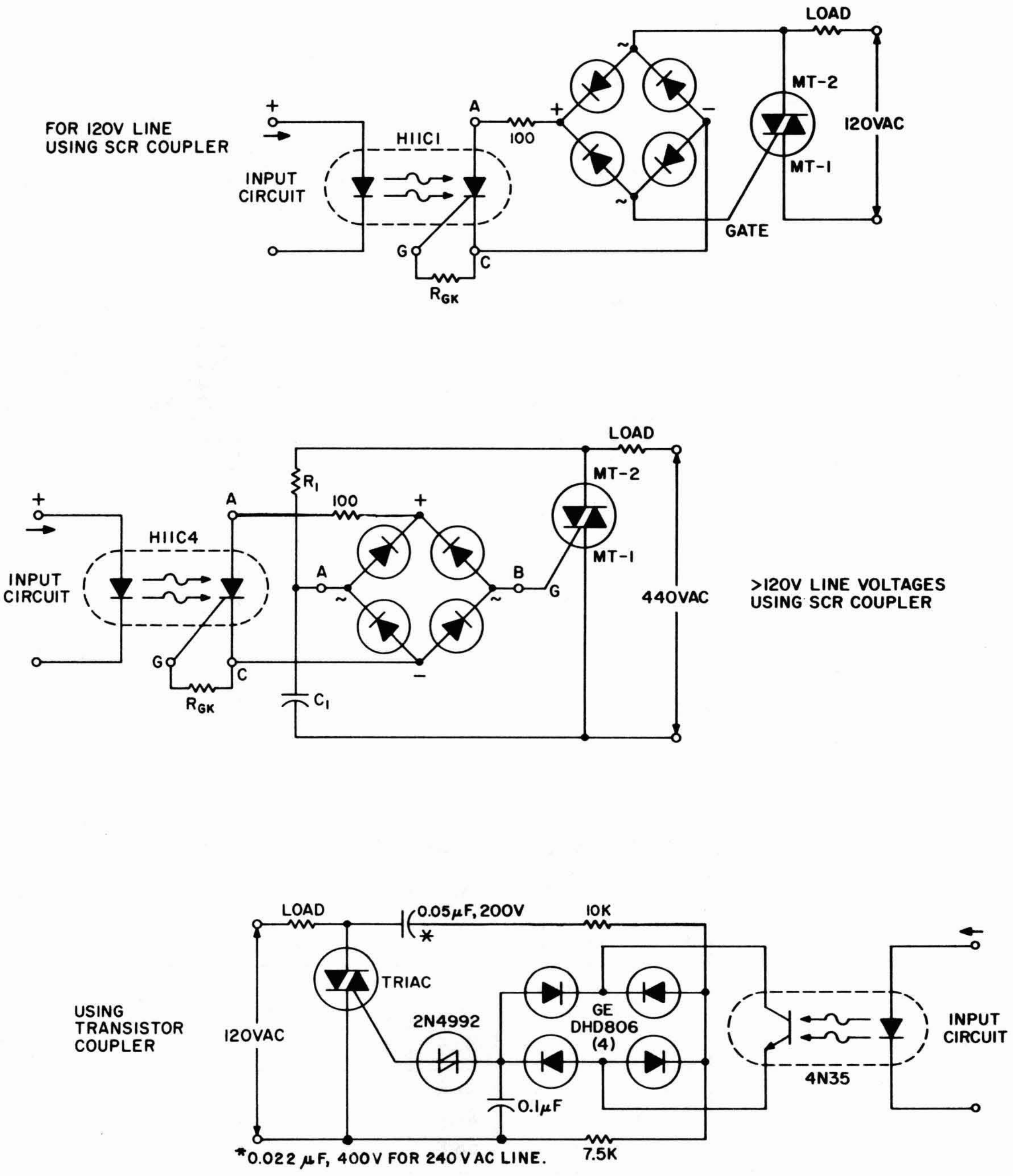
*Assumes over-current protection has been built in to limit the duration of an locked-rotor condition.

Source: Information for these charts was taken from National Electric Code, 1971 Edition.

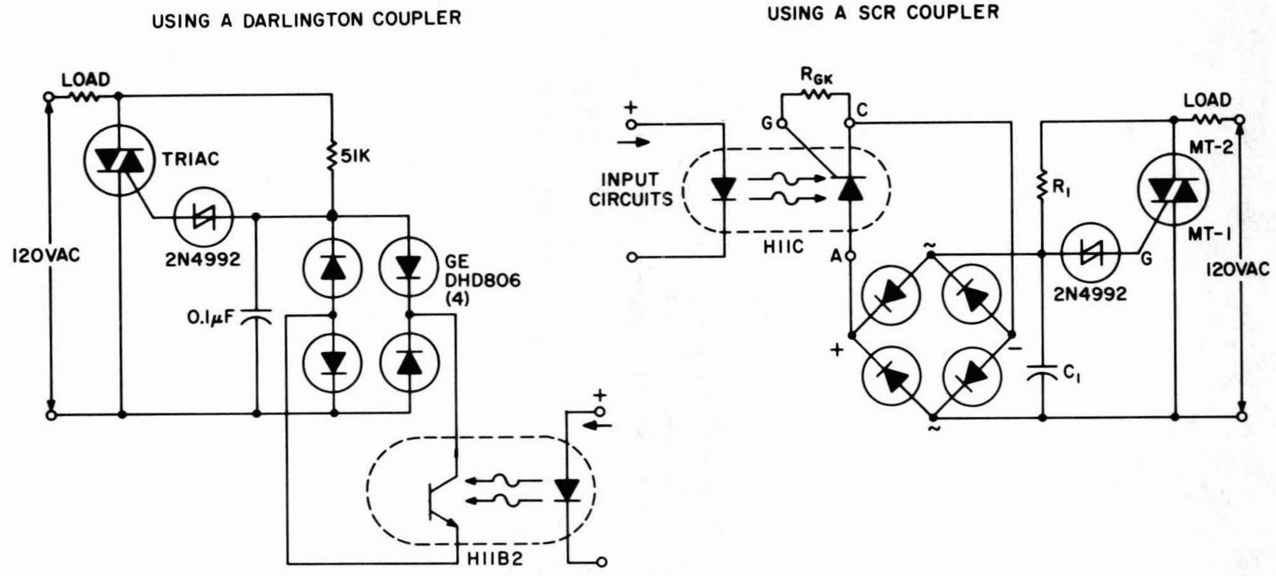
INCANDESCENT LAMP AND ELECTRIC MOTOR TRIAC SELECTION CHART

Other A.C. Relay Designs

When zero voltage switching is not required, the "contact" circuitry can be simplified. Several methods of providing this function are illustrated in the following diagrams. Note that an SCR coupler in a bridge, using a high gate resistor, directly across the line voltage, can give commutating dv/dt and dv/dt triggering problems, which are not evident in the ZVS circuits or at low voltages, and that not all these circuits are TTL drive compatible at the input.



NORMALLY OPEN CONTACT RELAY CIRCUITS

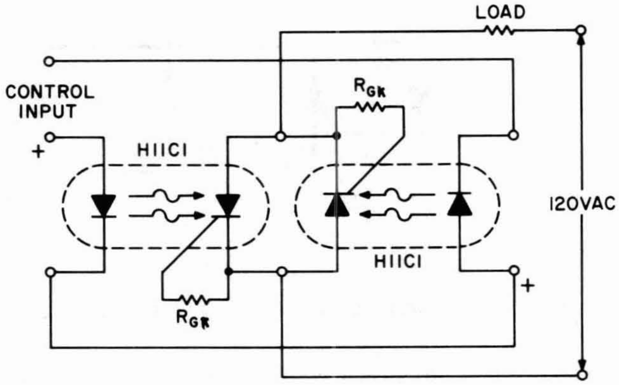


USING A DARLINGTON COUPLER

USING A SCR COUPLER

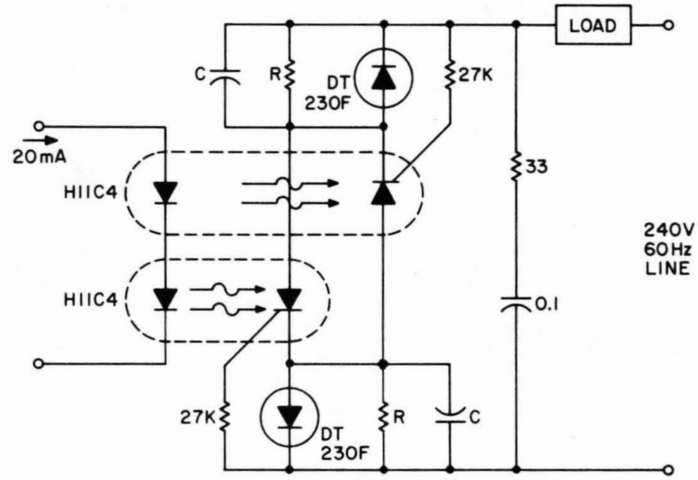
NORMALLY CLOSED CONTACT RELAY CIRCUITS

If load current requirements are relatively low (i.e., maximum forward RMS current of 500 mA), an AC solid state relay can be constructed quite simply by the connection of two H11C optically coupled SCR's in a back-to-back configuration as illustrated.



USING TWO PHOTON COUPLERS TO PROVIDE A SIMPLE AC RELAY

In the case where analog signals are being used as the logic control, hysteresis, via a Schmitt trigger input illustrated on pg. 75, can be used to prevent "chatter" or half wave power output. Circuit operation is straightforward, and will not be described. This basic circuit can be easily modified to provide the latching relay function as illustrated below. Latching is obtained by the storage of gate trigger energy from the preceding half cycle in the capacitors. Power must be interrupted for more than one full cycle of the line to insure turn-off.

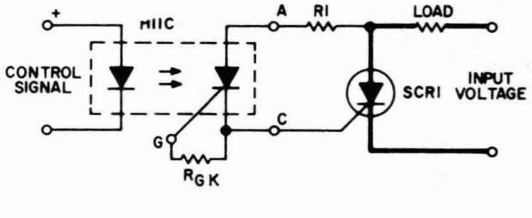


$RC \geq 10^{-3}$, $2 \leq R \cdot I_{LOAD(RMS)} \leq 4$

LATCHING A.C. SOLID STATE RELAY

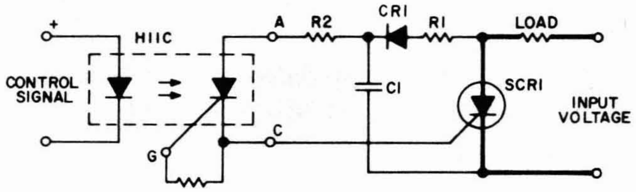
High Voltage AC Switching

A basic circuit to trigger an SCR is shown below. This circuit had the disadvantage that blocking voltage of the main SCR cannot be higher than the blocking voltage of the photon coupler output device.



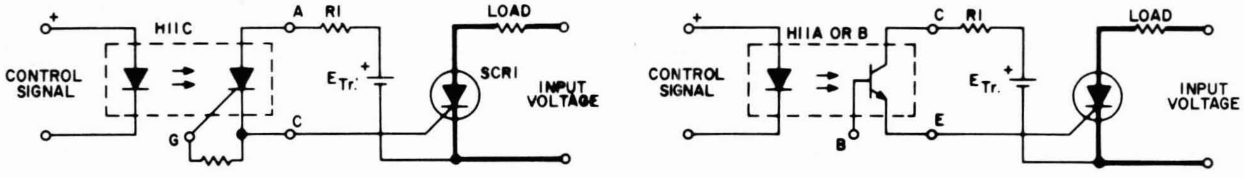
DERIVING THE ENERGY TO TRIGGER AN SCR FROM ITS ANODE SUPPLY

Adding a capacitor (C_1) to the circuit of above, as shown below will reduce the dv/dt seen by the photon coupler output device and the energy stored in C_1 when discharged into the gate of SCR_1 will improve the di/dt capability of the main SCR.



DERIVING THE ENERGY TO TRIGGER
AN SCR FROM ITS ANODE SUPPLY WITH AN ENERGY STORING FEATURE

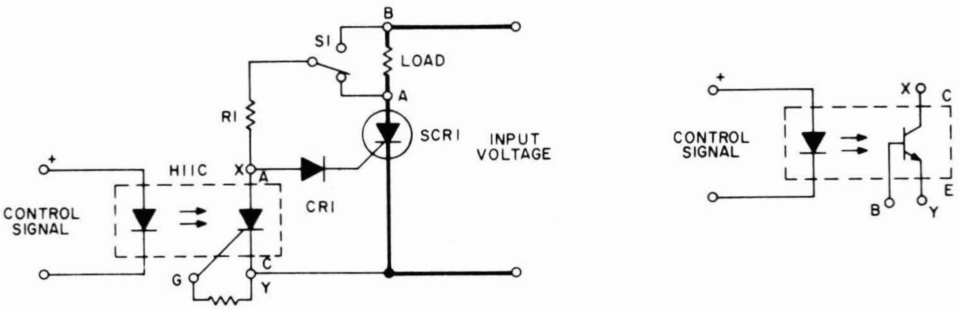
The employment of a separate power supply gives added flexibility to the trigger circuit, it removes the limitation of the blocking voltage capability of the photon coupler output device. The flexibility adds cost and more than one power supply may be necessary for multiple SCR's when no common reference points are available.



Photon Coupler With SCR – Output

Photon Coupler With Transistor Output

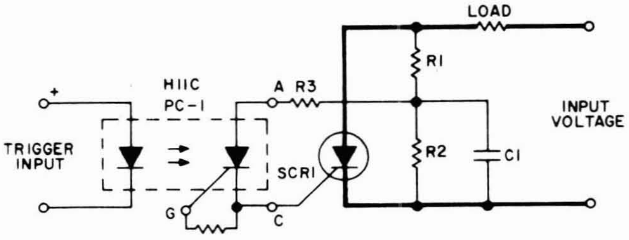
PHOTON COUPLER TRIGGERING MAIN SCR$_1$ USING SEPARATE POWER SUPPLY



Photon Coupler With SCR – Output

Photon Coupler With Transistor Output (connect in place of SCR coupler)

NORMALLY CLOSED CONFIGURATIONS



TRIGGERING SCR WITH PHOTON COUPLER AND SUPPLY VOLTAGE DIVIDER

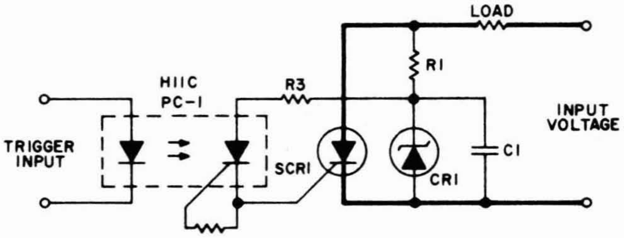
Note that in this illustration, R_1 can be connected to Point A which will remove the voltage from the coupler after SCR_1 is triggered or to Point B so that the coupler output will always see the voltage across the load and SCR_1. The former is preferred since it decreases the power dissipation in R_1. A more practical form of SCR triggering is shown below. Trigger energy is obtained from the anode supply and stored in C_1. Coupler voltage is limited by the zener diode.

This approach permits switching of higher voltages than the blocking voltage capability of the output device of the photon coupler. To reduce the power losses in R_1 and to obtain shorter time constants for charging C_1, the zener diode is used instead of a resistor.

Trigger energy is obtained from anode supply and stored in C_1. Coupler voltage is limited by zener diode. A guide to selecting component values would consist of the following steps:

1) Choose C_1 in a range of 0.05 to 1 microfarad. The maximum value may be limited by the recharging time constant $(R_L + R_1)\ C_1$ while the minimum value will be set by the minimum pulse width required to ensure SCR latching.

2) R_3 is determined from peak gate current limit (if applicable) and minimum pulse width requirements.



TRIGGERING SCR WITH PHOTON COUPLER WITH LOW VOLTAGE REFERENCE

3) Select a zener diode. A 25 volt zener is a practical value since this will meet the usual gate requirement of 20 volts – 20 ohms as well. This will also eliminate spurious triggering due to voltage transients.

4) Photon coupler triggering is ideal for SCR's handling inductive loads. By ensuring that the LASCR latches on, it can supply gate current to SCR_1 until it stays on. The following table lists values for R_1 and R_2 along with their power dissipation when the SCR is off for different values of I_{GT} and applied ac voltage.

5) Component values for dc voltage are easily computed from the following formulae:

$$R_1 = \frac{E_{IN} - V_Z}{I_G} \qquad (4)$$

Where: V_Z = zener voltage

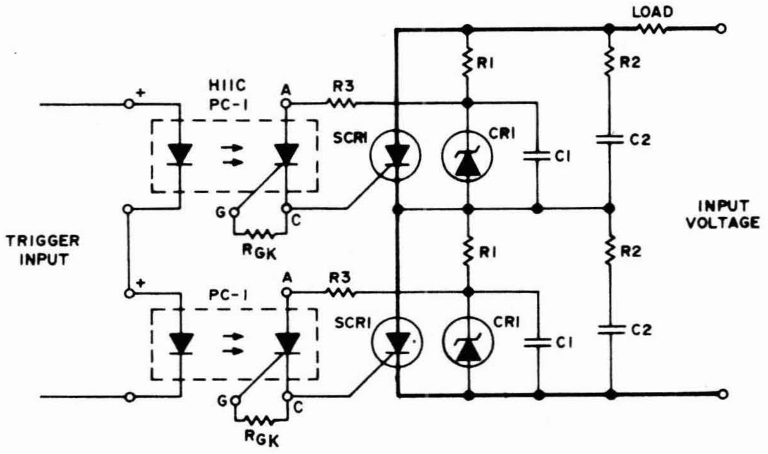
$$P_{(R_1)} = I_G \cdot (E_{IN} - V_Z) \qquad (5)$$

$$P_{(zener)} = I_G \cdot V_Z \qquad (6)$$

$E_{IN(RMS)}$	I_{GT}	R_1	$P_{(R1)}$	R_2	$P_{(R2)}$	$P_{(zener)}$
110/120	50 ma	1200	4.1	1000	.3	1.1
	100	600	8.3	470	.6	2.2
	150	400	12.5	330	.9	3.4
	200	300	16.5	220	1.2	4.5
	300	200	24.8	150	1.8	6.7
220	50	2250	9.2	670	.5	1.1
	100	1000	18.4	330	.9	2.2
	150	750	28.0	220	1.3	3.4
	200	500	37.0	150	1.7	4.5
	300	350	55.0	125	2.6	6.7
380	50	3500	17.4	560	.5	1.1
	100	2000	34.8	330	1.0	2.2
	150	1200	52.2	220	1.5	3.4
	200	1000	69.6	150	2.0	4.5
	300	600	105.0	100	3.0	6.7
440	50	4250	20.5	560	.5	1.1
	100	2100	41.0	330	1.0	2.2
	150	1500	62.0	220	1.5	3.4
	200	1000	82.0	150	2.1	4.5
	300	750	125.0	100	3.1	6.7
600	50	5800	29.0	560	1.1	1.1
	100	3000	58.0	270	1.6	2.2
	150	2000	86.0	200	2.1	3.4
	200	1500	115.0	150	2.7	4.5
	300	1000	175.0	100	3.2	6.7

COMPONENT VALUES AND POWER DISSIPATION ASSUMING 25V ZENER DIODE, 50/60 Hz AC LINE VOLTAGES

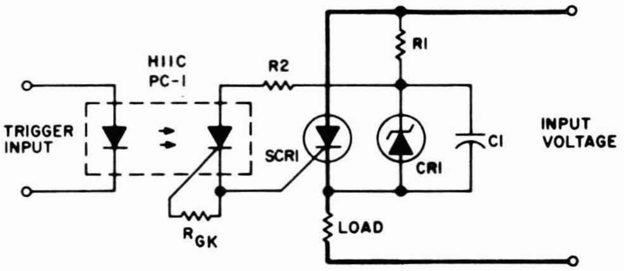
The following circuit utilizes the principle for triggering SCR's in series connection. A snubber circuit R2C2 as shown may be necessary as the dimension of R1 and C1 are tailored to obtain optimized triggering and not for dv/dt protection. Special photon couplers with fiber optics have to be used to switch thousands of volts.



HIGH VOLTAGE SWITCH

A photon coupler with transistor output will limit the trigger pulse amplitude and rise time due to CTR and saturation effects. Using the H11C1 the rise time of the input pulse to the photon coupler is not critical, and its amplitude is limited only by the H11C1 turn-on sensitivity.

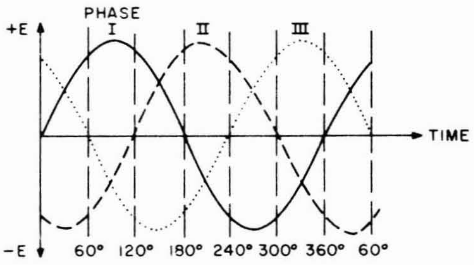
All the applications shown so far had the load connected to the anode, but the load can easily be connected to the cathode, as illustrated below:



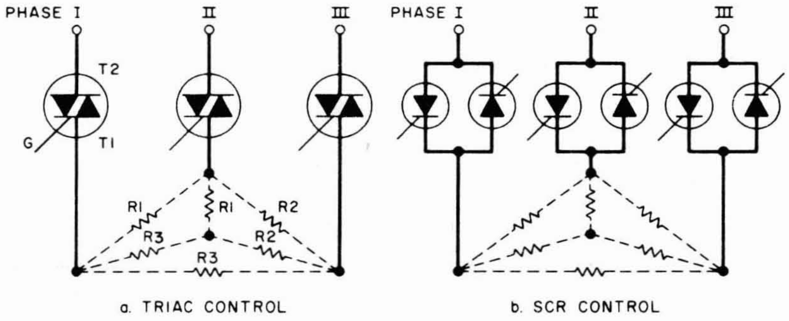
CONNECTION OF LOAD TO CATHODE OF MAIN SCR

Three Phase Circuits

Everything mentioned about single phase relays or single phase switching or triggering with photon couplers can be applied to three phase systems.



VOLTAGE WAVEFORM IN THREE PHASE SYSTEMS



a. TRIAC CONTROL b. SCR CONTROL

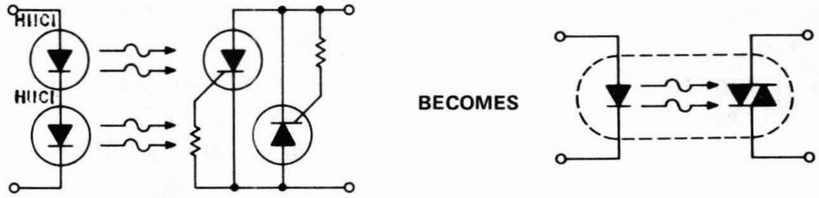
Y OR Δ CONNECTED RESISTIVE OR INDUCTIVE LOAD

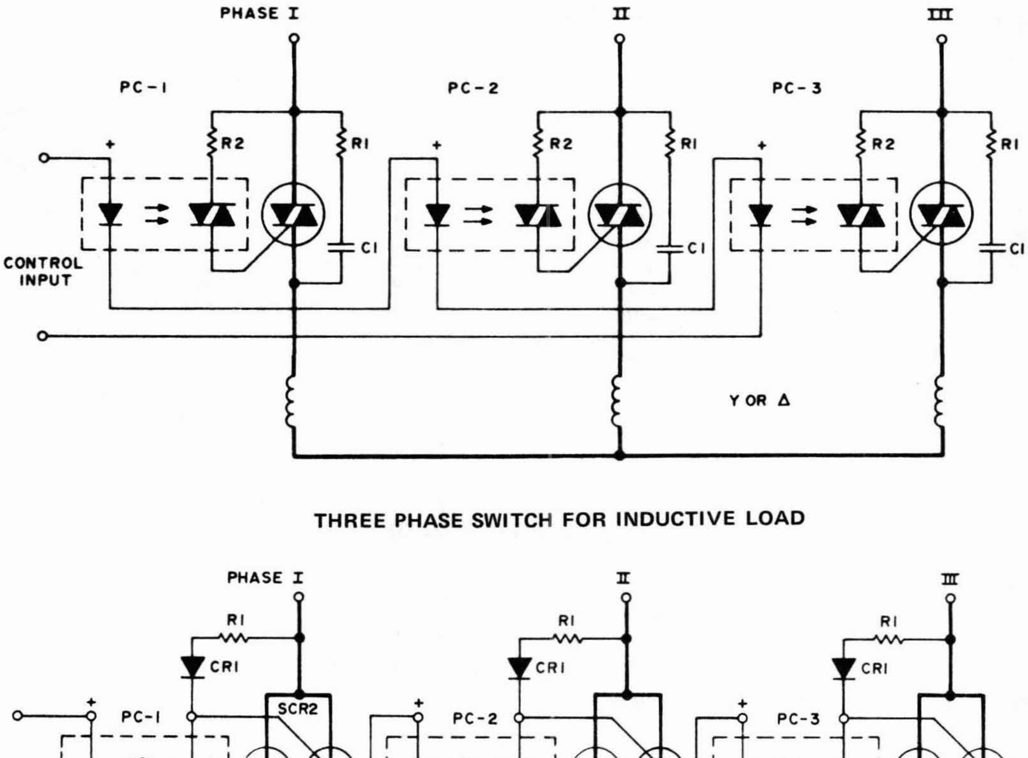
The above illustrates voltage waveform in a three phase system which would appear on the triac MT-2 terminal before triggering and at the MT-1 terminal after triggering. The use of the H11C to isolate the trigger circuitry from the power semiconductor will simplify the trigger circuitry significantly.

Following are three phase switches for low voltage. Higher currents can be obtained by using the inverse parallel SCR's which would be triggered as shown. For higher voltages and higher currents, the circuits of the previous page can be useful in three phase circuits.

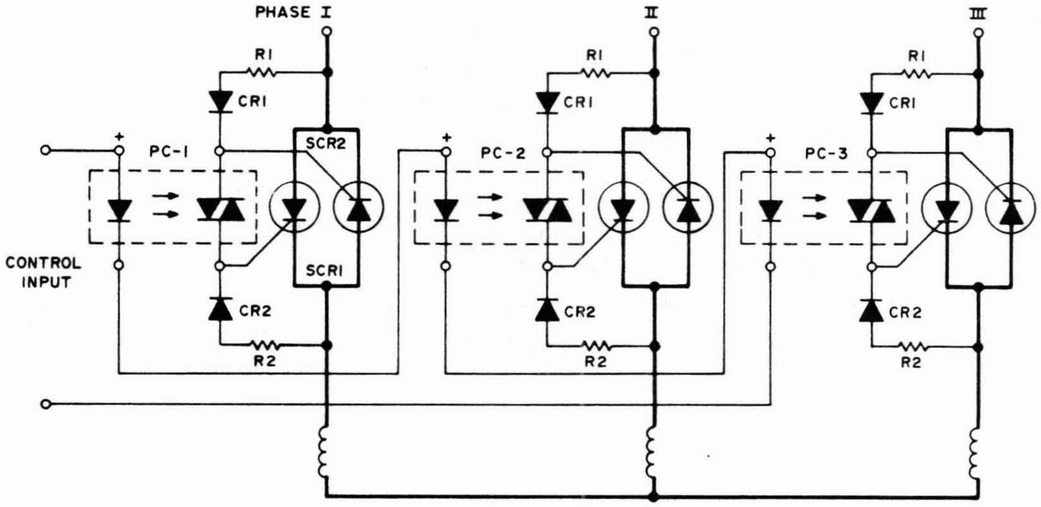
To simplify the following schematics and allow easy understanding of the principles involved, the following schematic substitution is used:

IN THE CIRCUITS BELOW





THREE PHASE SWITCH FOR INDUCTIVE LOAD



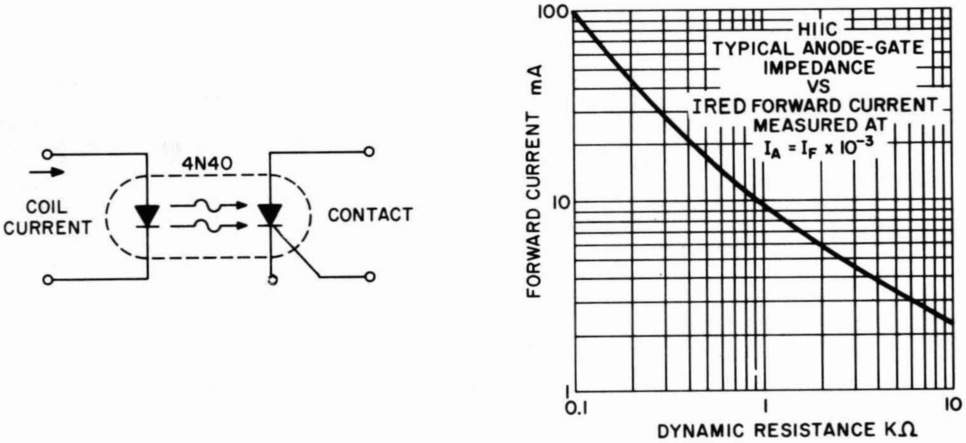
THREE PHASE SWITCH WITH INVERSE PARALLEL SCR'S FOR INDUCTIVE Y OR Δ

Many other A.C. power control circuits are practical and cost effective. The intent of this section was to stimulate the circuit designer by presenting a variety of circuits featuring opto control.

2. D C Solid State Relay Circuits

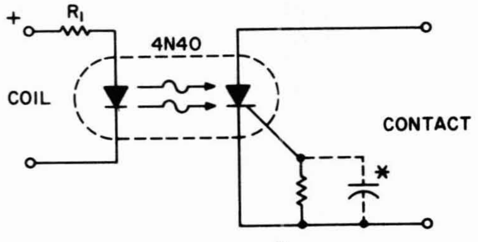
The dc relay built around an optocoupler is neither a relay nor strictly dc. This section will describe relay function circuits which didn't fit the ac solid state relay 60 Hz power line switching function, as well as strictly dc switching.

Solid State Reed Relay – In process control and instrumentation circuitry it is often necessary to switch low level signals, of unknown amplitude and polarity, on command of an isolated logic command. Resistive switching, i.e., minimal contact EMF and resistance, is desired to minimize changes in the signal caused by the switch. The photo SCR utilized in saturated switching as a symmetrical photo PNP provides minimal contact EMF (unmeasurable on a 576 curve tracer), an on to off resistance ratio typically over 10^6, switches in tens of microseconds, carries low level dc, ac or combination signals and is drive compatible with integrated circuit logic. Although the limited current transfer ratio of about 1% limits the usefulness to fairly low level signals (see transfer characteristics in Chapter 1), the 400V contact blocking capability, no bounce and no weld characteristics make it very attractive for acquiring audio signals, thermocouple and thermistor outputs, monitoring junction drops, strain gage outputs and many other testing and control functions at electronic speeds.



SOLID STATE REED RELAY

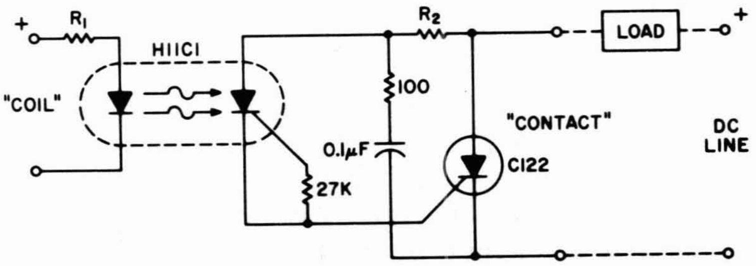
D.C. Latching Relay – The H11C readily supplies the dc latching relay function, reverse polarity blocking, for currents up to 300 mA (depending on ambient temperature). For dc use, the gate cathode resistor may be supplemented by a capacitor to minimize transient and dv/dt sensitivity. For pulsating dc operation, though, the capacitors value must be designated to either retrigger the SCR at the application of the next pulse or prevent retriggering at the next power



*SEE TEXT

D C LATCHING RELAY CIRCUIT

pulse. If not, random, or undesired, operation may occur. For higher current contacts, the H11C may be used to trigger a SCR capable of handling the current, as illustrated below.



COIL VOLTAGE	6	12	24	48	120	V
RI VALUE	470	1.1K	2.4K	4.7K	12K	Ω

LINE VOLTAGE	12	24	48	120	V
C122 PART	U	F	A	B	D
R2 VALUE	200	470	1K	2.2K	Ω

NO HEAT SINK RATINGS AT $T_A \leqslant 50°$

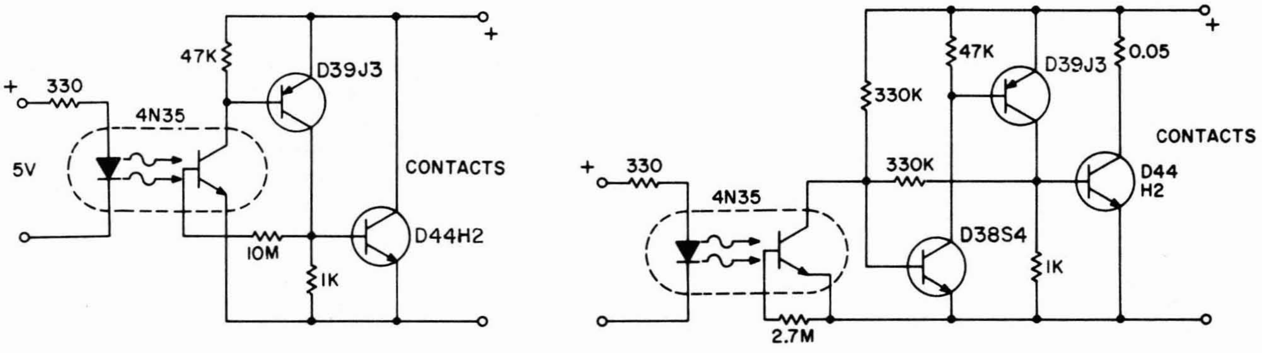
I CONTACT, MAX.	PULSE WIDTH	DUTY CYCLE
0.67 A	D.C.	100%
4.0 A	160 msec.	12%
8.0 A	160 msec.	3%
12 A	160 msec.	1%
15 A	160 msec.	0.3%

FOR HEAT SINK RATINGS SEE C122 SPECIFICATION SHEET NUMBER 150.35 AND APPLICATION NOTE NUMBER 200.55

HIGHER CURRENT D.C. LATCHING RELAY

Heat sinking on this, and all high current designs, must be designed for the load current and temperature environment.

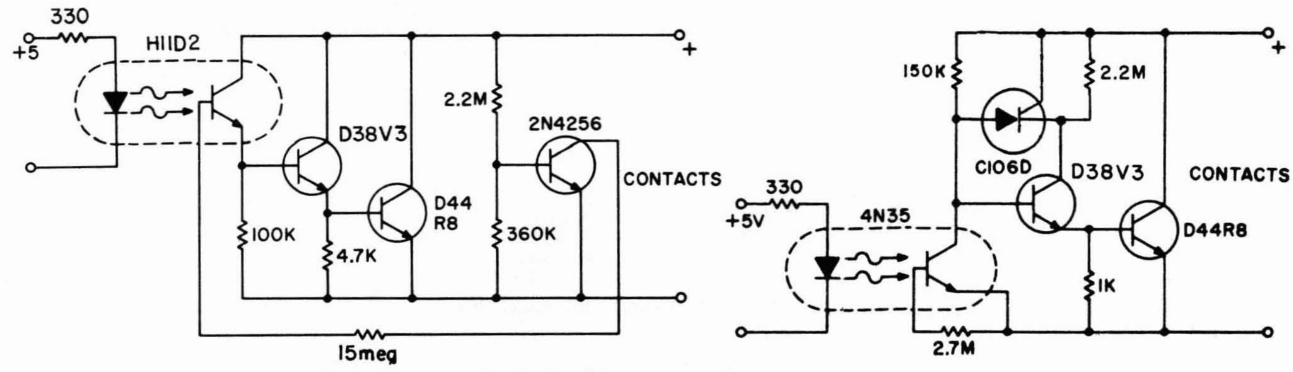
The phototransistor and photodarlington couplers, of course, act as dc relays in saturated switching, at currents to about 5 mA and 50 mA, respectively. This is illustrated by the H11A5 application as a high speed synchronous relay in the long range object detector shown earlier in the chapter. When higher currents or higher voltage capabilities are required, additional devices are required to buffer or amplify the photocoupler output. The addition of hysteresis to provide fast switching and stable pick up and drop out points can also be easily implemented at the same time. Illustrated below are normally open and normally closed examples of these circuits. These circuits provide several approaches to the D.C. relay and are meant to stimulate the creativity of other circuit designers, as well as serve as practical, cost effective examples.



Normally Open

Normally Closed

10A, 25V D.C. SOLID STATE RELAYS



Normally Open

Normally Closed

0.25A, 300V D.C. SOLID STATE RELAY

VI. GLOSSARY OF SYMBOLS AND TERMS

Optoelectronics spans the disciplines of electronics, photometry, radiometry and optics with dashes of physics and statistical analysis. The same word or symbol can have two different meanings, depending on the discipline involved. To simplify use of this glossary, words and symbols are separately listed, alphabetically; following each is the common discipline of usage and then the definition, as used in this Handbook.

A. Optoelectronic Symbols

A	**electronic**	gain of an amplifier.
A	**optic**	area.
A	**reliability**	acceleration factor, describes change in a predicted basic phenomena response due to secondary conditions denoted by subscript.
Å	**radiometric**	Angstrom, a unit of wavelength, equal to 10^{-10} meters.
B_L	**photometric**	luminous intensity of an area light source, usually expressed in candela/unit area.
B_r	**radiometric**	radiant intensity of an area source, Radiance, usually expressed in Watts/unit area.
β	**electronic**	Beta, current gain of a transistor. See h_{FE}.
C	**electronic**	inter-element capacitance, primarily junction capacitance, of a component. Terminals indicated by subscripts.
C.T.	**photometric**	Color Temperature. The temperature of a black body, when its color best approximates the designated source. Normally used for lamps, and determined at .45 and .65 microns.
CTR	**electronic**	Current Transfer Ratio. The ratio of input current to output current, at a specified bias, of an optocoupler.
DIP	**electronic**	Dual In-Line Package. Standard integrated circuit and optocoupler flat package with two rows of terminals on opposite sides. May be plastic or ceramic bodied.
di/dt	**electronic**	Critical rate-of-rise of current rating of a thyristor. Higher rates may cause current crowding and device damage.
dv/dt	**electronic**	Critical rate-of-rise of voltage parameter of a thyristor. Higher rates may cause device turn-on via junction capacitance charging currents providing gate signal.
E	**photometric**	Illumination. Luminous flux density incident on a receiver, usually in lumens per unit of surface.
f/#	**optic**	Lens parameter. The ratio of focal length to lens diameter.
F	**optic**	Focal length of a lens or lens system.
F	**photometric**	Illumination. Total luminous flux incidents on a receiver, normally in lumens. $F = \int E \cdot dA$.
GaAs	**electronic**	Gallium Arsenide. The crystalline compound which forms IRED's when suitably doped.
H	**radiometric**	Irradiance. Radiant flux density incident on a receiver, usually in Watts per unit area.
H_E	**radiometric**	Effective irradiance. The irradiance perceived by a given receiver, usually in effective Watts per unit area.
h_{FE}	**electronic**	Current gain of a transistor biased common emitter. The ratio of collector current to base current at specified bias conditions.
HTRB	**reliability**	High temperature reverse bias operating life test.
I_A	**electronic**	Thyristor or diode anode current, I_{TM} is preferred terminology for thyristors.
I_B	**electronic**	Transistor base current.
I_C	**electronic**	Transistor collector current.

I_D – electronic – Dark current. The leakage current of an unilluminated photodetector.

I_E – electronic – Transistor emitter current.

I_F – electronic – Forward bias current, usually of IRED. Subscripts denote measurement or stress bias condition, if required.

I_L – electronic – Light current. The current through an illuminated photodetector at specified bias conditions.

I_L – photometric – Luminous intensity of a point source of light, normally in candela.

IR – radiometric – Infrared. Radiation of too great a wavelength to be normally perceived by the eye. Radiation between 0.78 and 100 microns wavelength.

IRED – electronic – Infrared emitting diode. A diode which emits infrared radiation when forward bias current flows through it.

L – photometric – Luminance of an area source of light, usually in lumens per unit area.

LASCR – electronic – Light activated silicon control rectifier.

LED – electronic – Light emitting diode.

λ – electronic – Predicted failure rate of an electronic component subjected to specified stress and confidence limit.

λ – radiometric – Wavelength of radiation.

m – optics – Magnification of a lens. Ratio of image size to source size.

M – physics – Meter, international standard unit of length.

MSCP – photometric – Mean spherical candle power. Average luminous power output, of a source, per sterradian.

n.a. – optics – Numerical aperature of a lens. n.a. = $2f/\#$.

η – radiometric – Conversion efficiency of an electrically powered source. The ratio of radiant power output to electrical power input.

P – radiometric – Power, total flux in Watts.

P_D – electronic – Power dissipated as heat.

PPS – electronic – Repetition rate in pulses per second.

PRM – electronic – Pulse rate modulation, coding an analog signal on a train of pulses by varying the time between pulses.

PUT – electronic – Programmable Unijunction Transistor – a thyristor specified to provide the unijunction transistor function.

Si – electronic – Silicon. The semiconductor material which is selectively doped to make photodiodes, phototransistors, photodarlington and photoSCR detectors.

SCR – electronic – Silicon Controlled Rectifier. A thyristor, reverse blocking, which can block or conduct in forward bias, conduction between anode and cathode being initiated by forward bias of the gate-cathode junction.

T_A – electronic – Ambient temperature.

T_C – electronic – Case temperature, the temperature of a specified point on a component.

T_J – electronic – Junction temperature, the temperature of the chip of a semiconductor device. This is the factor which determines maximum power dissipation.

t – electronic – Time. Subscripts indicate switching times (d–delay, f–fall, r–rise and s–storage), intervals in reliability prediction (o–operating, x–equivalent operating), etc.

UCL – reliability – Upper confidence level. A statistical determination of the confidence of a prediction of the highest level of an occurrence based on the percent of occurrences in a quantity from a homogeneous population.

UJT – electronics – Unijunction transistor. A three terminal, voltage threshold semiconductor device commonly used for oscillators and time delays.

V – electronics – Voltage. Subscripts indicate the terminals which the voltage is measured across, the first subscript commonly denoting the positive terminal.

W – **radiometric** – Radiant emittance. The flux density, in Watts/unit area, emitted by the surface source.

B. Optoelectronic Terms

Acceleration Factor – **reliability** – a factor which describes the change in a predicted phenomena caused by a secondary effect.

Angstrom Unit – **radiometric** – 10^{-10} meters, obsolete term used to describe wavelength of radiation.

Anode – **electronic** – the main terminal, of a device, which is normally biased positive. See cathode.

Bandgap – **electronic** – the potential difference between the valence and conduction bands. This determines the forward voltage drop and frequency of light output of a diode.

Base – **electronic** – the control terminal of a transistor.

Beta – **electronic** – common emitter current gain of a transistor. Collector current divided by base current.

Bias – **electronic** – the electrical conditions of component operation or test.

Black Body – **radiometric** – a body which reflects no radiation. Its radiation spectrum is a simple function of its temperature.

Candela – **photometric** – unit of luminous intensity, defined by $1/60 \text{ cm}^2$ of a black body at 2042°K.

Cathode – **electronic** – the main terminal, of a device, which is normally biased negative. See anode.

Chatter – **electronic** – a rapid, normally undesired, oscillation of relay contacts between the open and closed state.

Collector – **electronic** – the main terminal of a transistor in which current flow is normally relatively independent of voltage to the base.

Color Temperature – **photometric** – the temperature of a black body when its color best approximates the designated source. Normally used for lamps and determined at .45 and .65 microns.

Commutating dv/dt – **electronic** – a measure of the ability of a triac to block a rapidly rising voltage immediately after conduction of the opposite polarity.

Coupled dv/dt – **electronic** – a measure of the ability of an opto thyristor coupler to block when the coupler is subjected to rapidly changing isolation voltage.

Coupler – **electronic** – abbreviation for optocoupler.

Critical Angle – **optics** – the largest angle of incidence of light, on the interface of two transmission mediums, that light will be transmitted between the mediums. Light at greater angles of incidence will be reflected.

Current Transfer Ratio – **electronic** – the ratio of output current to input current, at a specified bias, of an optocoupler.

Dark Current – **electronic** – Leakage current, usually I_{CEO}, of a photodetector with no incident light.

Darlington – **electronic** – A composite transistor containing two transistors connected to multiply current gain.

Detector – **radiometric** – A device which changes light energy (radiation) to electrical energy.

Diffraction – **optics** – The phenomena of light bending at the edge of an obstacle. Demonstrates wave properties of light.

Diode – **electronic** – A device that normally permits only one direction of current flow. A P-N junction diode will generate electricity when the junction is illuminated.

Doping	– **electronic**	– The addition of carrier supplying impurities to semiconductor crystals.
Duty Cycle	– **electronic**	– The ratio of on time to period of a pulse train.
Efficiency	– **electronic**	– In this handbook, refers to the ratio of output power of a source to electrical input power.
Effective Irradiance	– **electronic**	– Irradiance as perceived by a detector.
Emittance	– **radiometric**	– Power radiated per unit area from a surface.
Emitter	– **electronic**	– Main terminal of a transistor which bias voltage normally has a major effect on current.
Emitter	– **radiometric**	– A source of radiation.
Epitaxial	– **electronic**	– Material added to a crystalline structure which has and maintains the original crystals structure.
f/number	– **optics**	– Ratio of focal length to lens diameter.
Fiber Optics	– **optics**	– Transparent fibers which transmit light along the fiber's axis due to the critical angle at the fiber's circumference.
Foot Candle	– **photometric**	– Illumination level of one lumen per square foot.
Foot Lambert	– **photometric**	– Brightness of source of one lumen per square foot.
Gallium Arsenide	– **electronic**	– A crystalline compound which is doped to form IRED's.
Gate	– **electronic**	– Control terminal of an SCR or, a logic function component.
Hash	– **electronic**	– Random, high frequency noise on a signal or logic line.
Illumination	– **photometric**	– Light level on a unit area.
Infrared	– **photometric**	– Radiation of longer wavelength than normally perceived by the eye, i.e., .78 to 100 microns wavelength.
Interrupter Module	– **electronic**	– Optoelectronic device which detects objects which break the light beam from an emitter to a detector.
Irradiance	– **radiometric**	– Radiated power per unit area incident on a surface, broadband analogy to illumination.
Isolation Voltage	– **electronic**	– The dielectric withstanding voltage capability of an optocoupler under defined conditions and time.
Light	– **photometric**	– Radiation normally perceived by the eye, i.e., .38 to .78 microns wavelength.
Light current	– **electronic**	– Current through a photodetector when illuminated under specified bias conditions.
Lumen	– **photometric**	– Unit of radiant flux through one steradian from a one-candela source.
Micron	– **radiometric**	– 10^{-6} meters.
Modulation	– **electronic**	– The transmission of information by modifying a carrier signal – usually its amplitude or frequency.
Monochrometer	– **photometric**	– An instrument which is a source of any specific wavelength of radiation over a specified band.
Monochromatic	– **photometric**	– Of a single color, wavelength.
Nanometer	– **radiometric**	– 10^{-9} meters.
Normalized	– **electronic**	– Presentation of the change in a parameter, due to a test condition change, made by dividing the final value by the initial value.
Optocoupler	– **electronic**	– A single component which transmits electrical information, without electrical connection, between a light source and a light detector.
Optoisolator	– **electronic**	– Optocoupler.
Peak Spectral Emission	– **radiometric**	– Wavelength of highest intensity of a source.
Photoconductor	– **electronic**	– A material that's resistivity is a function of illumination level.

Photocoupler	**electronic**	Optocoupler.
Photodarlington	**electronic**	Light sensitive darlington connected transistor pair photodetector.
Photodetector	**electronic**	A device which provides an electrical signal when irradiated by infrared, light and/or ultraviolet.
Photodiode	**electronic**	p-n junction semiconductor diode photodetector.
Photon	**electronic**	Quantum of light from wave theory.
PhotoSCR	**electronic**	LASCR.
Phototransistor	**electronic**	A transistor photodetector.
Photovoltaic Cell	**electronic**	A photodiode connected to supply electricity, when illuminated.
Point Source	**radiometric**	A source with a maximum dimension less than 1/10 the distance between source and detector.
Reflector Module	**electronic**	Component containing a source and detector which detects objects which complete the light path by reflecting the light.
Silicon	**electronic**	Crystalline element which is doped to make photodiode, phototransistor, photodarlington, photoSCR, etc. detectors.
Silicon Controlled Rectifier	**electronic**	A reverse blocking thyristor which can block or conduct in forward bias, conduction between the anode and cathode being initiated by forward bias of the gate cathode junction.
Source	**radiometric**	A device which provides radiant energy.
Spectral Distribution	**radiometric**	A plot, usually normalized, of source intensity vs. wavelength observed.
Spectral Sensitivity	**radiometric**	A plot of detector sensitivity vs. wavelength detected.
Steradian	**radiometric**	Unit of solid angle. A sphere contains 4π steradians.
Synchroneous Detection	**electronic**	A technique which detects low level pulses by detecting only signal changes which occur at the same time as the pulse.
Thermopile	**radiometric**	A very broadband, heat sensing, radiation detector.
Transistor	**electronic**	Three terminal semiconductor device which behaves as a current controlled current source.
Triac	**electronic**	A thyristor which can block or conduct in either polarity. Conduction is initiated by forward bias of a gate – MTI junction.
Tungsten	**radiometric**	The element normally used for incandescent lamp filaments.
Unijunction Transistor	**electronic**	A three terminal voltage threshold semiconductor device normally used for oscillators and time delays.
Wavelength	**radiometric**	The speed of light divided by the frequency of the electromagnetic radiation-wave theory of light.
Watt	**electronic**	Unit of power, a volt ampere.
Watt	**photometric**	Unit of power, 685 lumens at 0.555 microns wavelength.

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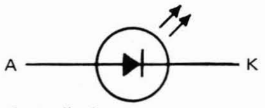
OPTO ELECTRONIC DEVICES

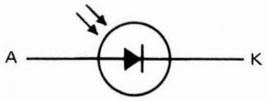
DIODES

light-emitting diode (LED)



◇ ○

photodiode



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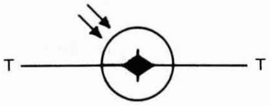
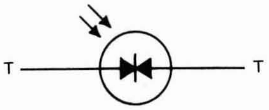
npn bidirectional photodiode
(photo-duo-diode)



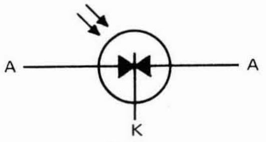
*

pnp bidirectional photodiode
(photo-duo-diode)



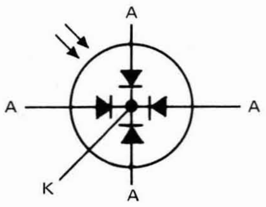
*

pnp two-segment photodiode,
with common cathode



*

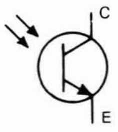
pnp four-quadrant photodiode,
with common cathode



*

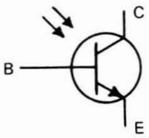
TRANSISTORS

npn phototransistor,
no base connection



◇

npn phototransistor,
with base connection



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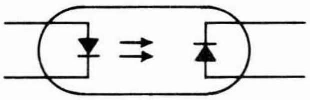
OPTICALLY COUPLED ISOLATORS

with photodiode output



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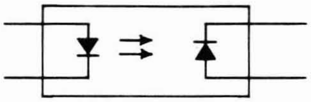
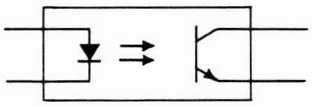


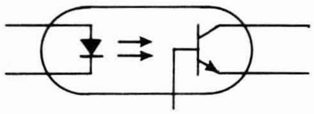
□

with phototransistor output,
no base connection



□

with phototransistor output,
and base connection



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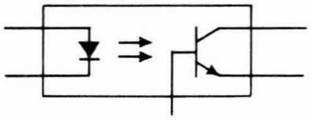
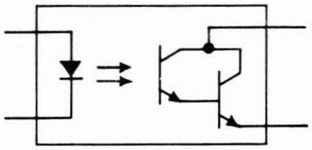


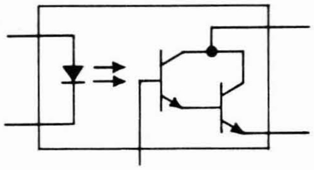
□

with photo-Darlington output, no base



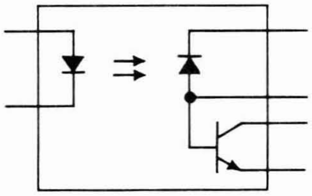
□

with photo-Darlington output, and base



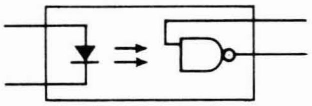
□

with photodiode and amplifier-
transistor output



□

with NAND-gate-photodetector output



□

◇ **IEEE/ANSI Approval**
○ **ICE Approval**
☆ **Proposed IEEE Revision**
□ **Popular Industry Usage**

VII. APPENDICES

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INDEX (continued)

GUIDE TO SPECIFICATIONS

OPTO COUPLERS

PHOTO TRANSISTOR OUTPUT

GE TYPE	PAGE NO.	ISOLATION VOLTAGE (V_{pk}) MIN.	CURRENT TRANSFER RATIO MIN.	I_D (nA) MAX.	BV_{CEO} (VOLTS) MIN.	TYPICAL (μSEC.)		$V_{CE(SAT)}$ MAX.
						t_r	t_f	
CNY17 I	228	4000	40- 80	50	70	2	2	.3
CNY17 II	228	4000	63-125	50	70	2	2	.3
CNY17 III	228	4000	100-200	50	70	2	2	.3
CNY17 IV	228	4000	160-320	50	70	2	2	.3
CNY32	242	4000 V_{RMS}	20%	100	30	3	3	.4
CNY47	250	2800	20- 60	100	30	2	2	.4
CNY47A	250	2800	40-	100	30	2	2	.4
CNY51		5656	100-	50	70	2	2	.4
H11A1	138	2500	50%	50	30	2	2	.4
H11A2	138	1500	20%	50	30	2	2	.4
H11A3	140	2500	20%	50	30	2	2	.4
H11A4	140	1500	10%	50	30	2	2	.4
H11A5	142	1500	30%	100	30	2	2	.4
H11A520	148	5656	20%	50	30	2	2	.4
H11A550	148	5656	50%	50	30	2	2	.4
H11A5100	148	5656	100%	50	30	2	2	.4
H15A1	188	4000 V_{RMS}	20%	100	30	3	3	.4
H15A2	188	4000 V_{RMS}	10%	100	30	3	3	.4
4N25	124	2500	20%	50	30	3	3	.5
4N25A	124	1775 V_{RMS}	20%	50	30	3	3	.5
4N26	124	1500	20%	50	30	3	3	.5
4N27	124	1500	10%	50	30	3	3	.5
4N28	124	500	10%	50	30	3	3	.5
4N35	128	2500 V_{RMS}	100%	50	30	5	5	.3
4N36	128	1750 V_{RMS}	100%	50	30	5	5	.3
4N37	128	1050 V_{RMS}	100%	50	30	5	5	.3
H74A1	152	1500		100	15			

PHOTO DARLINGTON OUTPUT

H11B1	158	2500	500%	100	25	125	100	1.0
H11B2	158	1500	200%	100	25	125	100	1.0
H11B3	158	1500	100%	100	25	125	100	1.0
H11B255	160	1500	100%	100	55	125	100	1.0
H15B1	190	4000 V_{RMS}	400%	100	30	125	100	1.4
H15B2	190	4000 V_{RMS}	200%	100	30	125	100	1.4
4N29	126	2500	100%	100	30	5	40	1.0
4N29A	126	1775 V_{RMS}	100%	100	30	5	40	1.0
4N30	126	1500	100%	100	30	5	40	1.0
4N31	126	1500	50%	100	30	5	40	1.2
4N32	126	2500	500%	100	30	5	100	1.0
4N32A	126	1775 V_{RMS}	500%	100	30	5	100	1.0
4N33	126	1500	500%	100	30	5	100	1.0
CNY31	240	4000 V_{RMS}	400%	100	30	125	100	1.4
CNY48	252	2120	600%	100	30	125	100	1.0

PHOTO SCR OUTPUT

GE TYPE	PAGE NO.	ISOLATION VOLTAGE MIN.	I_F TRIGGER (MAX.)	I_D 100°C (MAX.)μA	BLOCKING VOLTAGE (MIN.)	TYPICAL TON (μSEC.)	V_F (MAX.)
H11C1	164	2500	20mA	50	200	1	1.5
H11C2	164	2100	20mA	50	200	1	1.5
H11C3	164	1500	30mA	50	200	1	1.5
H11C4	168	2500	20mA	100	400	1	1.5
H11C5	168	2100	20mA	100	400	1	1.5
H11C6	168	1500	30mA	100	400	1	1.5
4N39	134	1500	14mA	50	200	1	1.5
4N40	134	1500	14mA	150	400	1	1.5
H74C1	172	1500			200		
H74C2	172	1500			400		
CNY30	236	2500	20mA	50	200	1	1.5
CNY34	236	2500	20mA	150	400	1	1.5

PROGRAMMABLE THRESHOLD COUPLER

GE TYPE	PAGE NO.	ISOLATION VOLTAGE (V_{pk}) MIN.	CURRENT TRANSFER RATIO MIN.	I_D (nA) MAX.	BV_{CEO} (VOLTS) MIN.	TYPICAL (μSEC.)		$V_{CE(SAT)}$ MAX.
						t_r	t_f	
H11A10	144	1500	10%	50	30	2	2	.4

AC INPUT COUPLER

GE TYPE	PAGE NO.	ISOLATION VOLTAGE (V_{pk}) MIN.	CURRENT TRANSFER RATIO MIN.	I_D (nA) MAX.	BV_{CEO} (VOLTS) MIN.	TYPICAL (μSEC.)		$V_{CE(SAT)}$ MAX.
						t_r	t_f	
H11AA1	154	1500	20%	100	30	2	2	.4
H11AA2	154	1500	10%	200	30	2	2	.4
CNY35	246	1500	10%	200	30	2	2	.4

HIGH VOLTAGE COUPLER

GE TYPE	PAGE NO.	ISOLATION VOLTAGE (V_{pk}) MIN.	CURRENT TRANSFER RATIO MIN.	I_D (nA) MAX.	BV_{CEO} (VOLTS) MIN.	TYPICAL (μSEC.)		$V_{CE(SAT)}$ MAX.
						t_r	t_f	
H11D1	174	2500	20%	100	300	5	5	.4
H11D2	174	1500	20%	100	300	5	5	.4
H11D3	174	1500	20%	100	200	5	5	.4
H11D4	174	1500	10%	100	200	5	5	.4
4N38	132	1500	10%	50	80	5	5	1.0
4N38A	132	1775 V_{RMS}	10%	50	80	5	5	1.0
CNY33	244	2500	20%	100	300	5	5	.4

HIGH VOLTAGE PHOTO DARLINGTON OUTPUT

GE TYPE	PAGE NO.	ISOLATION VOLTAGE (RMS) MIN.	CURRENT TRANSFER RATIO MIN.	I_D (nA) MAX.	BV_{CEO} (VOLTS) MIN.	TYPICAL (μSEC.)		$V_{CE(SAT)}$ MAX.
						t_r	t_f	
H11G1	180	2500	1000%	100	100	5	100	1.0
H11G2	180	2500	1000%	100	80	5	100	1.0
H11G3	182	1500	200%	100	55	5	100	1.0

BILATERAL ANALOG FET OUTPUT

GE TYPE	PAGE NO	ISOLATION VOLTAGE (pk) MIN.	ON-STATE RESISTANCE MAX. OHMS	OFF-STATE RESISTANCE MIN. OHMS	BREAKDOWN VOLTAGE	TURN-ON TIME (μSEC)	TURN-OFF TIME (μSEC)
H11F1	176	2500	200	300M	30	15	15
H11F2	176	2500	330	300M	30	15	15
H11F3	176	1500	470	330M	15	15	15

INFRARED EMITTERS

GE TYPE	PAGE NO.	MIN. P_O@ I_F=100mA	MAX. V_F@ I_F=100mA	PEAK EMISSION WAVELENGTH TYP.n.METERS	RISE TIME TYP.μ.SEC.	FALL TIME TYP.μ.SEC.	MAX. P_D mW	MAX. I_F CONT. mA
IN6264	104	6.0mW	1.7V	940	1.0	1.0	1300	100
IN6265	104	6.0mW	1.7V	940	1.0	1.0	1300	100
IN6266	106	25mW/sr	1.7V	940	1.0	1.0	1300	100
CQX14	220	5.4mW	1.7V	940	1.0	1.0	1300	100
CQX15	220	5.4mW	1.7V	940	1.0	1.0	1300	100
CQX16	220	1.5mW	1.7V	940	1.0	1.0	1300	100
CQX17	220	1.5mW	1.7V	940	1.0	1.0	1300	100
F5D1	110	12mW	1.7V	880	1.5	1.5	1300	100
F5D2	110	9mW	1.7V	880	1.5	1.5	1300	100
F5E1	110	12mW	1.7V	880	1.5	1.5	1300	100
F5E2	110	9mW	1.7V	880	1.5	1.5	1300	100
LED55C	114	5.4mW	1.7V	940	1.0	1.0	1300	100
LED55B	114	3.5mW	1.7V	940	1.0	1.0	1300	100
LED56	114	1.5mW	1.7V	940	1.0	1.0	1300	100
LED55CF	114	5.4mW	1.7V	940	1.0	1.0	1300	100
LED55BF	114	3.5mW	1.7V	940	1.0	1.0	1300	100
LED56F	114	1.5mW	1.7V	940	1.0	1.0	1300	100

DETECTORS

PHOTO TRANSISTORS

GE TYPE	PAGE NO	SENSITIVITY(ma/mw/cm^2)		BV_{CEO} (V)	BV_{CBO} (V)	I_D (nA) MAX.	SWITCHING TYP.		TYP. $V_{CE(SAT)}$
		MIN.	MAX.				t_r (μSEC.)	t_f (μSEC.)	
BPW36	224	.6	–	45	45	100	5	5	.4
BPW37	224	.3	–	45	45	100	5	5	.4
L14G1	120	.6	–	45	45	100	5	5	.4
L14G2	120	.3	–	45	45	100	5	5	.4
L14G3	120	1.2	–	45	45	100	5	5	.4
L14H1	122	.05	–	60	60	100	5	5	.4
L14H2	122	.2	–	30	30	100	5	5	.4
L14H3	122	.2	–	60	60	100	5	5	.4
L14H4	122	.05	–	30	30	100	5	5	.4

PHOTO DARLINGTONS

2N5777	116	.25	–	25	25	100	75	50	.8
2N5778	116	.25	–	40	40	100	75	50	.8
2N5779	116	1.0	–	25	25	100	75	50	.8
2N5780	116	1.0	–	40	40	100	75	50	.8
BPW38	226	15.0	–	25	25	100	75	50	.8
L14F1	118	15.0	–	25	25	100	75	50	.8
L14F2	118	5.0	–	25	25	100	75	50	.8

PHOTON COUPLED INTERRUPTER MODULE

PHOTO TRANSISTOR OUTPUT

GE TYPE	PAGE NO.	OUTPUT CURRENT		I_D (nA)	BV_{CEO} (V)	TYPICAL		$V_{CE(SAT)}$ MAX.
						TON (μSEC)	t_f (μSEC.)	
H13A1	184	I_F = 20mA	200μA	100	30	5	5	.4
H13A2	184	I_F = 20mA	50μA	100	30	5	5	.4
H20A1	196	I_F = 20mA	200μA	100	30	5	5	.4
H20A2	196	I_F = 20mA	50μA	100	30	5	5	.4
H21A1	200	I_F = 20mA	1.0mA	100	30	8	50	.4
H21A2	200	I_F = 20mA	2.0mA	100	30	8	50	.4
H21A3	200	I_F = 20mA	4.0mA	100	30	8	50	.4
H21A4	202	I_F = 20mA	1.0mA	100	55	8	50	.4
H21A5	202	I_F = 20mA	2.0mA	100	55	8	50	.4
H21A6	202	I_F = 20mA	4.0mA	100	55	8	50	.4
H22A1	208	I_F = 20mA	1.0mA	100	30	8	50	.4
H22A2	208	I_F = 20mA	2.0mA	100	30	8	50	.4
H22A3	208	I_F = 20mA	4.0mA	100	30	8	50	.4
H22A4	210	I_F = 20mA	1.0mA	100	55	8	50	.4
H22A5	210	I_F = 20mA	2.0mA	100	55	8	50	.4
H22A6	210	I_F = 20mA	4.0mA	100	55	8	50	.4
CNY28	232	I_F = 20mA	200μA	100	30	5	5	.4

PHOTO DARLINGTON OUTPUT

H13B1	186	I_F = 20mA	2500μA	100	25	150	150	1.2
H13B2	186	I_F = 20mA	1000μA	100	25	150	150	1.2
H20B1	198	I_F = 20mA	2500μA	100	25	150	150	1.2
H20B2	198	I_F = 20mA	1000μA	100	25	150	150	1.2
H21B1	204	I_F = 10mA	7.5mA	100	30	45	250	1.0
H21B2	204	I_F = 10mA	14mA	100	30	45	250	1.0
H21B3	204	I_F = 10mA	25mA	100	30	45	250	1.0
H21B4	206	I_F = 10mA	7.5mA	100	55	45	250	1.0
H21B5	206	I_F = 10mA	14mA	100	55	45	250	1,0
H21B6	206	I_F = 10mA	25mA	100	55	45	250	1.0
H22B1	212	I_F = 10mA	7.5mA	100	30	45	250	1.0
H22B2	212	I_F = 10mA	14mA	100	30	45	250	1.0
H22B3	212	I_F = 10mA	25mA	100	30	45	250	1.0
H22B4	214	I_F = 10mA	7.5mA	100	55	45	250	1.0
H22B5	214	I_F = 10mA	14mA	100	55	45	250	1.0
H22B6	214	I_F = 10mA	25mA	100	55	45	250	1.0
CNY29	234	I_F = 20mA	2.5mA	100	25	150	150	1.2

MATCHED EMITTER DETECTOR PAIRS

PHOTO TRANSISTOR OUTPUT

H17A1	192	I_F = 20mA	50μA	100	30	5	5	.4
H23A1	216	I_F = 30mA	1.5mA	100	30	8	50	.4

PHOTO DARLINGTON OUTPUT

H17B1	194	I_F = 20mA	1000μA	100	25	150	150	1.2
H23B1	218	I_F = 10mA	7.5 mA	100	30	45	250	1.0

SAFETY

Optoelectronics may be used in systems in which personnel or other hazard is involved. All components, including semiconductor devices, have the potential of failing or degrading in ways which could impair the proper operation of such systems. Well-known circuit techniques are available to protect against and minimize the effects of such occurrences. Examples of these techniques include redundant design, self-checking systems and other fail-safe techniques. Fault analysis of any systems relating to safety is recommended. Potential device reaction to various environmental factors are discussed in the reliability section of this manual. These and any other environmental factors should be analyzed in all circuit designs, particularly in safety related applications.

If the system analysis indicates the need for the highest degree of reliability in the component used, it is recommended that General Electric be contacted for a customized reliability program.

SOLID STATE OPTOELECTRONICS

Infrared Emitter

1N6264, 1N6265

Gallium Arsenide Infrared – Emitting Diode

The General Electric 1N6264 and 1N6265 Series are gallium arsenide, light emitting diodes which emit non-coherent, infrared energy. They are ideally suited for use with silicon detectors. The 1N6264 has a lens which provides a narrow beam angle while the 1N6265 has a flat window for a wide beam angle which is useful with external lensing.

absolute maximum ratings: (25°C unless otherwise specified)

Voltages			
† Reverse Voltage	V_R	3	volts
Currents			
† Forward Current (continuous)	I_F	100	mA
† Forward Current (pw 1 μs, 200 Hz)	I_F	10	A
Dissipation			
† Power Dissipation (T_A = 25°C)*	P_T	170	mW
Power Dissipation (T_C = 25°C)**	P_T	1.3	W
Temperatures			
† Junction Temperature	T_J	-65 to +150	°C
† Storage Temperature	T_{stg}	-65 to +150	°C
† Lead Soldering Time (1/16″ [1.6mm] from case for 10 sec.)	T_L	260	°C

*Derate 1.36 mW/°C above 25°C ambient.
**Derate 10.4 mW/°C above 25°C case.

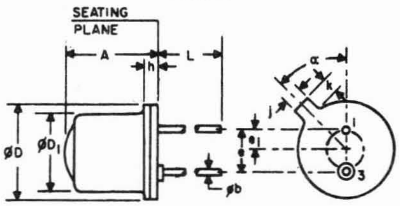
electrical characteristics: (25°C unless otherwise specified)

	SYM.	MIN.	TYP.	MAX.	UNITS
† Reverse Leakage Current (V_R = 3V)	I_R	–	–	10	μA
† Forward Voltage (I_F = 100 mA)	V_F	–	1.4	1.7	Volts
† Total Power Output (note 1) (I_F = 100 mA)	P_o	6	–	–	mW
† Peak Emission Wavelength (I_F = 100 mA)	λ_p	935	945	955	nm
Spectral Shift with Temperature		–	.28	–	nm/°C
† Spectral Bandwidth – 50%	$\Delta\lambda$	–	–	60	nm
† Half Intensity Beam Angle					
1N6264	θ_{HI}	–	–	20	deg
1N6265	θ_{HI}	–	–	80	deg
Rise Time – 0-90% of Output	t_r	–	1.0	–	μs
Fall Time – 100-10% of Output	t_f	–	1.0	–	μs

Note 1:
Total power output, P_O, is the total power radiated by the device into a solid angle of 2π steradians.

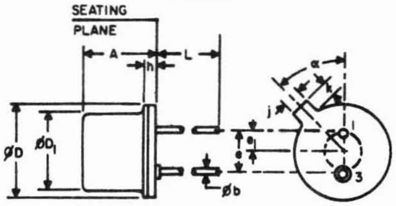
† Indicates JEDEC registered values.

1N6264

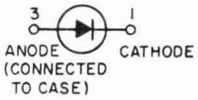


SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A		.255		6.47	
øb	.016	.021	.406	.534	
øD	.209	.230	530	5.85	
øD₁	.180	.187	4.58	4.75	
e	.100 NOM.		2.54 NOM.		2
e₁	.050 NOM.		1.27 NOM.		2
h		.030		.76	
j	.031	.044	.78	1.12	
k	.036	.046	.91	1.17	1
L	1.00		25.4		
α	45°		45°		3

1N6265

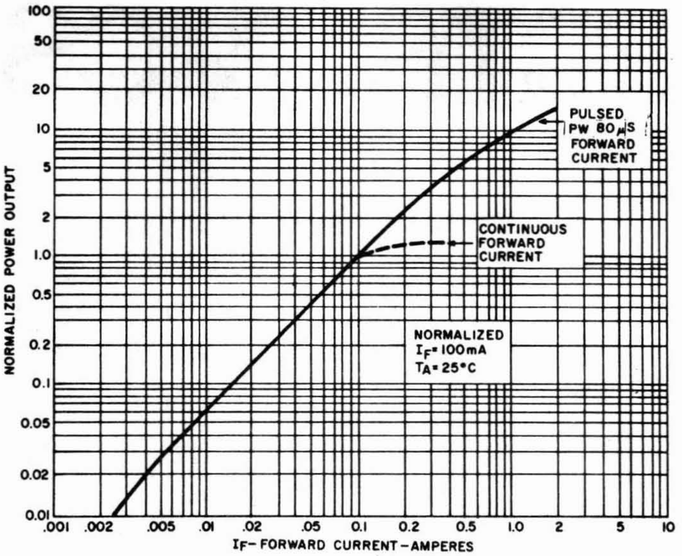


SYMBOL	INCHES MIN.	INCHES MAX	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A		.155		3.93	
øb	.016	.021	.406	.534	
øD	.209	.230	5.30	5.85	
øD₁	.180	.187	4.58	4.75	
e	.100 NOM.		2.54 NOM.		2
e₁	.050 NOM.		1.27 NOM		2
h		.030		:.76	
j	.031	.044	.78	1.12	
k	.036	.046	.91	1.17	1
L	1.00		25.4		
α	45°		45°		3

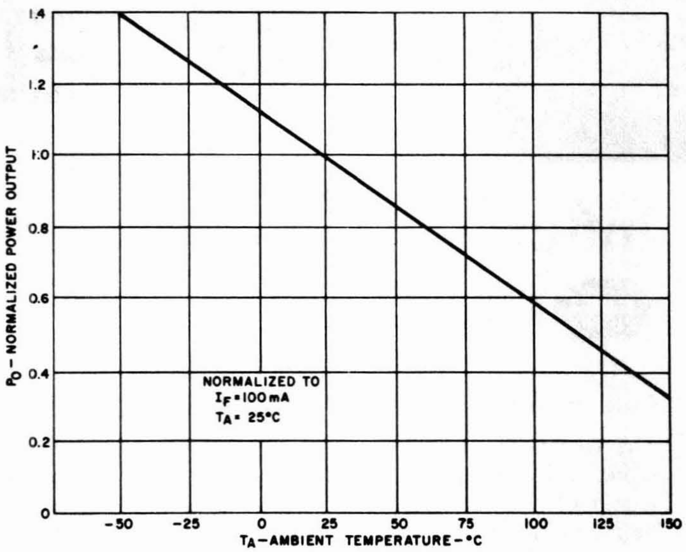


1. Measured from maximum diameter of device.
2. Leads having max. diameter .021″ (.533mm) measured in gaging plane .054″ + .001″ – .000 (137 + 025 – 000mm) below the reference plane of the device shall be within .007″ (.778mm) their true position relative to a maximum width tab.
3. From centerline tab.

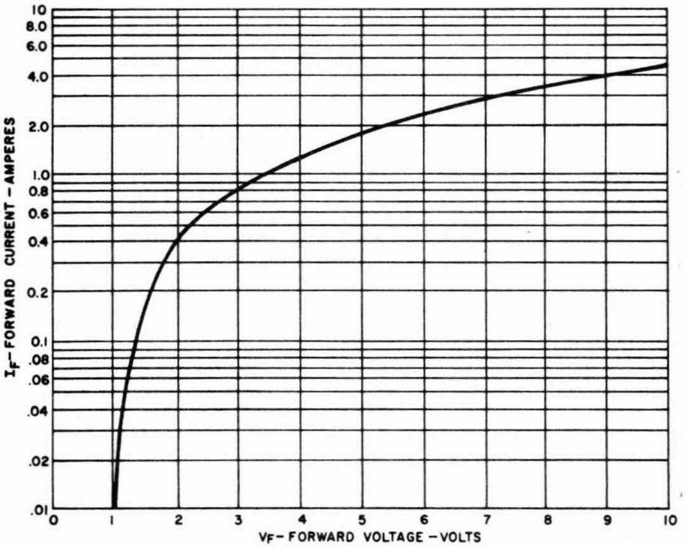
TYPICAL CHARACTERISTICS



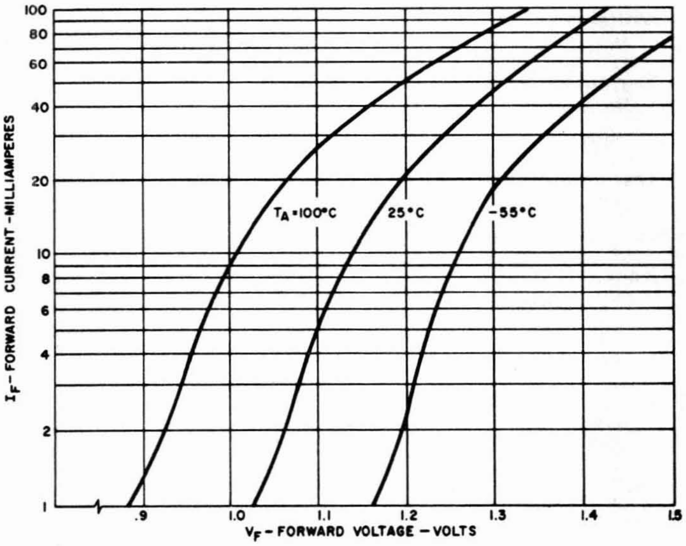
1. POWER OUTPUT VS. INPUT CURRENT



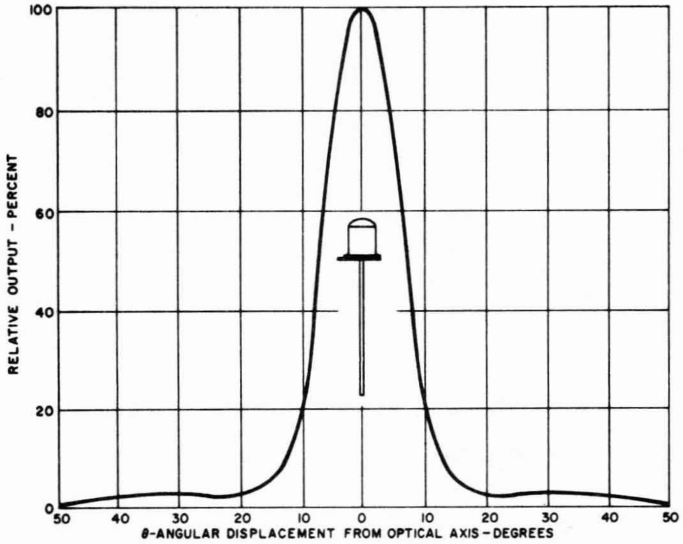
2. POWER OUTPUT VS. TEMPERATURE



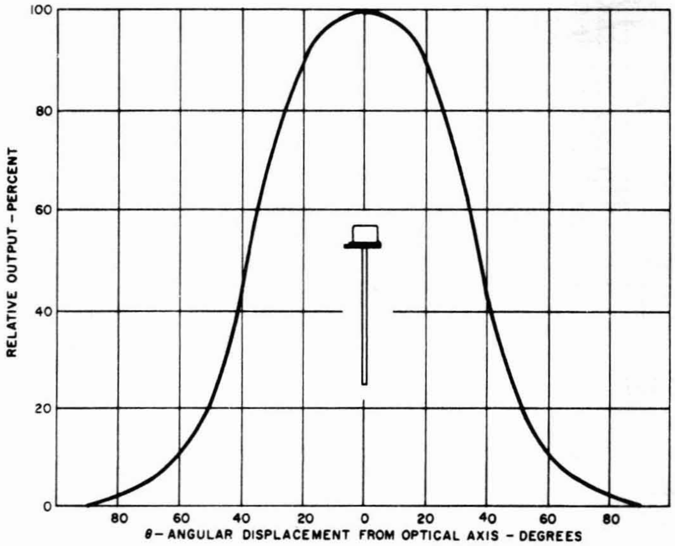
3. FORWARD VOLTAGE VS. FORWARD CURRENT



4. FORWARD VOLTAGE VS. FORWARD CURRENT



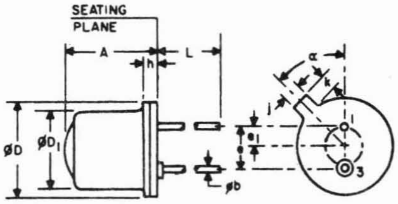
5. 1N6264 – TYPICAL RADIATION PATTERN



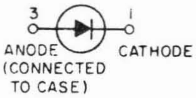
6. 1N6265 – TYPICAL RADIATION PATTERN

Infrared Emitter

1N6266



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A		.255		6.47	
øb	.016	.021	.406	.534	
øD	.209	.230	5.30	5.85	
øD1	.180	.187	4.58	4.75	
e	.100 NOM.		2.54 NOM.		2
e1	.050 NOM.		1.27 NOM.		2
h		.030		.76	
j	.031	.044	.78	1.12	
k	.036	.046	.91	1.17	1
L	1.00		25.4		
α	45°		45°		3



Gallium Arsenide Infrared – Emitting Diode

The General Electric 1N6266 is a gallium-arsenide, infrared emitting diode which emits non-coherent, infrared energy with a peak wavelength of 940 nanometers. This device is characterized to precisely define the infrared beam along the mechanical axis of the device.

absolute maximum ratings: ($T_A = 25°C$ unless otherwise specified)

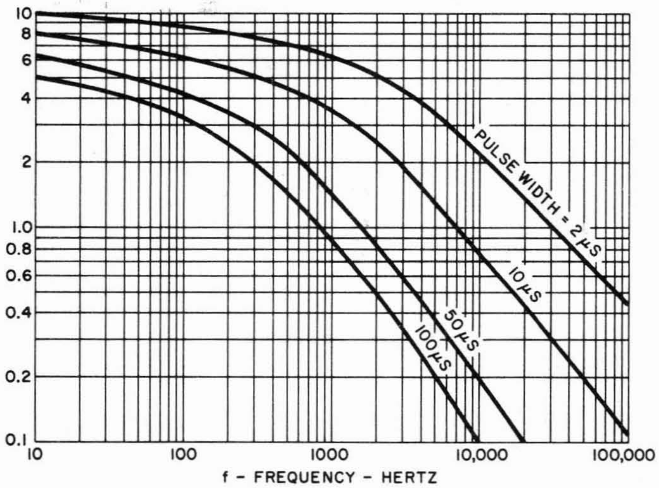
Voltages			
*Reverse Voltage	V_R	3	Volts
Currents			
*Forward Current (Continuous)	I_F	100	mA
*Forward Current (pw 1 μsec 200Hz)	I_F	10	A
Dissipation			
*Power Discipation ($T_A = 25°C$)†	P_T	170	mWatts
Power Dissipation ($T_C = 25°C$)††	P_T	13	Watts
Temperatures			
*Junction Temperature	T_J	-65 to +150	°C
*Storage Temperature	T_{STG}	-65 to +150	°C
*Lead Soldering Time (1/16″, 1.6mm, from case for 10 sec.)	T_L	+260	°C

†Derate 1.36mW/°C above 25°C ambient.
††Derate 10.4mW/°C above 25°C case.

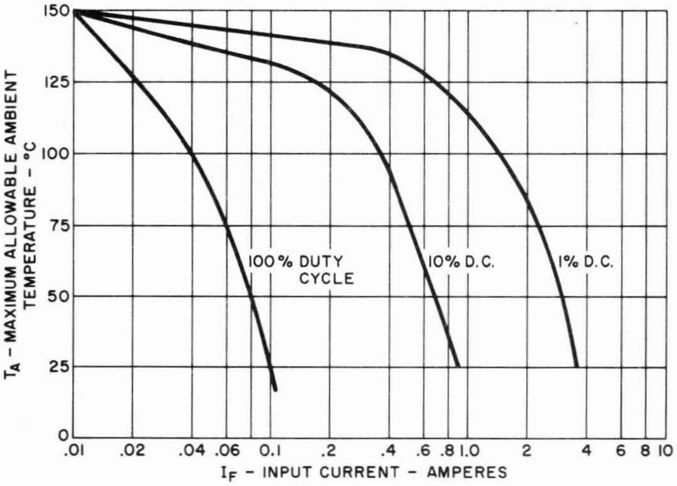
*Indicates JEDEC registered values.

1. Measured from maximum diameter of device.
2. Leads having max. diameter .021″ (.533mm) measured in gaging plane .054″ + .001″ – .000 (137 + 025 – 000mm) below the reference plane of the device shall be within .007″ (.778mm) their true position relative to a maximum width tab.
3. From centerline tab.

MAXIMUM RATING CURVES



MAXIMUM PULSE CAPABILITY



MAXIMUM TEMPERATURE VS. INPUT CURRENT

electrical characteristics: (T_A = 25°C unless otherwise specified)

Static Characteristics	SYMBOL	MIN.	TYP.	MAX.	UNITS
*Reverse Leakage Current (V_R = 3V)	I_R	–	–	10	μA
*Forward Voltage (I_F = 100 mA)	V_F	0.9	–	1.7	Volts
*Radiant Intensity (I_F = 100 mA, ω = 0.01 Sr)	I_e	25	–	–	mW/sr
*Peak Emission Wavelength (I_F = 100 mA)	λ_p	935	–	955	nm
Spectral Shift with Temperature		–	.28	–	nm/°C
*Spectral Bandwidth – 50%	$\Delta\lambda$	–	–	60	nm
*Half Intensity Beam Angle	θ_{HI}	–	–	20	deg.
Rise Time	t_r	–	1.0	–	μs
Fall Time	t_f	–	1.0	–	μs

*Indicates JEDEC registered values.

I_e

INFRARED EMITTING DIODE RADIANT INTENSITY

The design of an Infrared Emitting Diode (IRED)-photodetector system normally requires the designer to determine the minimum amount of infrared irradiance received by the photodetector, which then allows definition of the photodetector current. Prior to the introduction of the 1N6266, the best method of estimating the photodetector received infrared was to geometrically proportion the piecewise integration of the typical beam pattern with the specified minimum total power output of the IRED. However, due to the inconsistencies of the IRED integral lenses and the beam lobes, this procedure will not provide a valid estimation.

The General Electric 1N6266 now provides the designer specifications which precisely define the infrared beam along the device's mechanical axis. The 1N6266 is a premium device selected to give a minimum radiant intensity of 25 mW/steradian into the 0.01 steradians referenced by the device's mechanical axis and seating plane. Radiant intensity is the IRED beam power output, within a specified solid angle, per unit solid angle.

A quick review of geometry indicates that a steradian is a unit of solid angle, referenced to the center of a sphere, defined by 4π times the ratio of the area projected by the solid angle to the area of the sphere. The solid angle is equal to the projected area divided by the squared radius.

$$\text{Steradians} = 4\pi\ A/4\pi R^2 = A/R^2 = \omega.$$

As the projected area has a circular periphery, a geometric integration will solve to show the relationship of the Cartesian angle (α) of the cone, (from the center of the sphere) to the projected area.

$$\omega = 2\pi\ (1-\text{COS}\ \tfrac{\alpha}{2}).$$

Radiant intensity provides an easy, accurate tool to calculate the infrared power received by a photodetector located on the IRED axis. As the devices are selected for beam characteristics, the calculated results are valid for worst case analysis. For many applications a simple approximation for photodetector irradiance is:

$$H \cong I_e/d^2, \text{ in mw/cm}^2$$

where d is the distance from the IRED to the detector in cm.

IRED power output, and therefore I_e, depends on IRED current. This variation ($\Delta I_e/\Delta I$) is documented in Figure 1, and completes the approximation: $H = I_e/d^2\ (\Delta I_e/\Delta I)$. This normally gives a conservative value of irradiance. For more accurate results, the effect of precise angle viewed by the detector must be considered. This is documented in Figure 2 ($\Delta I_e/\Delta\omega$) giving:

$$H = I_e/d^2\ (\Delta I_e/\Delta I) \text{ in mw/cm}^2.$$

For worst case designs, temperature coefficients and tolerances must also be considered.

The minimum output current of the detector (I_L) can be determined for a given distance (d) of the detector from the IRED.

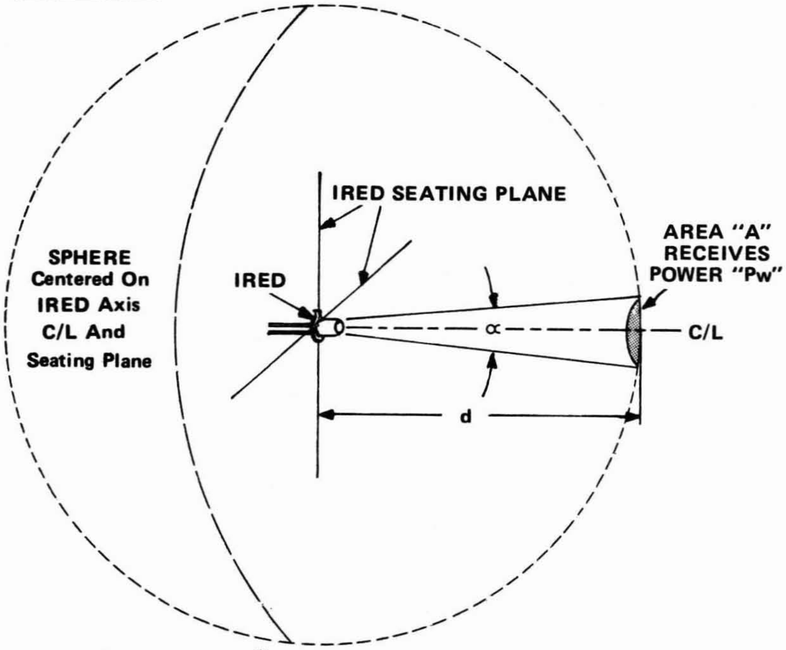
$$I_L = (S)H \cong (S)I_e/d^2$$

or

$$I_L = (S)H = (S)\ (I_e/d^2)\ (\Delta I_e/\Delta\omega)\ (\Delta I_e/\Delta I)$$

where S is the sensitivity of the detector in terms of output current per unit irradiance from a GaAs source.

IRED RADIANT INTENSITY SPECIFICATION CONCEPT



$\omega = A/d^2 = 2\pi\,(1-\cos\frac{\alpha}{2})$ Steradians

$I_e = P_w/\omega$ mW/Steradian

$H = P_w/A = I_e/d^2$ mW/cm²

MATCHING A PHOTOTRANSISTOR WITH 1N6266

Assume a system requiring a 10mA I_L at an IRED to detector spacing of 2cm (seating plane to seating plane), with bias conditions at specification points.

Given: $d_1 = 2$ cm; $I_{L_1} = 10$ mA min.; Ie = 25 mW/Steradian

Then: $H_1 \cong Ie/D_1{}^2 = 25/(2)^2 = 6.25$ mW/cm².

Detector Evaluation:

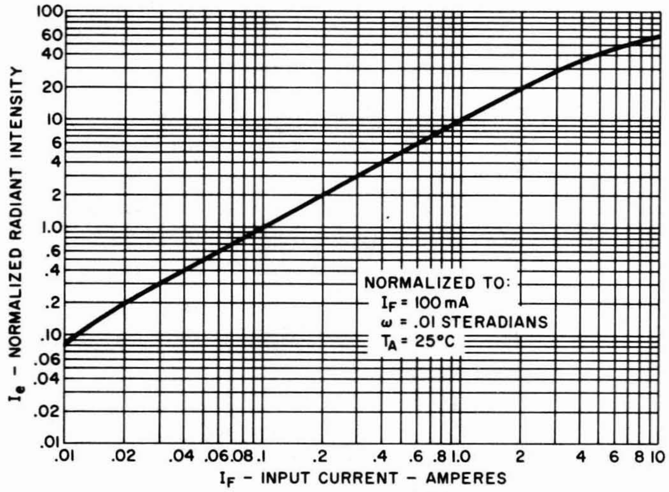
TYPE	I_L MIN. @ mA	H (Tungsten) mw/cm²	≅ H(GaAs) mw/cm²	S(GaAs) mA/mw/cm²
L14G1	6	10	3	2
L14G2	3	10	3	1

Calculated $I_L = d_1$ is:

L14G1 (S) H_1 = (2) 6.25 = 12.5 mA
L14G2 (S) H_1 = (1) 6.25 = 6.25 mA

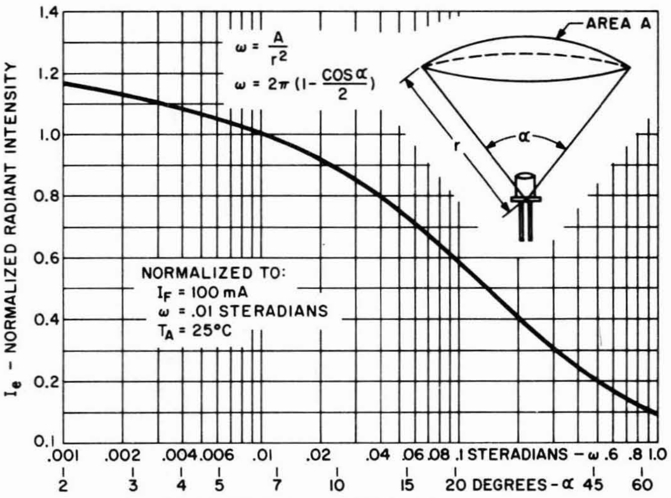
Since the system requires an I_L of 10 mA minimum the correct device to use is the L14G1.

TYPICAL CHARACTERISTICS



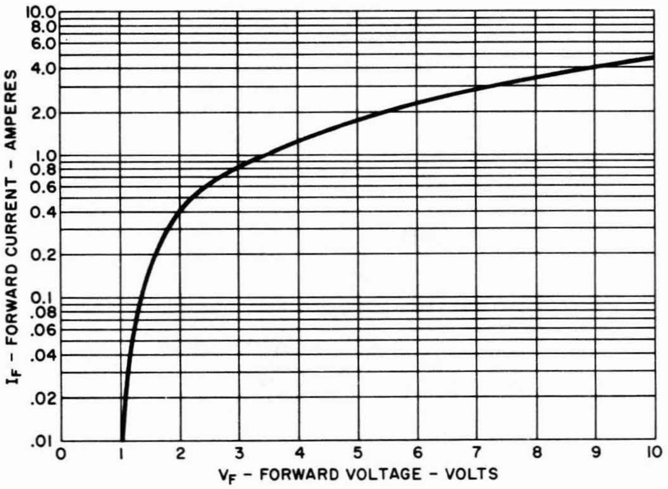
1. RADIANT INTENSITY VS. INPUT CURRENT

Δ Ie/ΔI

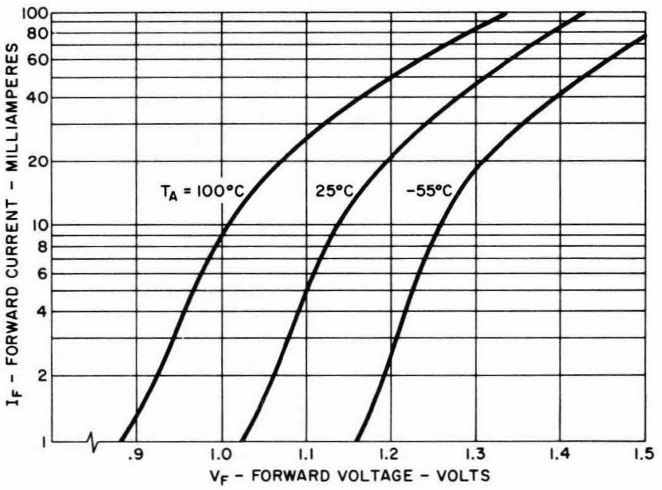


2. INTENSITY AND POWER VS. ANGLE

Δ Ie/$\Delta\omega$

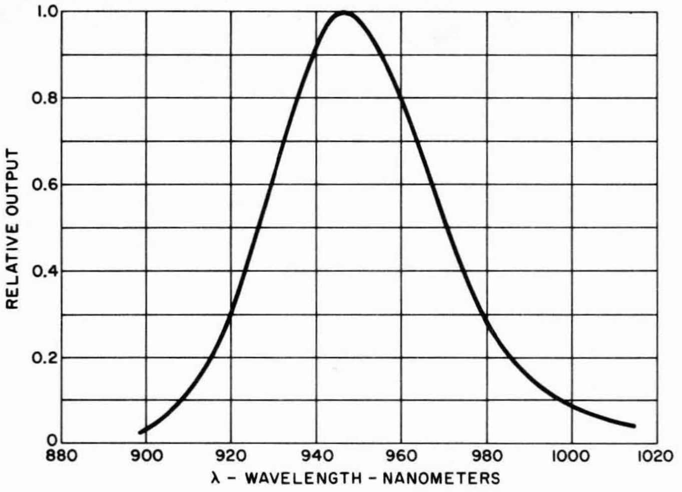


3. FORWARD VOLTAGE VS. FORWARD CURRENT

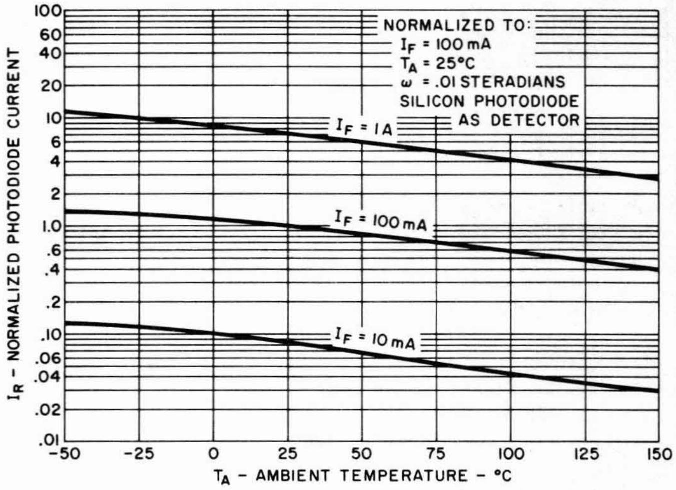


4. FORWARD VOLTAGE VS. FORWARD CURRENT

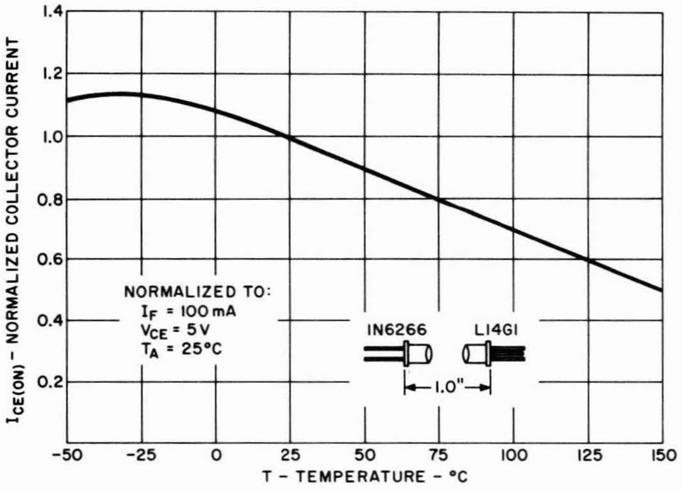
TYPICAL CHARACTERISTICS



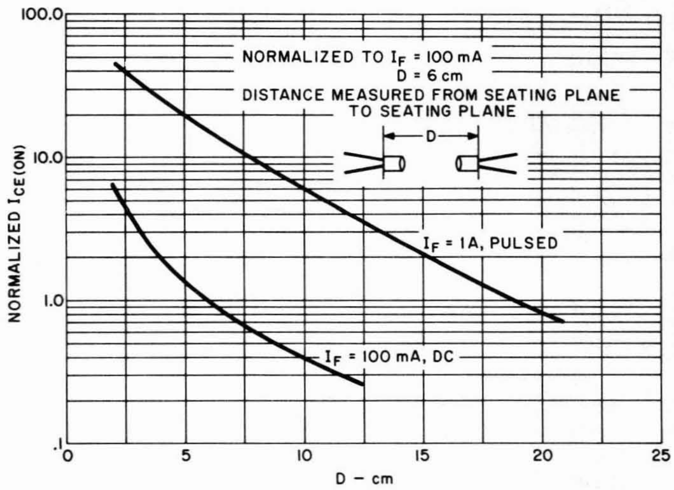
5. SPECTRAL OUTPUT



6. OUTPUT VS. TEMPERATURE

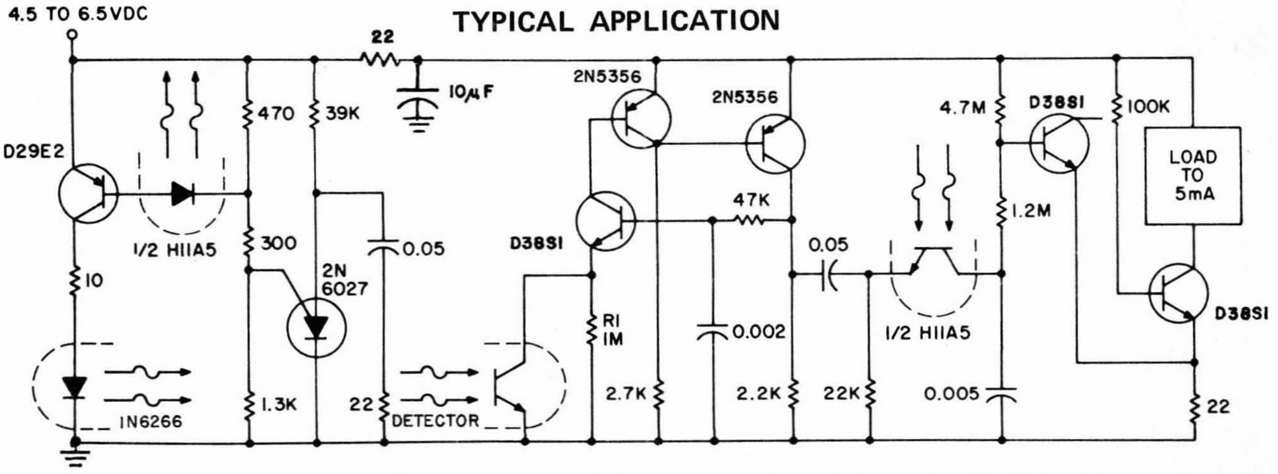


7. OUTPUT VS. TEMPERATURE IRED/PHOTOTRANSISTOR PAIR



8. IL VS. DISTANCE IRED/PHOTOTRANSISTOR PAIR

TYPICAL APPLICATION



DETECTOR SELECTION	TRANSMISSION RANGE	REFLECTIVE RANGE
L14H3	12"	3"
L14G1	36"	9"

OBJECT DETECTOR FEATURING LOW POWER CONSUMPTION AND LONG-RANGE CAPABILITY.

SOLID STATE OPTOELECTRONICS

Infrared Emitter

F5D1, F5D2, F5E1, F5E2

F5D1, F5D2　　F5E1, F5E2

Gallium Aluminum Arsenide Infrared – Emitting Diode

The General Electric F5D and F5E Series are infrared emitting diodes. They exhibit high power output and a typical peak wavelength of 880 nanometers. They provide a significant increase in system efficiency, when used with silicon detectors, compared to GaAs infrared emitting diodes.

absolute maximum ratings: (25°C, unless otherwise specified)

	SYMBOL		UNITS
Voltage			
Reverse Voltage	V_R	3	V
Current			
Forward Current (continuous)	I_F	100	mA
Forward Current (pw, 1 μs; 200 Hz)	I_F	10	A
Forward Current (pw, 10 μs; 100 Hz)	I_F	3	A
Dissipation			
Power Dissipation (T_A = 25°C)*	P_T	170	mW
Power Dissipation (T_C = 25°C)**	P_T	1.3	W
Temperatures			
Junction Temperature	T_J	-65 to +150	°C
Storage Temperature	T_{stg}	-65 to +150	°C
Lead Soldering Time (1/16″ [1.6 mm] from case for 10 sec.)	T_L	+260	°C

*Derate 1.36 mW/°C above 25°C ambient.
**Derate 10.4 mW/°C above 25°C case.

electrical characteristics: (25°C, unless otherwise specified)

	SYMBOL	MIN.	TYP.	MAX.	UNITS
Reverse Leakage Current (V_R = 3 V)	I_R	–	–	10	μA
Forward Voltage					
(I_F = 100 mA)	V_F	–	–	1.7	Volts
(I_F = 1 A)	V_F	–	–	3.5	Volts

optical characteristics: (25°C, unless otherwise specified)

		SYMBOL	MIN.	TYP.	MAX.	UNITS
Total Power Output (I_F = 100 mA)(Note 1)	– F5D1, F5E1	P_o	12	–	–	mW
	– F5D2, F5E2		9	–	–	mW
Peak Emission Wavelength (I_F = 100 mA)		λ_p	–	880	–	nm

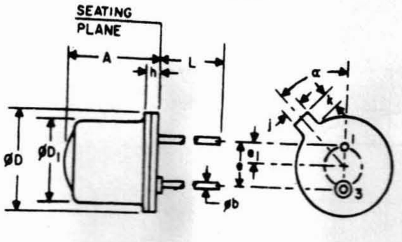
optical characteristics (continued): (25°C, unless otherwise specified)

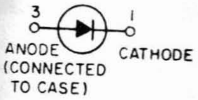
	SYMBOL	MIN.	TYP.	MAX.	UNITS
Spectral Shift with Temperature		–	.3	–	nm/°C
Spectral Bandwidth – 50%	$\Delta\lambda$	–	80	–	nm
Half Intensity Beam Angle					
– F5D1, F5D2	θ_{HI}	–	–	20	Deg.
– F5E1, F5E2		–	–	80	Deg.
Rise Time 0-90% of Output (Note 2)	t_r	–	1.5	–	μs
Fall Time 100-10% of Output (Note 2)	t_f	–	1.5	–	μs

NOTES:

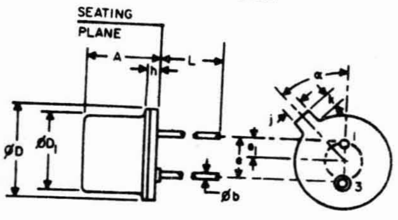
1. Total power output, P_O, is the total power radiated by the device into a solid angle of 2π steradians.
2. At $I_F = 100\text{mA}$, $t_r \leqslant 10\text{ns}$ input current pulse.

F5D1 – F5D2





F5E1 – F5E2



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	–	.255	–	6.47	
φb	.016	.021	.406	.534	
φD	.209	.230	5.30	5.85	
φD₁	.180	.187	4.58	4.75	
e	.100 NOM		2.54 NOM		2
e₁	.050 NOM		1.27 NOM		2
h	–	.030	–	.76	
j	.031	.044	.78	1.12	
k	.036	.046	.91	1.17	1
L	1.00	–	25.4	–	
α	45°	45°	45°	45°	3

NOTES:

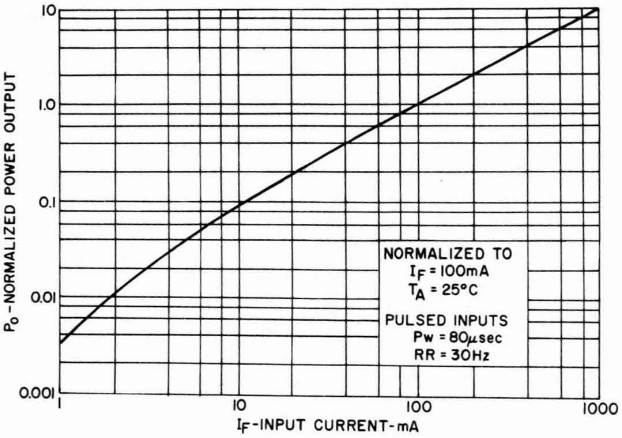
1. *Measured from maximum diameter of device.*
2. Leads having maximum diameter .021″ (.533mm) measured in gauging plane .054″ + .001″ – .000 (137 + 025 – 000mm) below the reference plane of the device shall be within .007″ (.778mm) their true position relative to a maximum width tab.
3. From centerline tab.

SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	–	.155	–	3.93	
φb	.016	.021	.406	.534	
φD	.209	.230	5.30	5.85	
φD₁	.180	.187	4.58	4.75	
e	.100 NOM		2.54 NOM		2
e₁	.050 NOM		1.27 NOM		2
h	–	.030	–	.76	
j	.031	.044	.78	1.12	
k	.036	.046	.91	1.17	1
L	1.00	–	25.4	–	
α	45°	45°	45°	45°	3

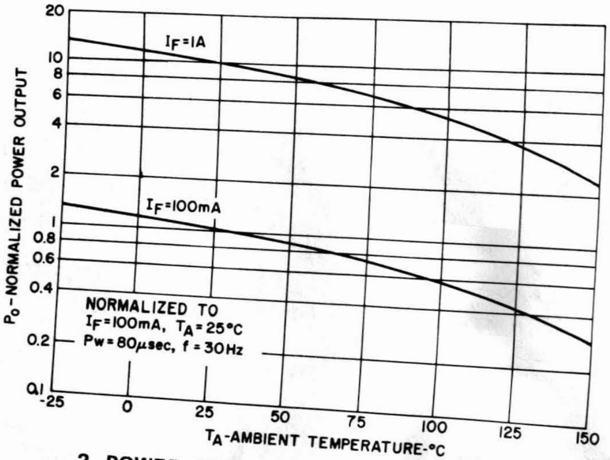
NOTES:

1. Measured from maximum diameter of device.
2. Leads having maximum diameter .021″ (.533mm) measured in gauging plane .054″ + .001″ – .000 (137 + 025 – 000mm) below the reference plane of the device shall be within .007″ (.778mm) their true position relative to a maximum width tab.
3. From centerline tab.

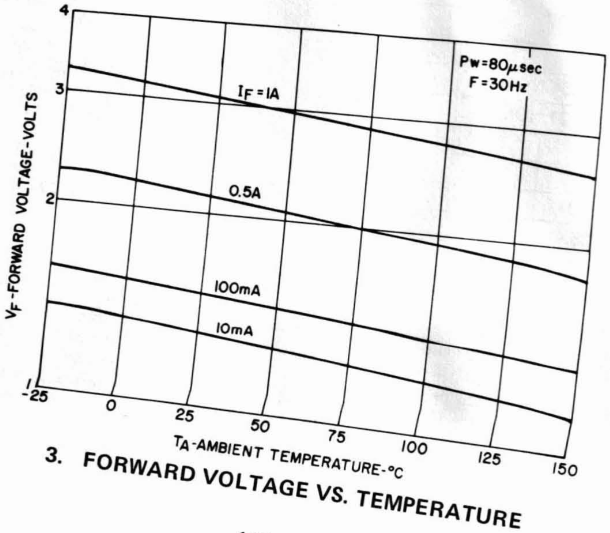
TYPICAL CHARACTERISTICS



1. POWER OUTPUT VS. INPUT CURRENT

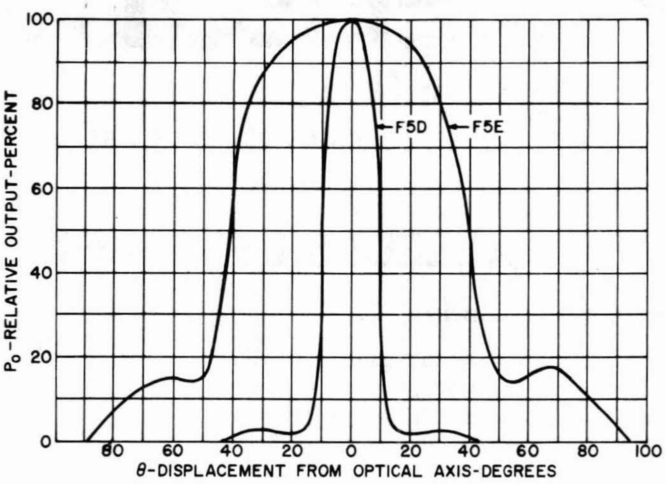


2. POWER OUTPUT VS. TEMPERATURE

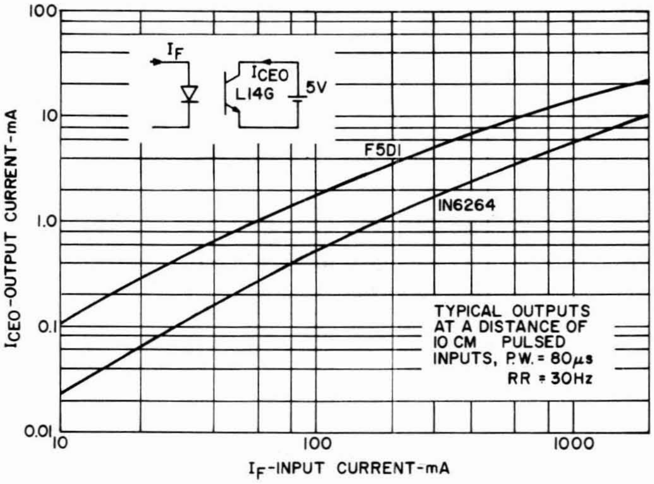


3. FORWARD VOLTAGE VS. TEMPERATURE

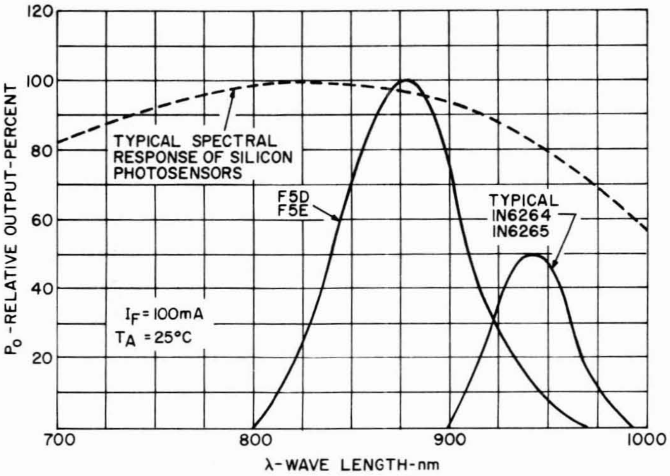
TYPICAL CHARACTERISTICS



4. TYPICAL RADIATION PATTERN



5. OUTPUT VS. INPUT WITH L14G DETECTOR



6. OUTPUT VS. WAVELENGTH

SOLID STATE OPTOELECTRONICS

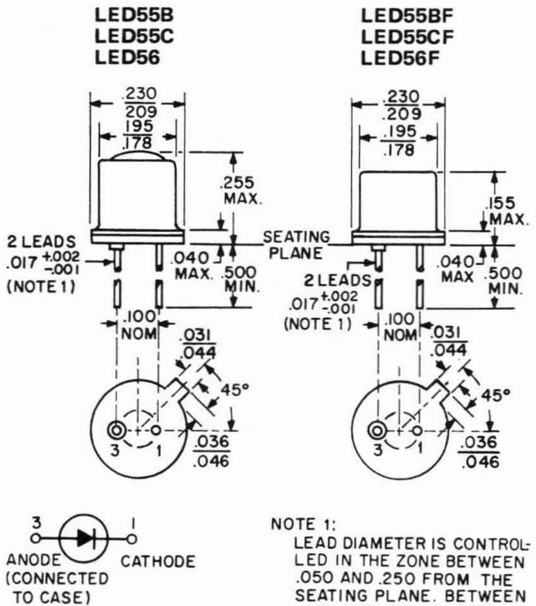
Direct replacement for SSL55B, SSL55C, SSL56, SSL55BF, SSL55CF, SSL56F

Infrared Emitter

LED55B, LED55C, LED56, LED55BF, LED55CF, LED56F

Gallium Arsenide Infrared-Emitting Diode

The General Electric LED55B-LED55C-LED56 Series are gallium arsenide, light emitting diodes which emit non-coherent, infrared energy with a peak wave length of 940 nanometers. They are ideally suited for use with silicon detectors. The "F" versions of these devices have flat lens caps.



NOTE 1:
LEAD DIAMETER IS CONTROLLED IN THE ZONE BETWEEN .050 AND .250 FROM THE SEATING PLANE. BETWEEN .250 AND END OF LEAD A MAX. OF .021 IS HELD.

absolute maximum ratings: (25°C unless otherwise specified)

Voltage:			
Reverse Voltage	V_R	3	volts
Currents:			
Forward Current Continuous	I_F	100	mA
Forward Current (pw 1 μsec 200 Hz)	I_F	10	A
Dissipations:			
Power Dissipation (T_A = 25°C)*	P_T	170	mW
Power Dissipation (T_C = 25°C)**	P_T	1.3	W
Temperatures:			
Junction Temperature	T_J	-65°C to +150°C	
Storage Temperature	T_{STG}	-65°C to +150°C	
Lead Soldering Time		10 seconds at 260°C	

*Derate 1.36 mW/°C above 25°C ambient.
**Derate 10.4 mW/°C above 25°C case.

electrical characteristics: (25°C unless otherwise specified)

		MIN.	TYP.	MAX.	UNITS
Reverse Leakage Current (V_R = 3V)	I_R			10	μA
Forward Voltage (I_F = 100mA)	V_F		1.4	1.7	V

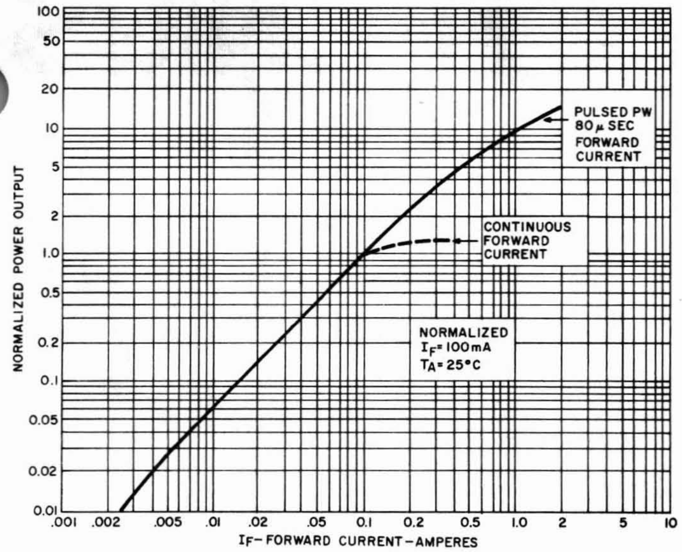
optical characteristics: (25°C unless otherwise specified)

		MIN.	TYP.	MAX.	UNITS
Total Power Output (note 1) (I_F = 100mA)					
LED55B-LED55BF	P_O	3.5			mW
LED55C-LED55CF		5.4			mW
LED56 -LED56F		1.5			mW
Peak Emission Wavelength (I_F = 100mA)			940		nm
Spectral Shift with Temperature			.28		nm/°C
Spectral Bandwidth 50%			60		nm
Rise Time 0-90% of Output			1.0		μsec
Fall Time 100-10% of Output			1.0		μsec

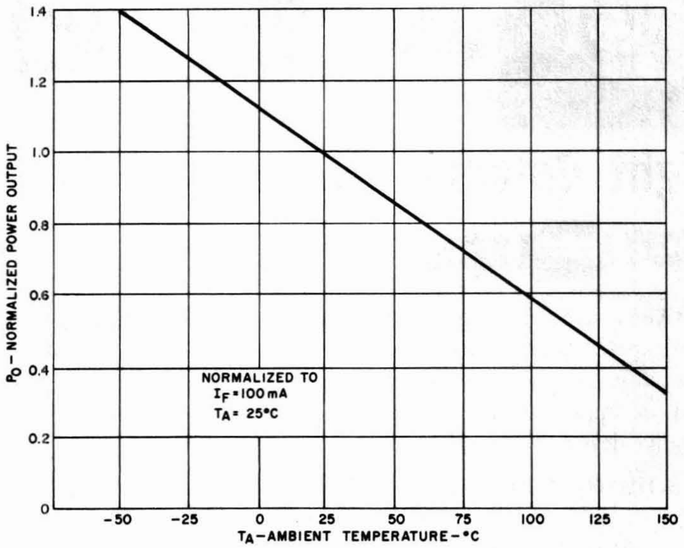
Note 1: Total power output, P_O, is the total power radiated by the device into a solid angle of 2 π steradians.

TYPICAL CHARACTERISTICS

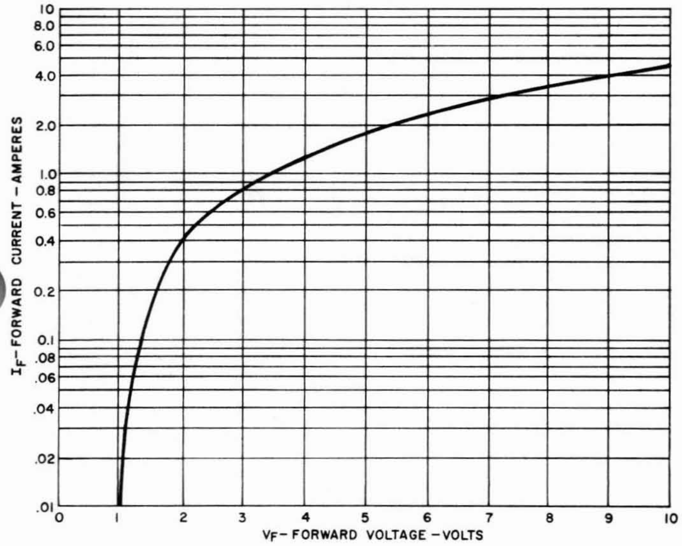
LED55B, LED55C, LED56, LED55BF, LED55CF, LED56F



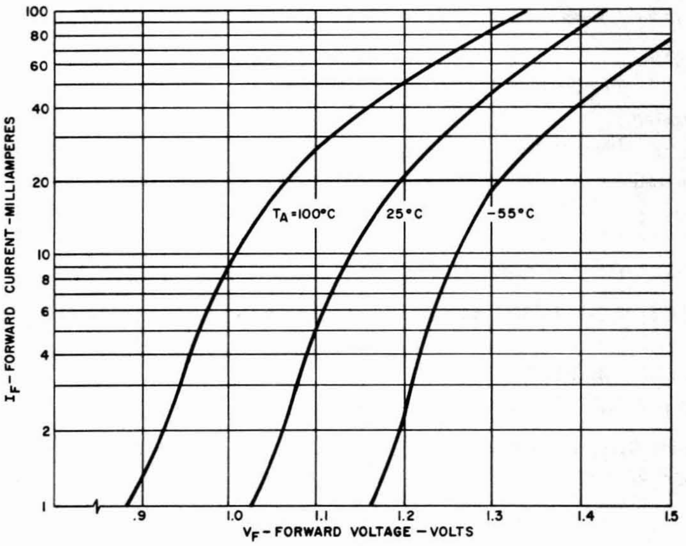
1. POWER OUTPUT VS. INPUT CURRENT



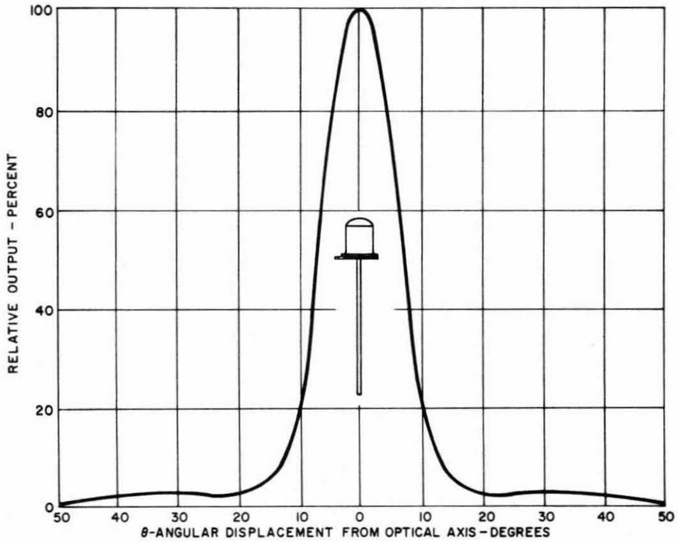
2. POWER OUTPUT VS. TEMPERATURE



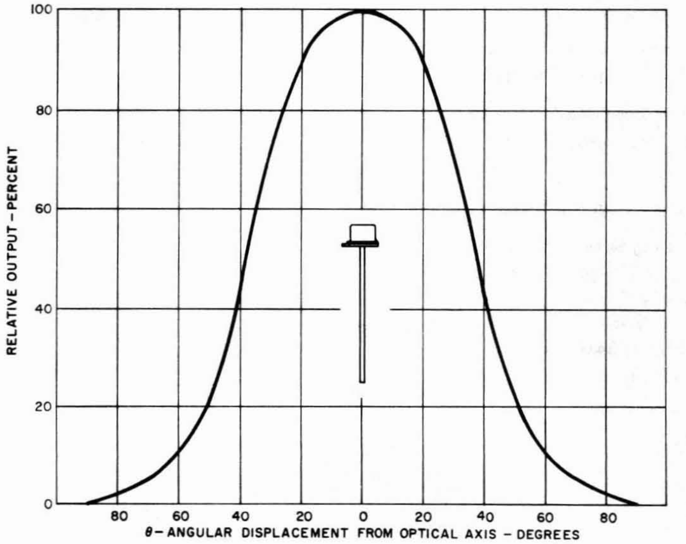
3. LED 55B, 55C, 56, 55BF, 55CF, 56F FORWARD VOLTAGE VS. FORWARD CURRENT



4. FORWARD VOLTAGE VS. FORWARD CURRENT



5. LED 55B, 55C, 56 TYPICAL RADIATION PATTERN



6. LED 55BF, 55CF, 56F TYPICAL RADIATION PATTERN

SOLID STATE
OPTOELECTRONICS

Light Detector Planar Silicon Photo-Darlington Amplifier

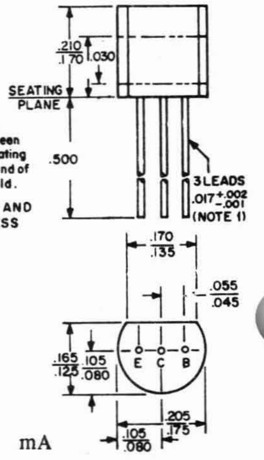
NPN 2N5777-80

This General Electric Light Sensor Series is an NPN planar silicon photo-darlington amplifier. For many applications, only the collector and emitter leads are used. A base lead is provided to control sensitivity and the gain of the device. They are packaged in clear epoxy encapsulant and can be used in industrial and commercial applications requiring a low-cost, general purpose, photosensitive device.

absolute maximum ratings: (25°C) (unless otherwise specified)

		2N5777, 79 (L14D1,3)	2N5778, 80 (L14D2,4)	
Voltages—Dark Characteristics				
Collector to Emitter	V_{CEO}	25	40	Volts
Collector to Base	V_{CBO}	25	40	Volts
Emitter to Base	V_{EBO}	8	12	Volts
Current				
Light Current	I_L	250	250	mA
Dissipation				
Power Dissipation*	P_T	200	200	mW
Temperature				
Junction Temperature	T_J	←——100°C——→		
Storage Temperature	T_{stg}	←-65°C to +100°C——→		

*Derate 2.67mW/°C above 25°C ambient



DIMENSIONS WITHIN JEDEC OUTLINE TO-92.

NOTE 1: Lead diameter is controlled in the zone between .070 and .250 from the seating plane. Between .250 and end of lead a max. of .021 is held.

ALL DIMEN. IN INCHES AND ARE REFERENCE UNLESS TOLERANCED.

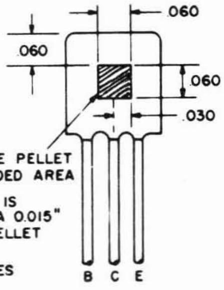
electrical characteristics: (25°C) (unless otherwise specified)

Static Characteristics		2N5777, 78 Min.	2N5777, 78 Max.	2N5779, 80 Min.	2N5779, 80 Max.	
Light Current (V_{CE} = 5V, H = 2mW/cm² **)	I_L	0.5	–	2.0	–	mA
Forward Current Transfer Ratio (V_{CE} = 5V, I_C = 2.0mA)	h_{FE}	1.0k	–	2.0k	–	

		2N5777, 79 Min.	2N5777, 79 Max.	2N5778, 80 Min.	2N5778, 80 Max.	
Dark Current (V_{CE} = 12V, I_B = 0)	I_D	–	100	–	100	nA
Collector-Emitter Breakdown Voltage (I_C = 10mA, H = 0)	$V_{(BR)CEO}$	25	–	40	–	Volts
Collector-Base Breakdown Voltage (I_C = 100µA, H = 0)	$V_{(BR)CBO}$	25	–	40	–	Volts
Emitter-Base Breakdown Voltage (I_E = 100µA, H = 0)	$V_{(BR)EBO}$	8	–	12	–	Volts

Dynamic Characteristics		2N5777-80 Min.	2N5777-80 Typ.	2N5777-80 Max.	
Switching Speeds (V_{CE} = 10V, I_L = 10mA, R_L = 100 ohms, GaAs LED source)					
Delay Time	t_d	–	30	100	µsec.
Rise Time	t_r	–	75	250	µsec.
Storage Time	t_s	–	0.5	5	µsec.
Fall Time	t_f	–	45	150	µsec.
Collector-Base Capacitance (V_{CB} = 10V, f = 1MHz)	C_{cb}	–	7.6	10	pF
Emitter-Base Capacitance (V_{EB} = 0.5V, f = 1MHz)	C_{eb}	–	10.5	–	pF
Collector-Emitter Capacitance (V_{CEO} = 10V, f - 1MHz)	C_{ceo}	–	3.4	–	pF

**H = Radiation Flux Density. Radiation source is an unfiltered tungsten filament bulb at 2870°K color temperature.



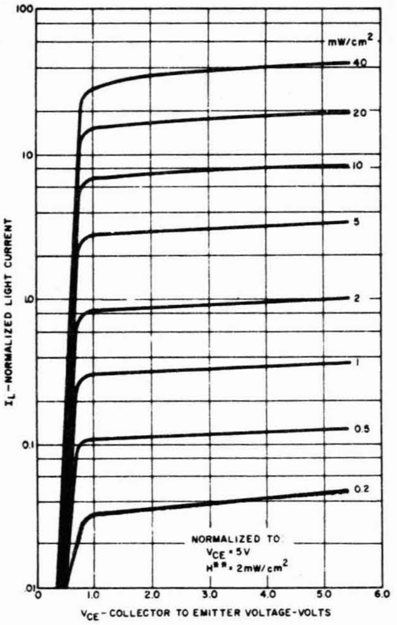
THE 0.026" SQUARE PELLET IS WITHIN THE SHADED AREA

THE ACTIVE AREA IS CENTERED WITHIN A 0.015" SQUARE ON THE PELLET SURFACE

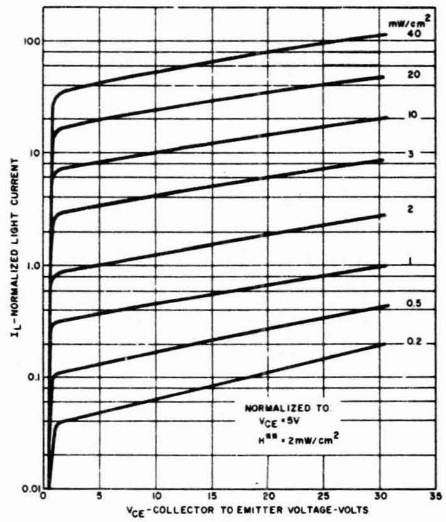
DIMENSIONS IN INCHES

PELLET LOCATION

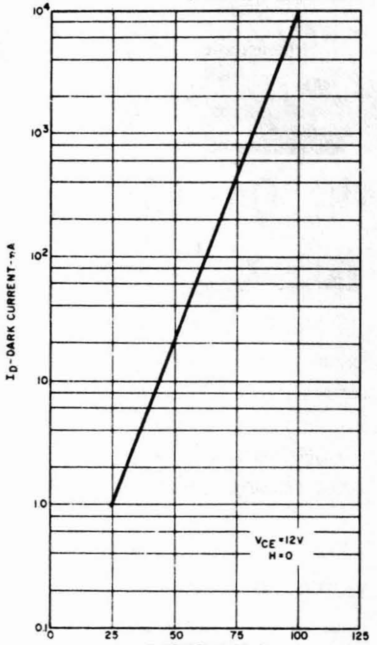
TYPICAL ELECTRICAL CHARACTERISTICS



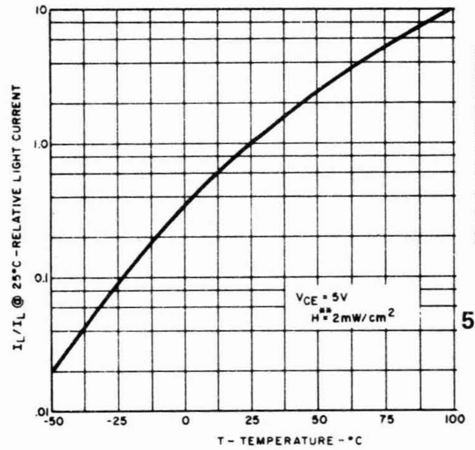
1. NORMALIZED LIGHT CURRENT VS. COLLECTOR TO EMITTER VOLTAGE



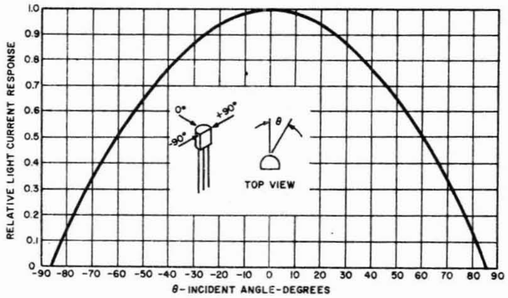
2. NORMALIZED LIGHT CURRENT VS. COLLECTOR TO EMITTER VOLTAGE



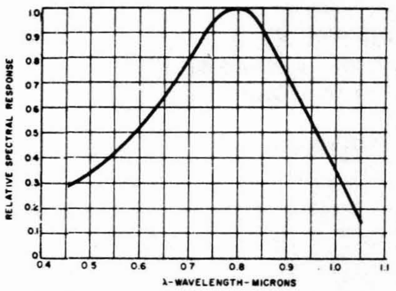
3. DARK CURRENT VS. TEMPERATURE



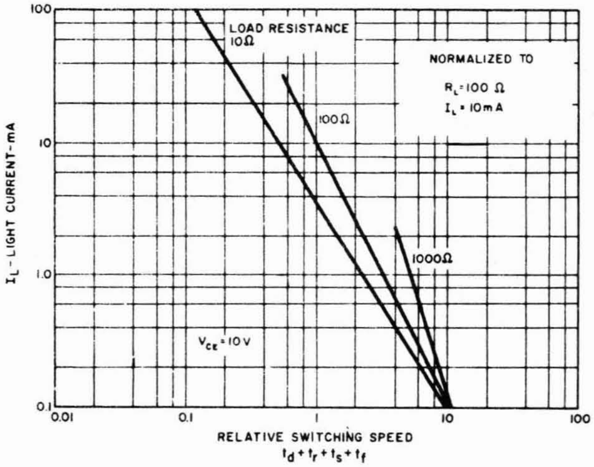
4. RELATIVE LIGHT CURRENT VS. AMBIENT TEMPERATURE



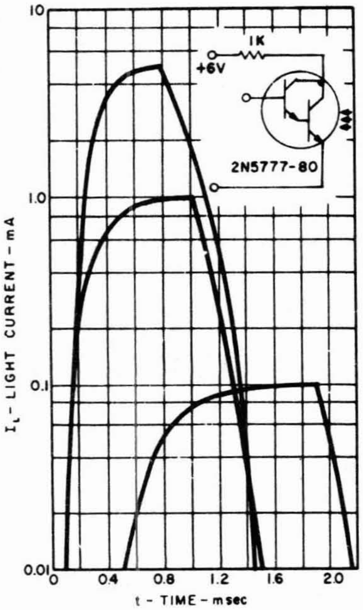
5. RELATIVE RESPONSE VS. INCIDENT ANGLE



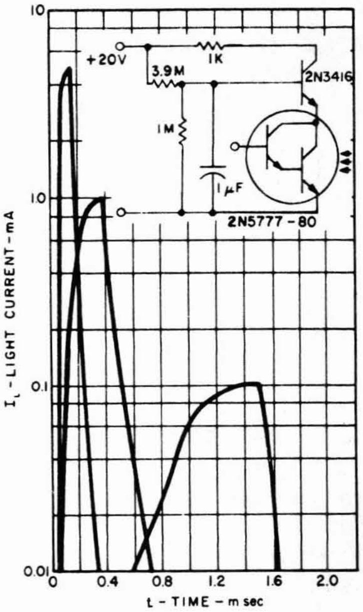
6. SPECTRAL RESPONSE CURVE



7. LIGHT CURRENT VS. RELATIVE SWITCHING SPEED



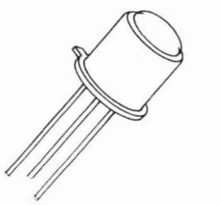
8. TRANSIENT RESPONSE WITH RESISTIVE BIASING



9. TRANSIENT RESPONSE WITH CASCODE BIASING

Light Detector Planar Silicon Photo-Darlington Amplifier

N P N L14F1, L14F2

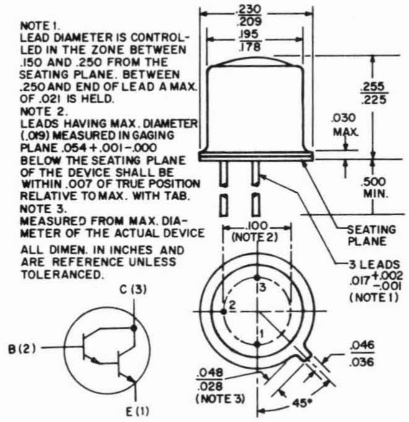


The General Electric L14F1 and L14F2 are supersensitive NPN Planar Silicon Photodarlington Amplifiers. For many applications, only the collector and emitter leads are used; however, a base lead is provided to control sensitivity and the gain of the device. The L14F1 – L14F2 are a TO-18 Style hermetically sealed packages with lens cap and are designed to be used in optoelectronic sensing applications requiring very high sensitivity.

absolute maximum ratings: (25°C) (unless otherwise specified)

VOLTAGES – DARK CHARACTERISTICS			
Collector to Emitter Voltage	V_{CEO}	25	volts
Collector to Base Voltage	V_{CBO}	25	volts
Emitter to Base Voltage	V_{EBO}	12	volts
CURRENTS			
Light Current	I_L	200	mA
DISSIPATIONS			
Power Dissipation (T_A = 25°C)*	P_T	300	mW
Power Dissipation (T_C = 25°C)**	P_T	600	mW
TEMPERATURES			
Junction Temperature	T_J	150	°C
Storage Temperature	T_{STG}	-65 to 150	°C

*Derate 2.4 mW/°C above 25°C ambient.
**Derate 4.8 mW/°C above 25°C case.



NOTE 1.
LEAD DIAMETER IS CONTROLLED IN THE ZONE BETWEEN .150 AND .250 FROM THE SEATING PLANE. BETWEEN .250 AND END OF LEAD A MAX. OF .021 IS HELD.
NOTE 2.
LEADS HAVING MAX. DIAMETER (.019) MEASURED IN GAGING PLANE .054 + .001 – .000 BELOW THE SEATING PLANE OF THE DEVICE SHALL BE WITHIN .007 OF TRUE POSITION RELATIVE TO MAX. WITH TAB.
NOTE 3.
MEASURED FROM MAX. DIAMETER OF THE ACTUAL DEVICE

ALL DIMEN. IN INCHES AND ARE REFERENCE UNLESS TOLERANCED.

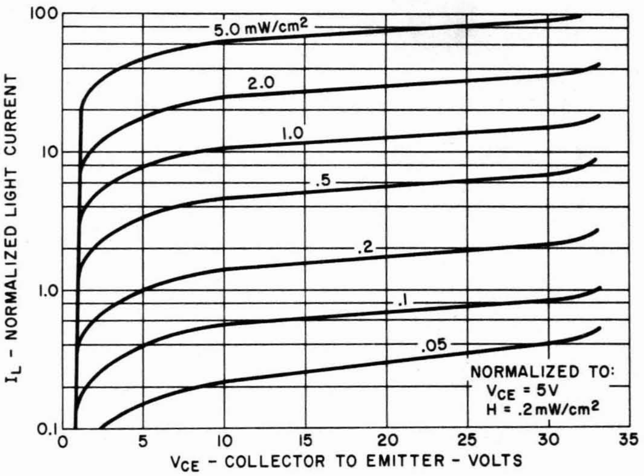
electrical characteristics: (25°C) (unless otherwise specified)

STATIC CHARACTERISTICS		L14F1 MIN.	L14F1 MAX.	L14F2 MIN.	L14F2 MAX.	
LIGHT CURRENT						
(V_{CE} = 5V, H† = 0.2 mW/cm²)	I_L	3	–	1	–	mA
DARK CURRENT						
(V_{CE} = 12V, I_B = 0)	I_D	–	100	–	100	nA
EMITTER-BASE BREAKDOWN VOLTAGE						
(I_E = 100 μA)	$V_{(BR)EBO}$	12	–	12	–	V
COLLECTOR-BASE BREAKDOWN VOLTAGE						
(I_C = 100 μA)	$V_{(BR)CBO}$	25	–	25	–	V
COLLECTOR-EMITTER BREAKDOWN VOLTAGE						
(I_C = 10 mA)	$V_{(BR)CEO}$	25	–	25	–	V
SWITCHING CHARACTERISTICS (see Switching Circuit)						
SWITCHING SPEEDS						
(V_{CC} = 10V, I_L = 10 mA, R_L = 100 Ω)						
DELAY TIME	t_d	–	50	–	50	μsec
RISE TIME	t_r	–	300	–	300	μsec
STORAGE TIME	t_s	–	10	–	10	μsec
FALL TIME	t_f	–	250	–	250	μsec

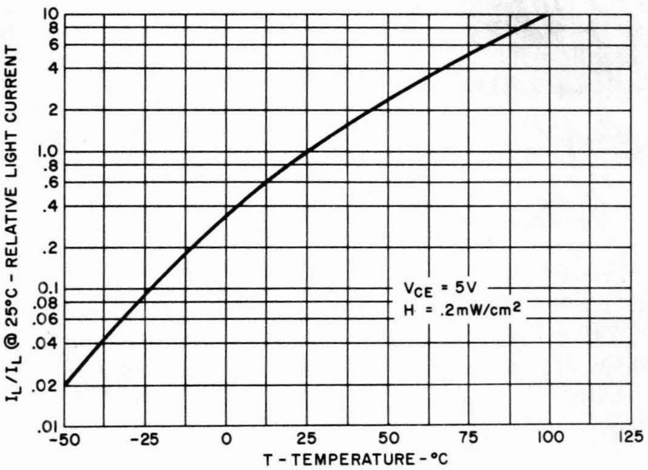
†H = Radiation Flux Density. Radiation source is an unfiltered tungsten filament bulb at 2870°K color temperature.

NOTE: The 2870°K radiation is 25% effective on the photodarlington; i.e., a GaAs source of 0.05 mW/cm² is equivalent to this 0.2 mW/cm² tungsten source.

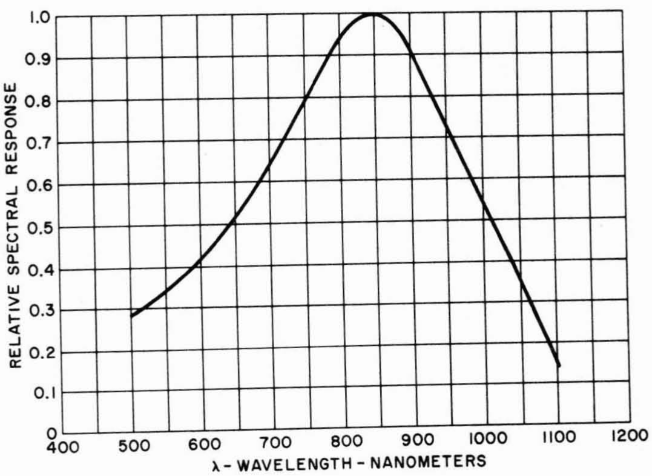
TYPICAL ELECTRICAL CHARACTERISTICS



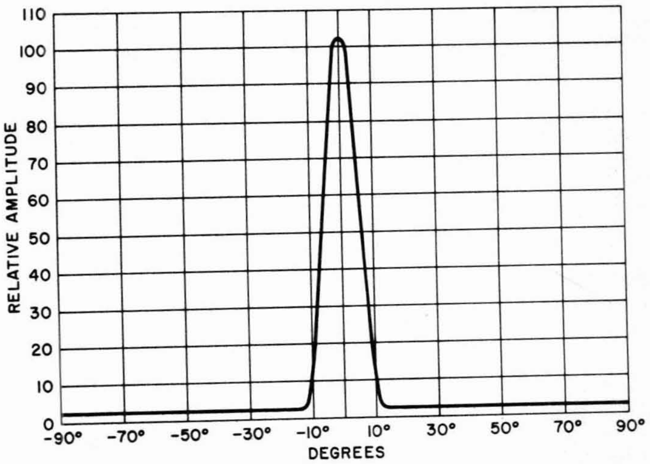
1. LIGHT CURRENT VS. COLLECTOR TO EMITTER VOLTAGE



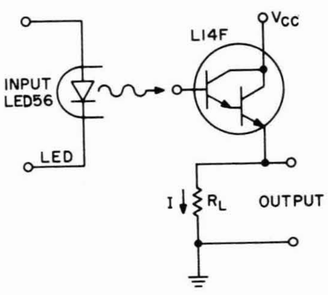
2. RELATIVE LIGHT CURRENT VS. AMBIENT TEMPERATURE



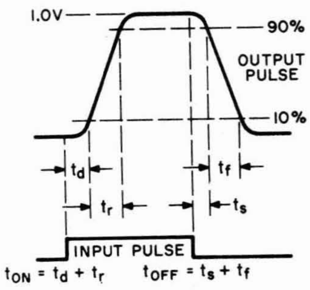
3. SPECTRAL RESPONSE CURVE



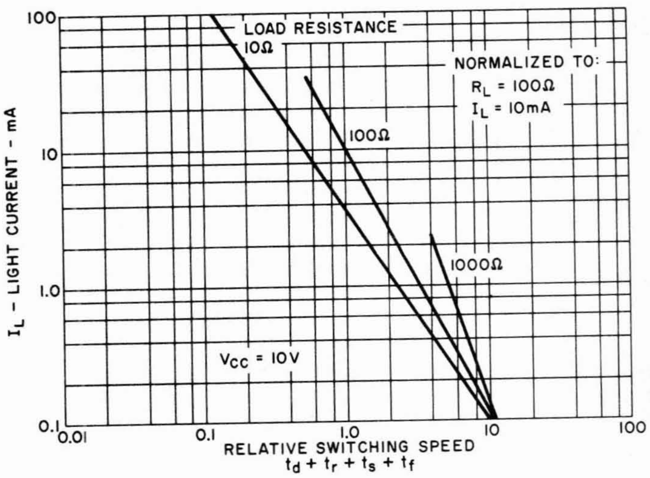
4. ANGULAR RESPONSE



5. TEST CIRCUIT



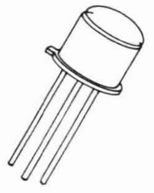
6. WAVE FORMS



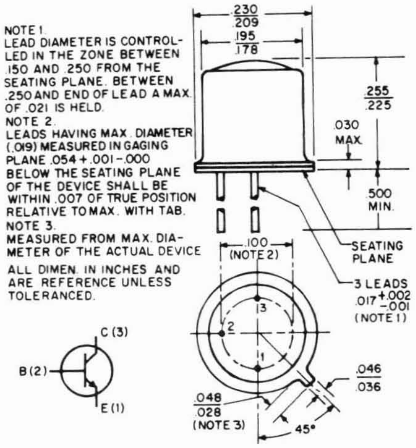
7. LIGHT CURRENT VS. RELATIVE SWITCHING SPEED

Light Detector Planar Silicon Photo Transistor

NPN L14G1,L14G2,L14G3



The General Electric L14G1 thru L14G3 are highly sensitive NPN Planar Silicon Phototransistors. They are housed in a TO-18 style hermetically sealed package with lens cap. The L14G series is ideal for use in optoelectronic sensing applications where both high sensitivity and fast switching speeds are important parameters. Generally only the collector and emitter leads are used; a base lead is provided, however, to control sensitivity and gain of the device.



NOTE 1.
LEAD DIAMETER IS CONTROLLED IN THE ZONE BETWEEN .150 AND .250 FROM THE SEATING PLANE. BETWEEN .250 AND END OF LEAD A MAX. OF .021 IS HELD.
NOTE 2.
LEADS HAVING MAX. DIAMETER (.019) MEASURED IN GAGING PLANE .054 + .001 − .000 BELOW THE SEATING PLANE OF THE DEVICE SHALL BE WITHIN .007 OF TRUE POSITION RELATIVE TO MAX. WITH TAB.
NOTE 3.
MEASURED FROM MAX. DIAMETER OF THE ACTUAL DEVICE

ALL DIMEN. IN INCHES AND ARE REFERENCE UNLESS TOLERANCED.

absolute maximum ratings: (25°C unless otherwise specified)

Voltages – Dark Characteristics			
Collector to Emitter Voltage	V_{CEO}	45	volts
Collector to Base Voltage	V_{CBO}	45	volts
Emitter to Base Voltage	V_{EBO}	5	volts
Currents			
Light Current	I_L	50	mA
Dissipations			
Power Dissipation ($T_A = 25°C$)*	P_T	300	mW
Power Dissipation ($T_C = 25°C$)**	P_T	600	mW
Temperatures			
Junction Temperature	T_J	+150	°C
Storage Temperature	T_{STG}	−65 to +150	°C

*Derate 2.4 mW/°C above 25°C ambient
**Derate 4.8 mW/°C above 25°C case

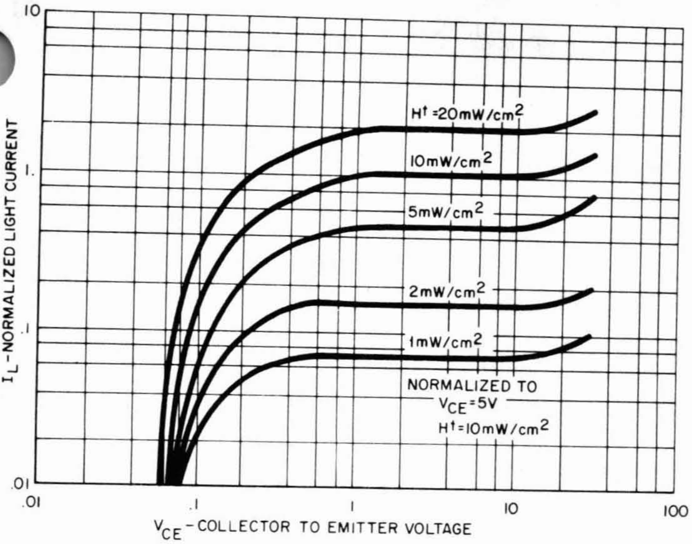
electrical characteristics: (25°C unless otherwise specified)

STATIC CHARACTERISTICS		L14G1 MIN.	L14G1 MAX.	L14G2 MIN.	L14G2 MAX.	L14G3 MIN.	L14G3 MAX.	
Light Current (V_{CE} = 5V, H† = 10mW/cm^2)	I_L	6		3		12		mA
Dark Current (V_{CE} = 10V, H ≈ 0)	I_D		100		100		100	nA
Emitter-Base Breakdown Voltage ($I_E = 100\mu A$, $I_C = 0$, H ≈ 0)	$V_{(BR)EBO}$	5		5		5		V
Collector-Base Breakdown Voltage ($I_C = 100\mu A$, $I_E = 0$, H ≈ 0)	$V_{(BR)CBO}$	45		45		45		V
Collector-Emitter Breakdown Voltage (I_C = 10mA, H ≈ 0	$V_{(BR)CEO}$	45		45		45		V
Saturation Voltage (I_C = 10mA, I_B = 1mA)	$V_{CE(SAT)}$		0.4		0.4		0.4	V
Turn-On Time (V_{CE} = 10V, I_C = 2mA,	t_{on}		8		8		8	μsec
Turn-Off Time $R_L = 100\Omega$)	t_{off}		7		7		7	μsec

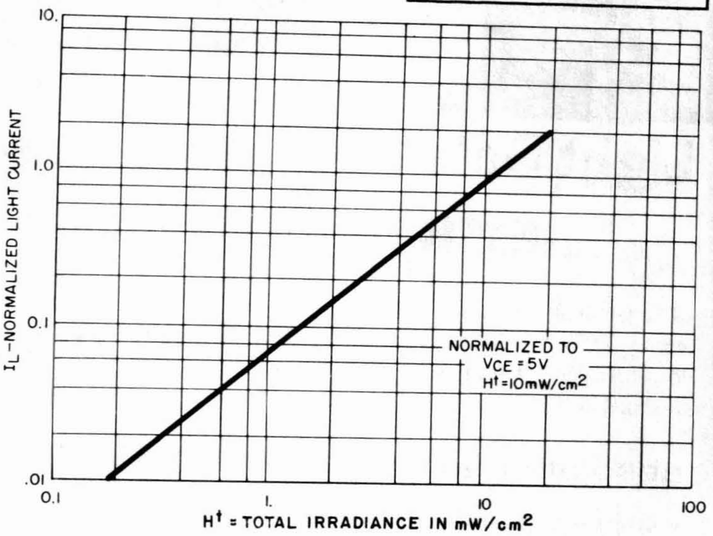
†H = Radiation Flux Density. Radiation source is on unfiltered tungsten filament bulb at 2870°K color temperature.

NOTE: A GaAs source of 3.0 mW/cm^2 is approximately equivalent to a tungsten source, at 2870°K, of 10 mW/cm^2

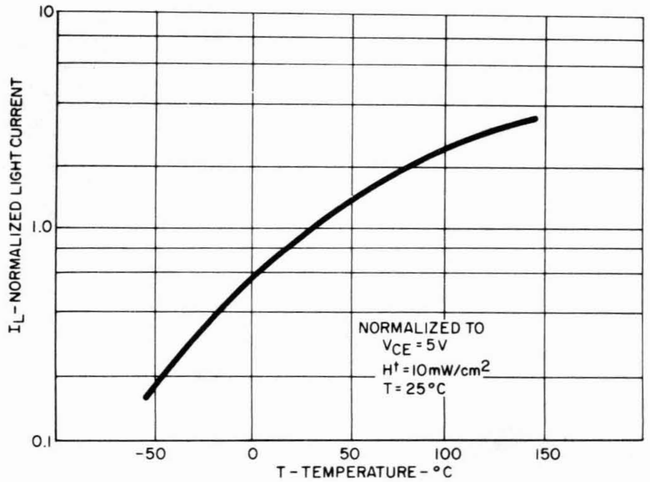
TYPICAL ELECTRICAL CHARACTERISTICS



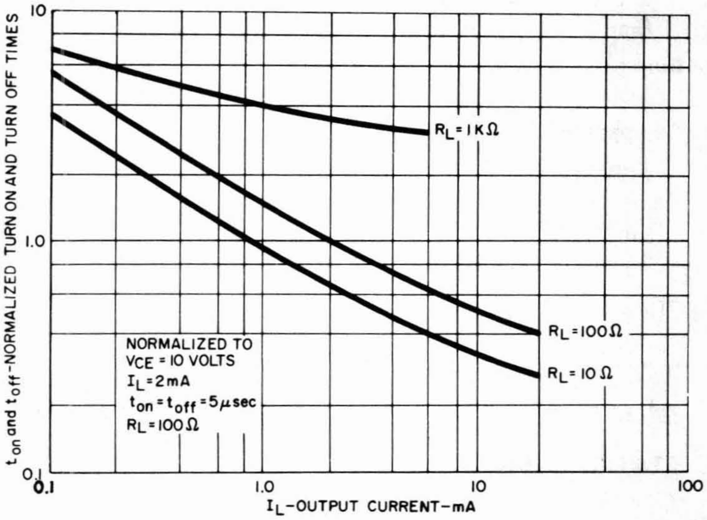
Light Current vs Collector to Emitter Voltage



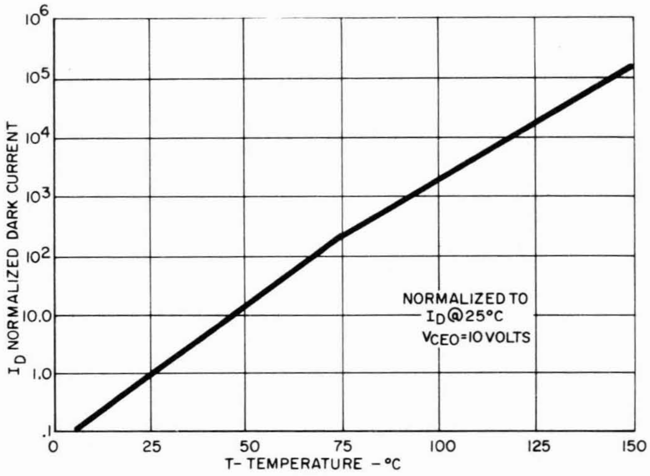
Normalized Light Current vs Radiation



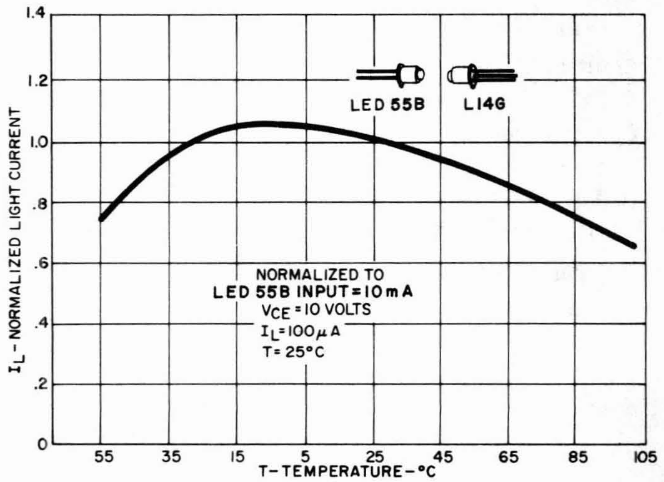
Normalized Light Current vs Temperature



Switching Times vs Output Current



Dark Current vs Temperature



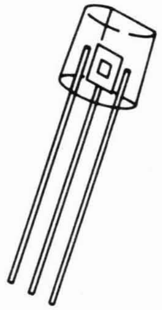
Normalized Light Current vs Temperature

Both Emitter (LED55B) and Detector (L14G) at Same Temperature

SOLID STATE
OPTOELECTRONICS

Light Detector Planar Silicon Photo Transistor

NPN L14 H1-4

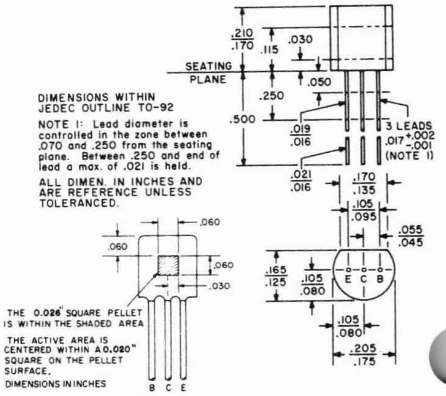


The General Electric Light Sensor Series are NPN Planar Silicon Phototransistors in a clear epoxy TO-92 package. They can be used in industrial and commercial applications requiring a low cost, general purpose, photosensitive device. Generally only the collector and emitter leads are used; a base lead is provided, however, to control sensitivity and gain of the device.

absolute maximum ratings: (25°C) (unless otherwise specified)

		L14H2, H4	L14H1, H3	
Voltages – Dark Characteristics				
Collector to Emitter Voltage	V_{CEO}	30V	60V	volts
Collector to Base Voltage	V_{CBO}	30V	60V	volts
Emitter to Base Voltage	V_{EBO}	5		volts
Currents				
Light Current	I_L	100		mA
Dissipations				
Power Dissipation ($T_A = 25°C$)*	P_T	200		mW
Temperatures				
Junction Temperature	T_J	100		°C
Storage Temperature	T_{STG}	–65 to 100		°C

*Derate 2.67 mW/°C above 25°C ambient



DIMENSIONS WITHIN JEDEC OUTLINE TO-92

NOTE 1: Lead diameter is controlled in the zone between .070 and .250 from the seating plane. Between .250 and end of lead a max. of .021 is held.

ALL DIMEN. IN INCHES AND ARE REFERENCE UNLESS TOLERANCED.

THE 0.026" SQUARE PELLET IS WITHIN THE SHADED AREA

THE ACTIVE AREA IS CENTERED WITHIN A 0.020" SQUARE ON THE PELLET SURFACE.

DIMENSIONS IN INCHES

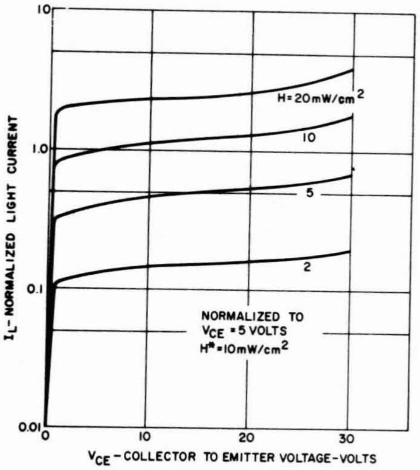
PELLET LOCATION

electrical characteristics: (25°C) (unless otherwise specified)

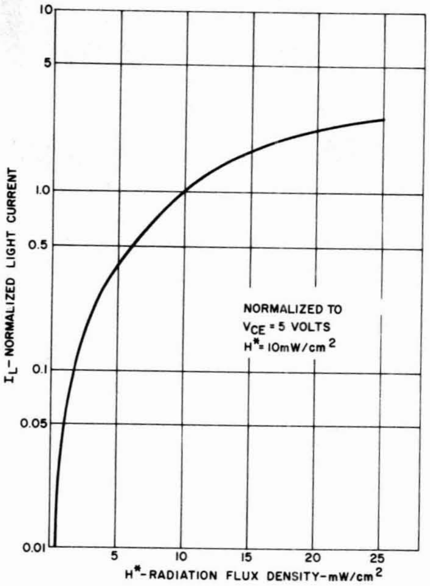
STATIC CHARACTERSITICS		L14H1 Min.	L14H1 Max.	L14H2 Min.	L14H2 Max.	L14H3 Min.	L14H3 Max.	L14H4 Min.	L14H4 Max.	Units
Light Current ($V_{CE} = 5V$, H† = 10mW/cm²)	I_L	.5		2.0		2.0		.5		mA
Dark Current ($V_{CE} = 10V$, $H \approx 0$, $I_B = 0$)	I_D		100		100		100		100	nA
Emitter-Base Breakdown Voltage ($I_E = 100\mu A$, $I_C = 0$, $H \approx 0$)	$V_{(BR)EBO}$	5		5		5		5		volts
Collector-Base Breakdown Voltage ($I_C = 100\mu A$, $I_E = 0$, $H \approx 0$)	$V_{(BR)CBO}$	60		30		60		30		volts
Collector-Emitter Breakdown Voltage ($I_C = 10mA$, $H \approx 0$) (Pulse Width≤300μsec, Duty cycle≤1%)	$V_{(BR)CEO}$	60		30		60		30		volts
Saturation Voltage ($I_C = 10mA$, $I_B = 1mA$)	$V_{CE(SAT)}$		0.4		0.4		0.4		0.4	volts
Switching Speeds ($V_{CE} = 30V$, $I_L = 800\ \mu A$, $R_L = 1k\Omega$)**										
On Time ($t_d + t_r$)	t_{on}		8		8		8		8	μsec
Off Time ($t_s + t_r$)	t_{off}		7		7		7		7	μsec

†H = Radiation Flux Density. Radiation source is an unfiltered tungsten filament bulb at 2870°K color temperature.
**Radiant source is a gallium arsenide light emitting diode.

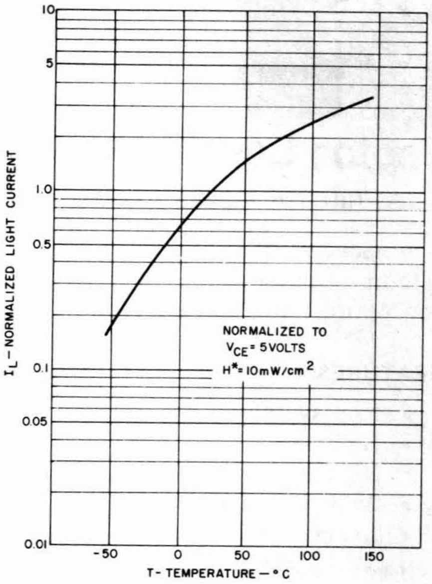
TYPICAL ELECTRICAL CHARACTERISTICS



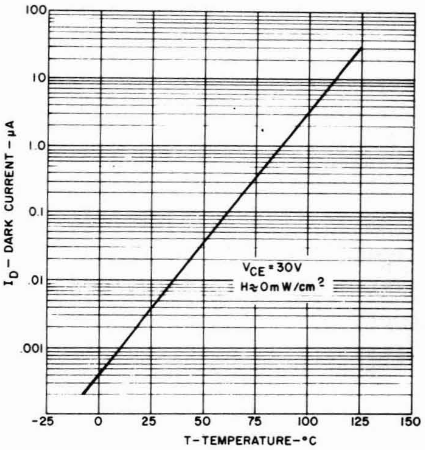
1. NORMALIZED LIGHT CURRENT VS. COLLECTOR TO EMITTER VOLTAGE



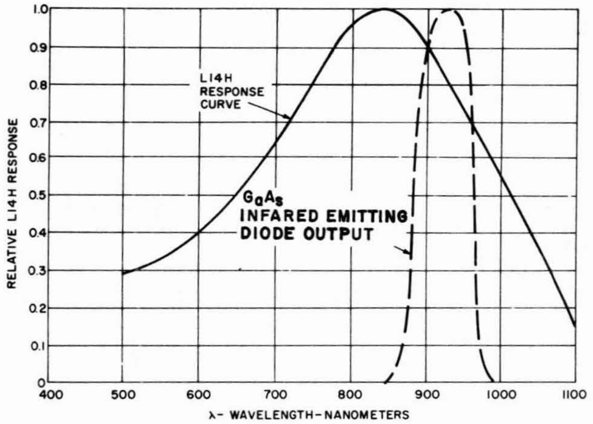
2. NORMALIZED LIGHT CURRENT VS. RADIATION



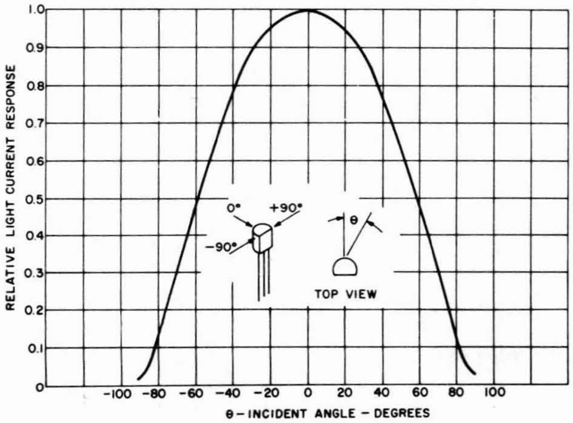
3. NORMALIZED LIGHT CURRENT VS. TEMPERATURE



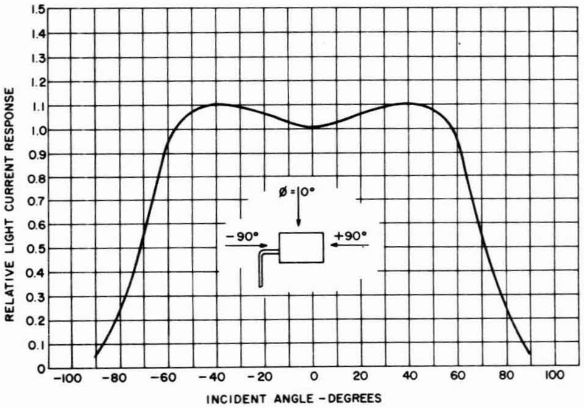
4. DARK CURRENT VS. TEMPERATURE



5. SPECTRAL CURVES



6. RELATIVE RESPONSE VS. INCIDENT ANGLE



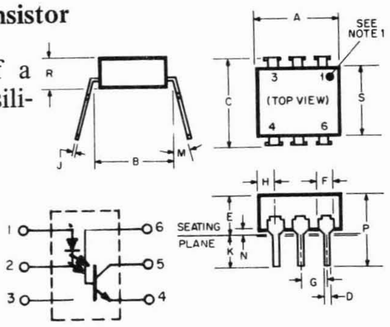
7. RELATIVE RESPONSE VS. INCIDENT ANGLE

SOLID STATE
OPTOELECTRONICS

Photon Coupled Isolator 4N25-4N25A-4N26-4N27-4N28

Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric 4N25-4N26-4N27-4N28 consist of a gallium arsenide infrared emitting diode coupled with a silicon photo transistor in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

FEATURES:

- Fast switching speeds
- High DC current transfer ratio
- High isolation resistance
- 2500 volts isolation voltage
- I/O compatible with integrated circuits

†Parameters are JEDEC registered values.

absolute maximum ratings: (25°C) (unless otherwise specified)

†Storage Temperature -55 to 150°C. Operating Temperature -55 to 100°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE		
† Power Dissipation	*150	milliwatts
†Forward Current (Continuous)	80	milliamps
†Forward Current (Peak) (Pulse width 300 μsec 2% duty cycle)	3	ampere
†Reverse Voltage	3	volts

*Derate 2.0mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
†Power Dissipation	**150	milliwatts
†V_{CEO}	30	volts
†V_{CBO}	70	volts
†V_{ECO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0mW/°C above 25°C ambient.

†Total device dissipation @ 24-25°C. P_D 250mW.

†Derate 3.3 mW/°C above 25°C ambient.

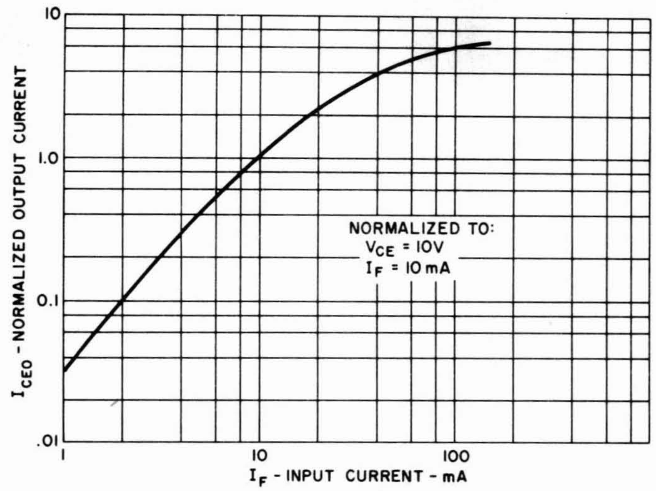
individual electrical characteristics (25°C)

INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
†Forward Voltage (I_F = 10 mA)	1.1	1.5	volts
†Reverse Current (V_R = 3V)	–	100	microamps
Capacitance V = O, f = 1 MHz	50	–	picofarads

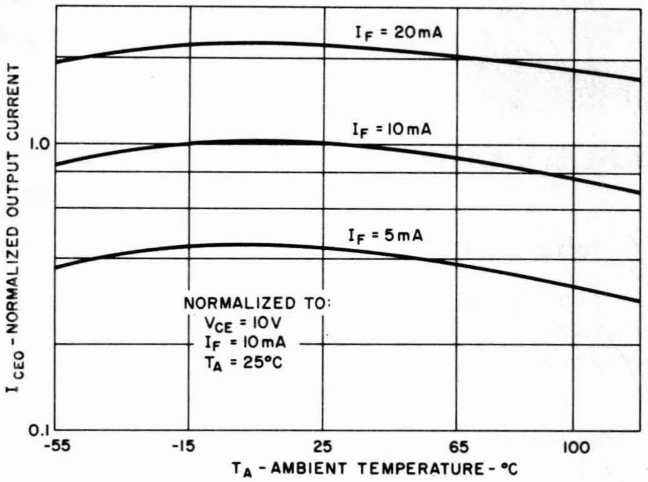
PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
†Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 1mA, I_F = O)	30	–	–	volts
†Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = O)	70	–	–	volts
†Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = O)	7	–	–	volts
†Collector Dark Current I_{CEO} 4N25-27 (V_{CE} = 10V, I_F = O)	–	5	50	nanoamps
4N28	–	–	100	nanoamps
†Collector Dark Current – I_{CBO} (V_{CB} = 10V, I_F = O)	–	2	20	nanoamps

coupled electrical characteristics (25°C)

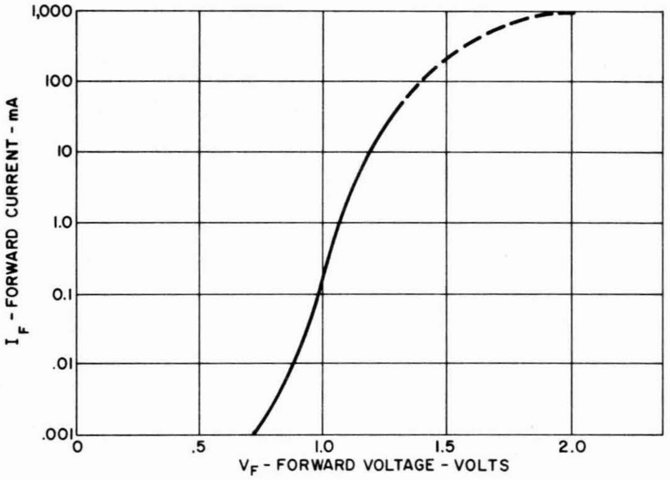
		MIN.	TYP.	MAX.	UNITS
†DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)	4N25, 4N25A, 4N26	20	–	–	%
	4N27, 4N28	10	–	–	%
†Saturation Voltage – Collector – Emitter (I_F = 50mA, I_C = 2 mA)		–	0.1	0.5	volts
Resistance – IRED to Photo-Transistor (@ 500 volts)		–	100	–	gigaohms
Capacitance – IRED to Photo-Transistor (@ 0 volts, f = 1 MHz)		–	1	–	picofarad
†Isolation Voltage – voltage @ 60 Hz with the input terminals (diode) shorted together and the output terminals (transistor) shorted together.	4N25	2500	–	–	volts (peak)
	4N26, 4N27	1500	–	–	volts (peak)
	4N28	500	–	–	volts (peak)
	4N25A	1775	–	–	volts (RMS) (1 sec.)
Rise/Fall Time (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)		–	2	–	microseconds
Rise/Fall Time (V_{CB} = 10V, I_{CB} = 50μA, R_L = 100Ω)		–	300	–	nanoseconds



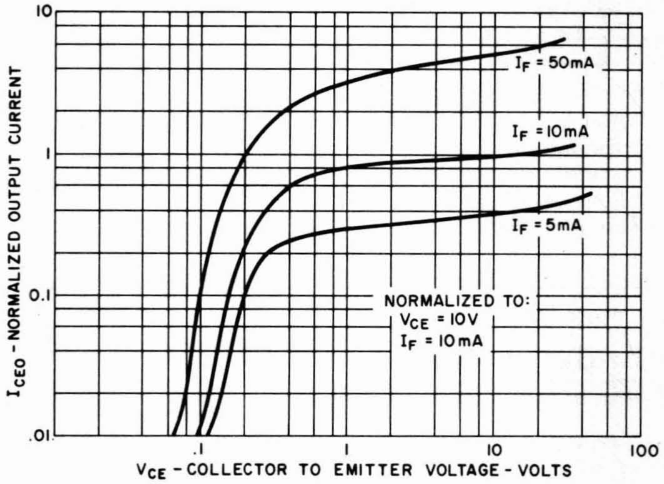
OUTPUT CURRENT VS INPUT CURRENT



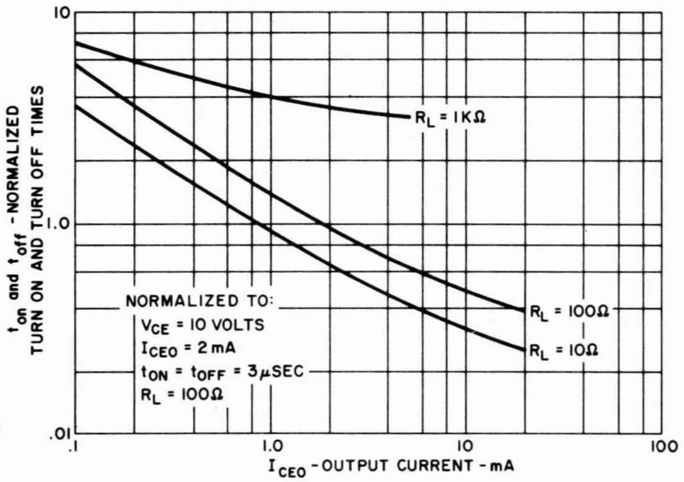
OUTPUT CURRENT VS TEMPERATURE



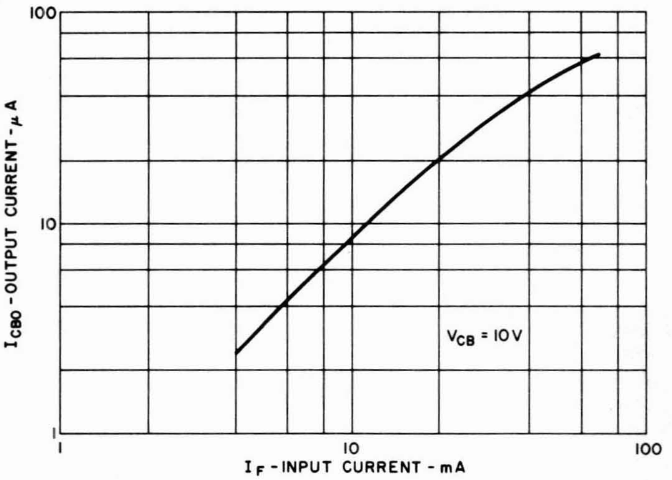
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS



SWITCHING TIMES VS OUTPUT CURRENT



OUTPUT CURRENT (I_{CBO}) VS INPUT CURRENT

SOLID STATE
OPTOELECTRONICS

Photon Coupled Isolator 4N29-4N29A-4N30-4N31 4N32-4N32A-4N33

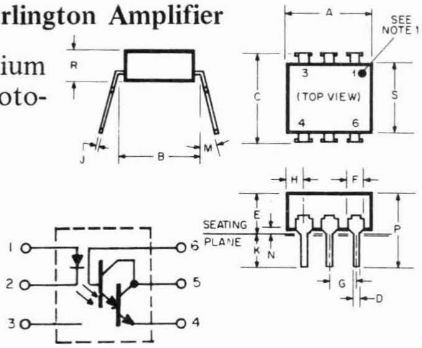
Ga As Infrared Emitting Diode & NPN Silicon Photo-Darlington Amplifier

The General Electric 4N29 thru 4N33 consist of a gallium arsenide infrared emitting diode coupled with a silicon photo-darlington amplifier in a dual in-line package.

FEATURES:

- High DC current transfer ratio
- High isolation resistance
- 2500 volts isolation voltage
- I/O compatible with integrated circuits

†Parameters are JEDEC registered values.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C) (unless otherwise specified)

†Storage Temperature -55 to 150°C. Operating Temperature -55 to 100°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE			PHOTO-DARLINGTON		
†Power Dissipation	*150	milliwatts	†Power Dissipation	**150	milliwatts
†Forward Current (Continuous)	80	milliamps	†V_{CEO}	30	volts
†Forward Current (Peak) (Pulse width 300μsec, 2% duty cycle)	3	ampere	†V_{CBO}	30	volts
†Reverse Voltage	3	volts	†V_{ECO}	5	volts
			Collector Current (Continuous)	100	milliamps
*Derate 2.0mW/°C above 25°C ambient.			**Derate 2.0mW/°C above 25°C ambient.		

†Total device dissipation @ T_A = 25°C. P_D 250 mW. †Derate 3.3 mW/°C above 25°C ambient.

individual electrical characteristics (25°C)

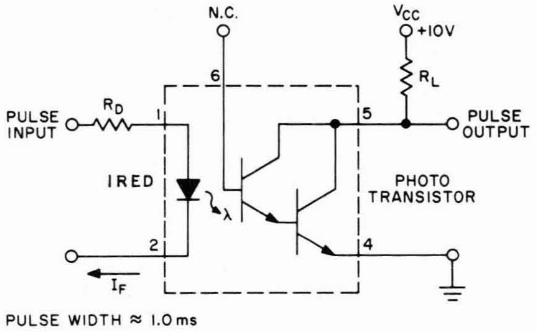
INFRARED EMITTING	TYP.	MAX.	UNITS
†Forward Voltage (I_F = 10mA)	1.2	1.5	volts
†Reverse Current (V_R = 3V)	–	100	microamps
Capacitance V = 0,f = 1 MHz	50	–	picofarads

PHOTO-DARLINGTON	MIN.	TYP.	MAX.	UNITS
†Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	30	–	–	volts
†Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 1mA, I_F = 0)	30	–	–	volts
†Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = 0)	5	–	–	volts
†Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	–	100	nanoamps

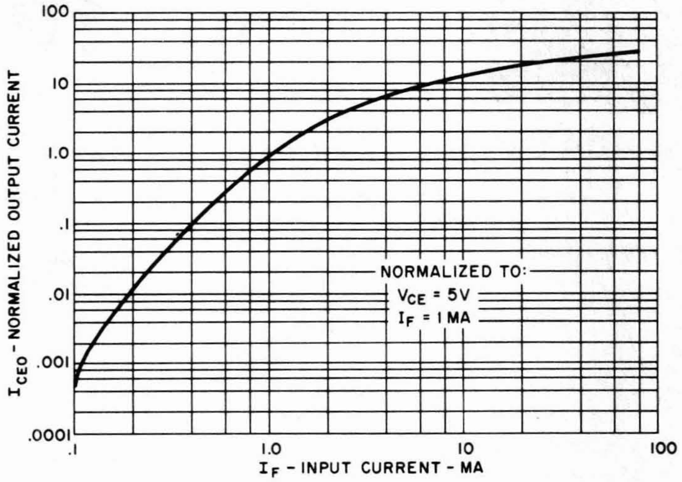
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
†Collector Output Current (I_F = 10mA, V_{CE} = 10V)	4N32, 4N32A, 4N33	50	–	–	mA
	4N29, 4N29A, 4N30	10	–	–	mA
	4N31	5	–	–	mA
†Saturation Voltage – Collector – Emitter	4N29,29A,30,32,32A,33	–	–	1.0	volts
(I_F = 8mA, I_C = 2mA)	4N31	–	–	1.2	volts
Resistance – IRED to Photo-Transistor (@ 500 volts)		–	100	–	gigaohms
Capacitance – IRED to Photo-Transistor (@ 0 volts, f = 1 MHz)		–	1	–	picofarad
†Isolation Voltage 60 Hz with the input terminals (diode)	4N29,29A,32,32A	2500	–	–	volts (peak)
shorted together and the output terminals (transistor)	4N30, 4N31, 4N33	1500	–	–	volts (peak)
shorted together	4N29A, 4N32A	1775	–	–	volts (RMS) (1 sec.)
†Switching Speeds: I_C = 50mA, I_F = 200mA) Figure 1					
Turn-On Time – t_{on}		–	–	5	microseconds
Turn-Off Time – t_{off}	4N29, 4N29A, 4N30, 4N31	–	–	40	microseconds
Turn-Off Time – t_{off}	4N32, 4N32A, 4N33	–	–	100	microseconds

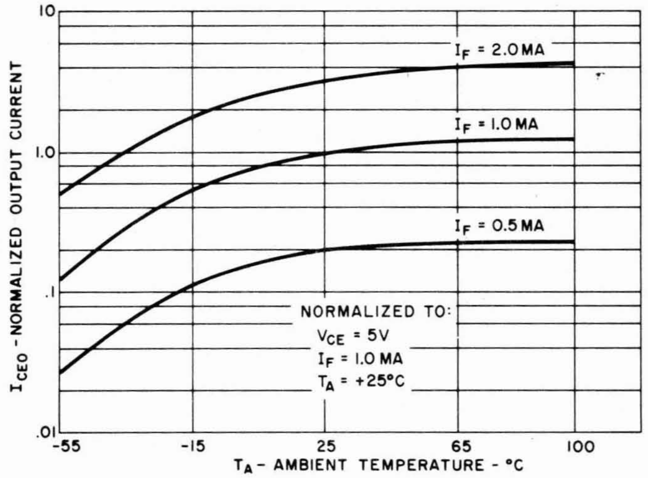
TYPICAL CHARACTERISTICS



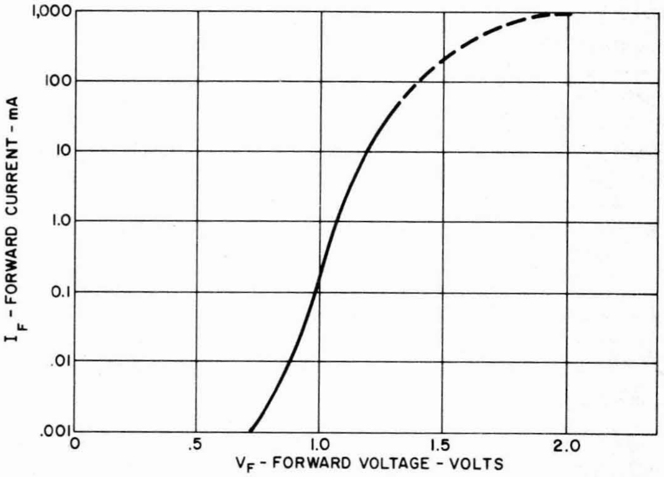
SWITCHING TIME TEST CIRCUIT



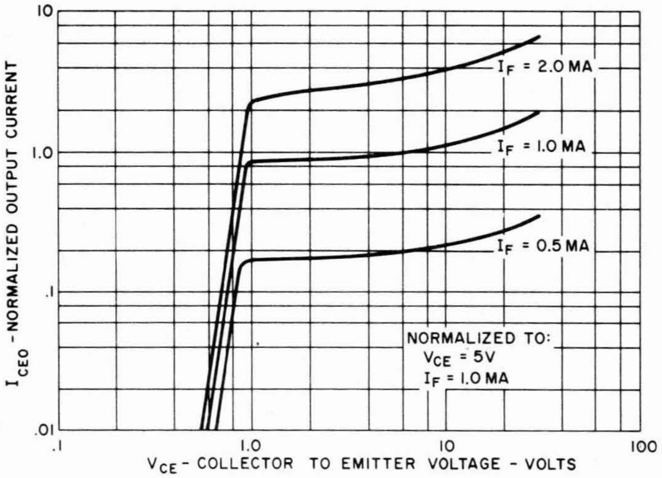
OUTPUT CURRENT VS INPUT CURRENT



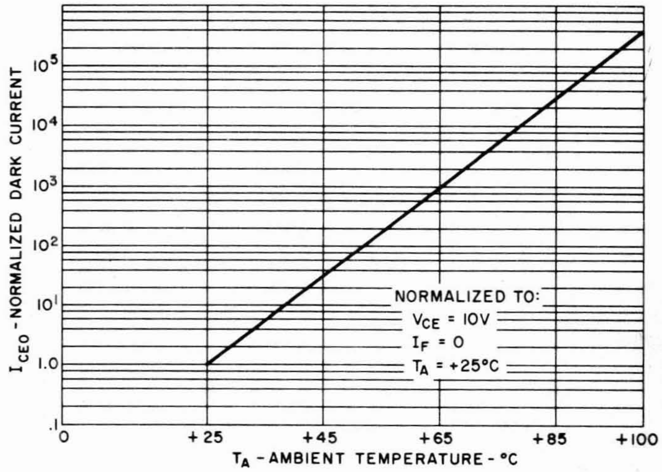
OUTPUT CURRENT VS TEMPERATURE



INPUT CHARACTERISTICS



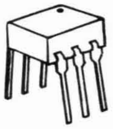
OUTPUT CHARACTERISTICS



NORMALIZED DARK CURRENT VS TEMPERATURE

Photon Coupled Isolator 4N35,4N36,4N37

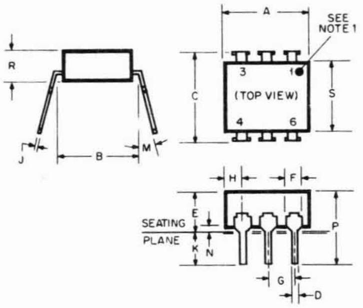
Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor



The General Electric 4N35-4N36-4N37 are gallium arsenide infrared emitting diodes coupled with a silicon photo-transistor in a dual in-line package.

FEATURES:

- Fast switching speeds
- High DC current transfer ratio
- High isolation resistance
- High isolation voltage
- I/O compatible with integrated circuits
- Covered under U.L. component recognition program, reference file E51868



absolute maximum ratings: (25 °C) (unless otherwise specified)

INFRARED EMITTING DIODE

* Power Dissipation	T_A = 25°C	☆100	milliwatts
* Power Dissipation	T_C = 25°C	☆100	milliwatts
(T_C indicates collector lead temperature 1/32″ from case)			
* Forward Current (Continuous)		60	milliamps
* Forward Current (Peak)		3	ampere
(Pulse width 1 usec, 300 pps)			
* Reverse Voltage		6	volts

☆Derate 1.33mW/°C above 25°C

PHOTO-TRANSISTOR

* Power Dissipation	T_A = 25°C	☆☆300	milliwatts
* Power Dissipation	T_C = 25°C	☆☆☆500	milliwatts
(T_C indicates collector lead temperature 1/32″ from case)			
* V_{CEO}		30	volts
* V_{CBO}		70	volts
* V_{ECO}		7	volts
* Collector Current (Continuous)		100	milliamps

☆☆Derate 4.0mW/°C above 25°C
☆☆☆Derate 6.7mW/°C above 25°C

TOTAL DEVICE

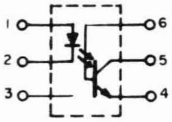
- * Storage Temperature -55 to 150°C
- * Operating Temperature -55 to 100°C.
- * Lead Soldering Time (at 260°C) 10 seconds.
- * Relative Humidity 85%@85°C
- * Input to Output Isolation Voltage

4N35	2500 V(RMS)	3550 V(peak)
4N36	1750 V(RMS)	2500 V(peak)
4N37	1050 V(RMS)	1500 V(peak)

* Indicates JEDEC registered values

SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.



individual electrical characteristics (25 °C) (unless otherwise specified)

INFRARED EMITTING DIODE	SYMBOL	MIN.	MAX.	UNITS
* Forward Voltage (I_F = 10 mA)	V_F	.8	1.5	volts
* Forward Voltage (I_F = 10 mA) T_A = -55°C	V_F	.9	1.7	volts
* Forward Voltage (I_F = 10 mA) T_A = +100°C	V_F	.7	1.4	volts
* Reverse Current (V_R = 6V)	I_R	–	10	microamps
Capacitance (V=O, f=1 MHz)	C_J		100	picofarads

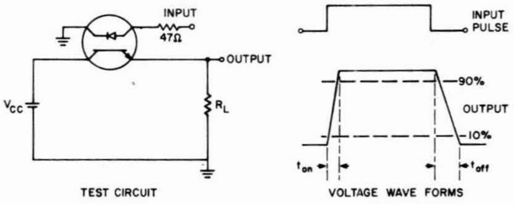
PHOTO-TRANSISTOR	SYMBOL	MIN.	TYP.	MAX.	UNITS
* Breakdown Voltage (I_C = 10 mA, I_F = O)	$V_{(BR)\,CEO}$	30	–	–	volts
* Breakdown Voltage (I_C = 100uA, I_F = O)	$V_{(BR)\,CBO}$	70	–	–	volts
* Breakdown Voltage (I_E = 100uA, I_F = O)	$V_{(BR)\,ECO}$	7	–	–	volts
Collector Dark Current (V_{CE} = 10V, I_F = O)	I_{CEO}	–	5	50	nanoamps
* Collector Dark Current (V_{CE} = 30V, I_F = O) T_A = 100°C	I_{CEO}	–		500	microamps
Capacitance (V_{CE} = 10V, f = 1MHz)	C_{CE}	–	2	–	picofarads

coupled electrical characteristics (25 °C) (unless otherwise specified)

	MIN.	TYP.	MAX.	UNITS
* DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)	100	–	–	%
* DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V) T_A = -55°C	40	–	–	%
* DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V) T_A = +100°C	40	–	–	%
* Saturation Voltage–Collector To Emitter (I_F = 10mA, I_C = 0.5mA)	–	–	0.3	volts
* Input to Output Isolation Current (Pulse Width = 8 msec)				
(See Note 1) Input to Output Voltage = 3550 $V_{(peak)}$ 4N35	–	–	100	microamps
Input to Output Voltage = 2500 $V_{(peak)}$ 4N36	–	–	100	microamps
Input to Output Voltage = 1500 $V_{(peak)}$ 4N37	–	–	100	microamps
* Input to Output Resistance (Input to Output Voltage = 500V - See Note 1)	100	–	–	gigaohms
* Input to Output Capacitance (Input to Output Voltage = 0, f = 1MHz - See Note 1)	–	–	2.5	picofarads
* Turn on Time -- t_{on} (V_{CC} = 10V, I_C = 2MA, R_L = 100Ω) (See Figure 1)	–	5	10	microseconds
* Turn off Time – t_{off} (V_{CC} = 10V, I_C = 2MA, R_L = 100Ω) (See Figure 1)	–	5	10	microseconds

Note 1: Tests of input to output isolation current resistance, and capacitance are performed with the input terminals (diode) shorted together and the output terminals (transistor) shorted together

* Indicates JEDEC registered values.



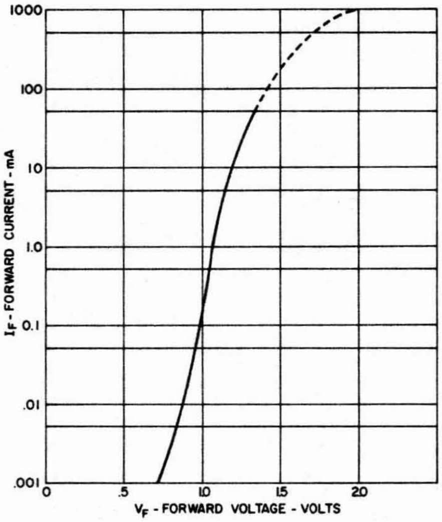
TEST CIRCUIT

VOLTAGE WAVE FORMS

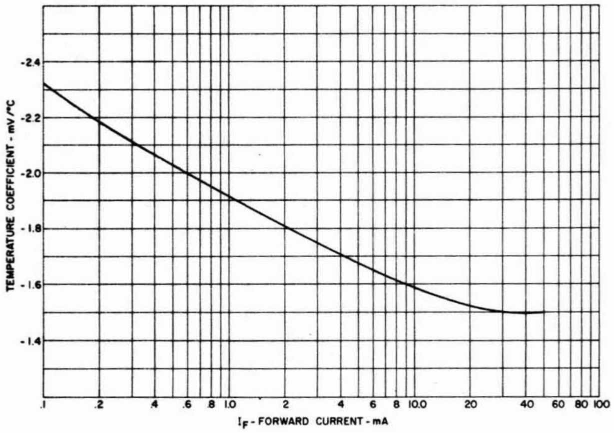
Adjust Amplitude of Input Pulse for Output (I_C) of 2 mA

FIGURE 1

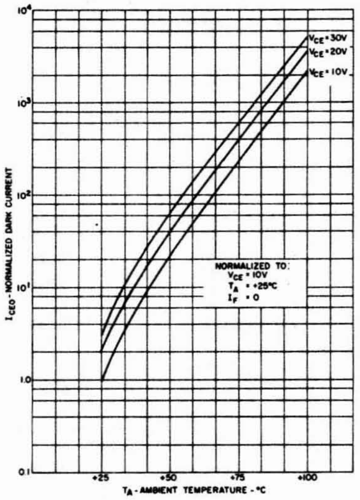
TYPICAL CHARACTERISTICS



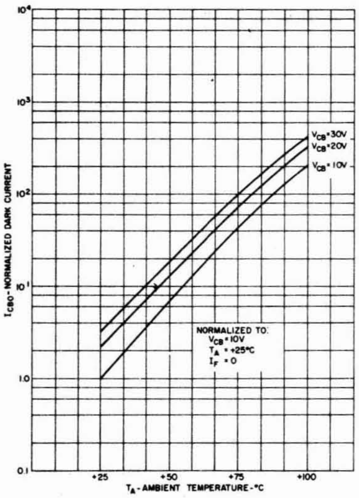
1. INPUT CHARACTERISTICS



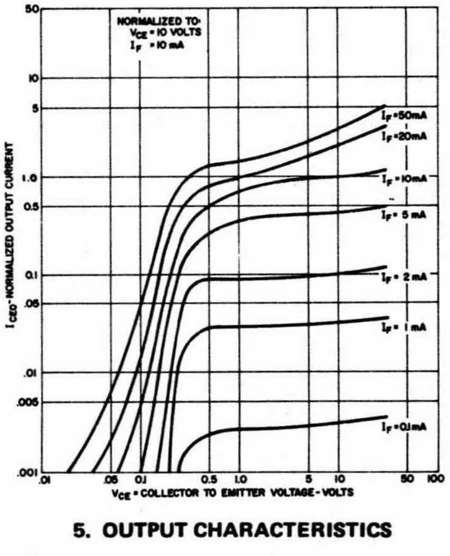
2. FORWARD CURRENT TEMPERATURE COEFFICIENT



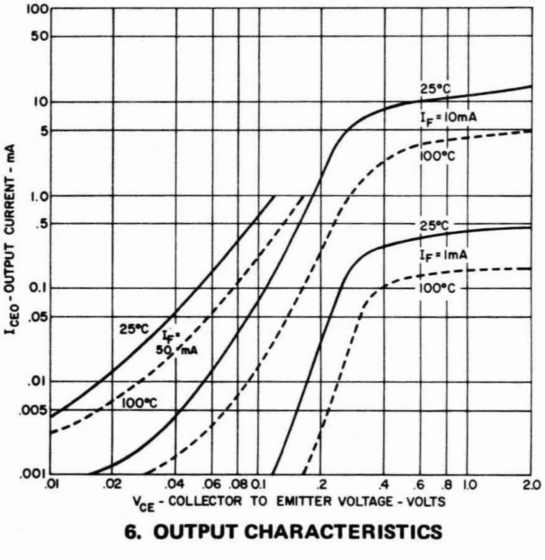
3. DARK I_{CEO} CURRENT VS TEMPERATURE



4. I_{CBO} VS TEMPERATURE

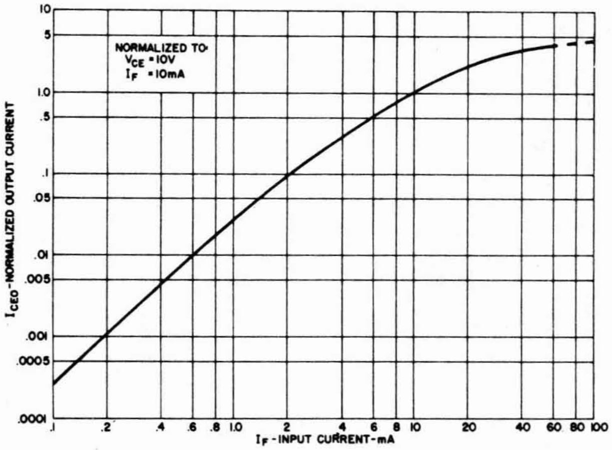


5. OUTPUT CHARACTERISTICS

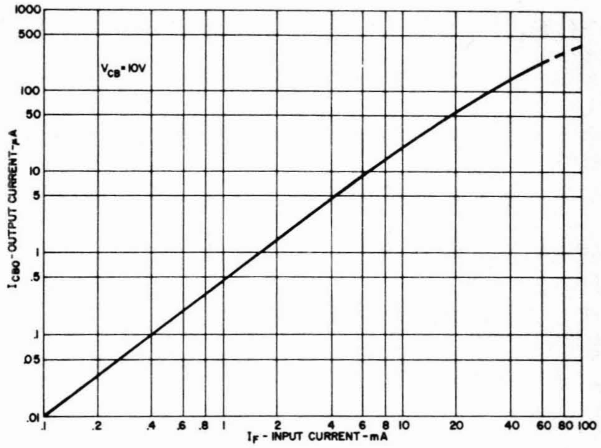


6. OUTPUT CHARACTERISTICS

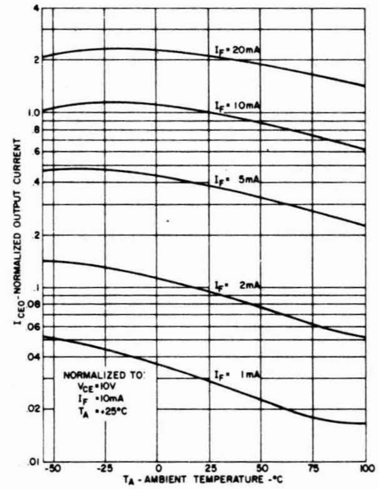
TYPICAL CHARACTERISTICS



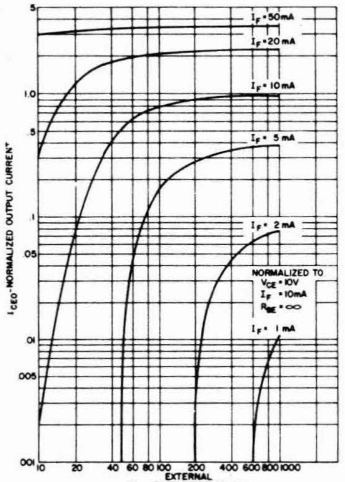
7. OUTPUT CURRENT VS INPUT CURRENT



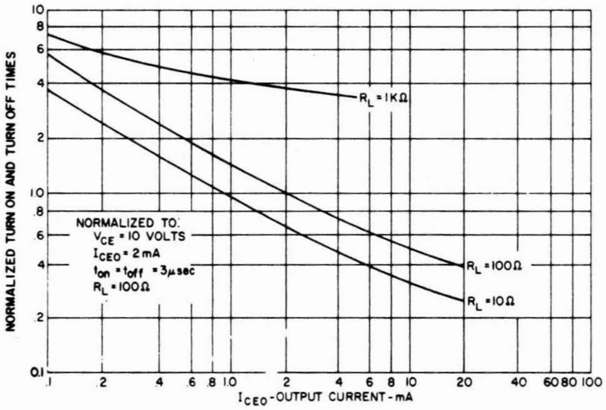
8. OUTPUT CURRENT – COLLECTOR TO BASE VS INPUT CURRENT



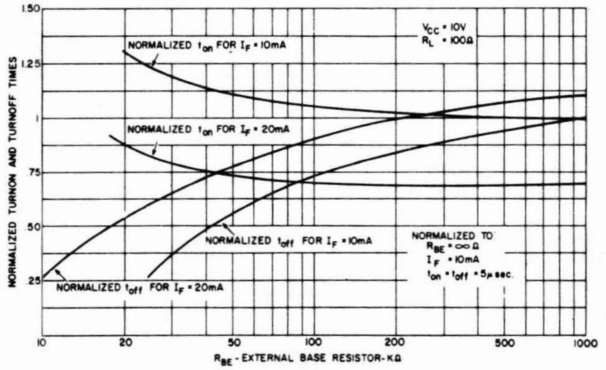
9. OUTPUT CURRENT VS TEMPERATURE



10. OUTPUT CURRENT VS BASE EMITTER RESISTANCE



11. SWITCHING TIMES VS OUTPUT CURRENT



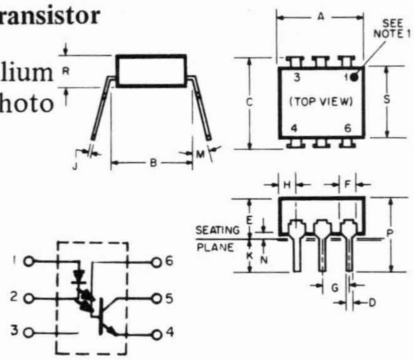
12. SWITCHING TIME VS R_{BE}

SOLID STATE
OPTOELECTRONICS

Photon Coupled Isolator 4N38, 4N38A

Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric 4N38 and 4N38A consist of a gallium arsenide infrared emitting diode coupled with a silicon photo transistor in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

FEATURES:

- Fast switching speeds
- High DC current transfer ratio
- High isolation resistance
- 2500 volts isolation voltage
- I/O compatible with integrated circuits

†Indicates JEDEC registered values

absolute maximum ratings: (25°C) (unless otherwise specified)

†Storage Temperature -55 to 150°C. Operating Temperature -55 to 100°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE		
†Power Dissipation	*150	milliwatts
†Forward Current (Continuous)	80	milliamps
†Forward Current (Peak) (Pulse width 300μsec, 2% duty cycle)	3	ampere
†Reverse Voltage	3	volts

*Derate 2.0 mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
†Power Dissipation	**150	milliwatts
†V_{CEO}	80	volts
†V_{CBO}	80	volts
†V_{ECO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0 mW/°C above 25°C ambient.

†Total device dissipation @ T_A = 25°C. P_D 250 mW.

†Derate 3.3 mW/°C above 25°C ambient.

individual electrical characteristics (25°C)

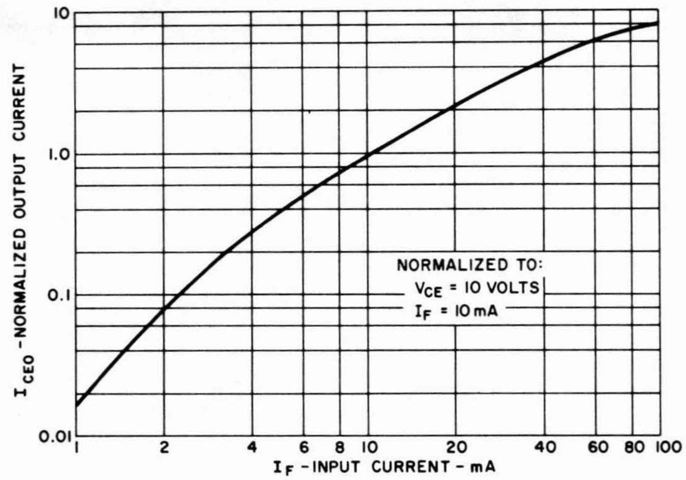
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
†Forward Voltage (I_F = 10mA)	1.2	1.5	volts
†Reverse Current (V_R = 3V)	–	100	microamps
Capacitance V = O,f = 1 MHz	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
†Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 1mA, I_F = O)	80	–	–	volts
†Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 1μA, I_F = O)	80	–	–	volts
†Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = O)	7	–	–	volts
†Collector Dark Current – I_{CEO} (V_{CE} = 60V, I_F = O)	–	–	50	nanoamps
†Collector Dark Current – I_{CBO} (V_{CE} = 60V, I_F = O)	–	–	20	nanoamps

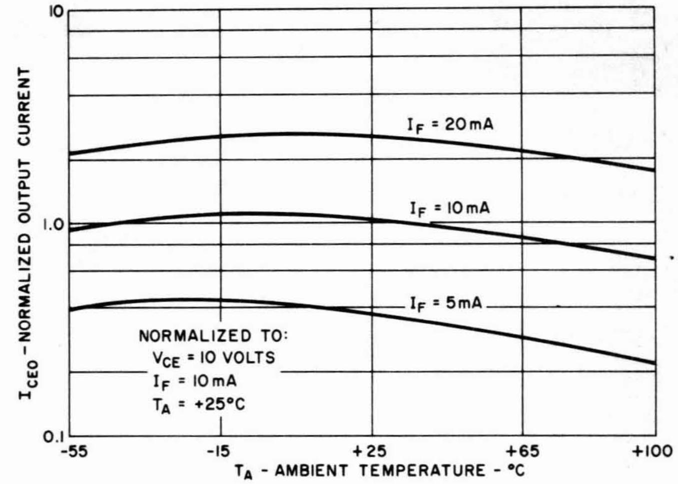
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
†Isolation Voltage 60Hz with the input terminals (diode)	4N38	1500	–	–	volts (peak)
shorted together and the output terminals (transistor)	4N38A	2500	–	–	volts (peak)
shorted together.	4N38A	1775	–	–	volts (RMS) (1 sec.)
†Saturation Voltage – Collector – Emitter (I_F = 20mA, I_C = 4mA)		–	–	1.0	volts
Resistance – IRED to Photo-Transistor (@ 500 volts)		–	100	–	gigaohms
Capacitance – IRED to Photo-Transistor (@ 0 volts, f = 1 MHz)		–	1	–	picofarad
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)		10		–	%
Switching Speeds (V_{CE} = 10V, I_C, = 2mA, R_L = 100Ω)					
Turn-On Time – t_{on}		–	5	–	microseconds
Turn-Off Time – t_{off}		–	5	–	microseconds

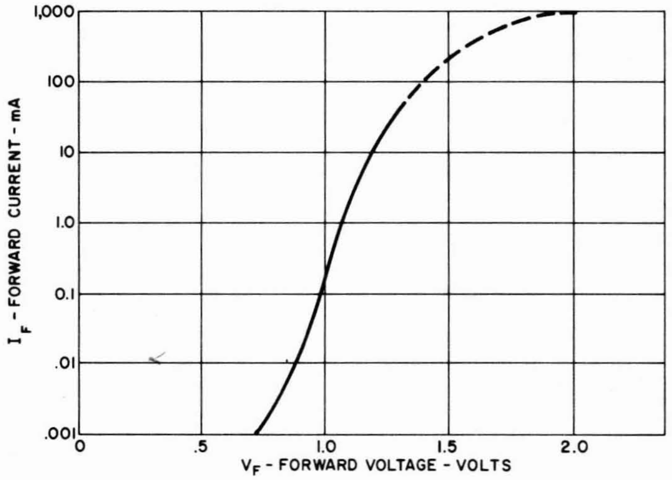
TYPICAL CHARACTERISTICS



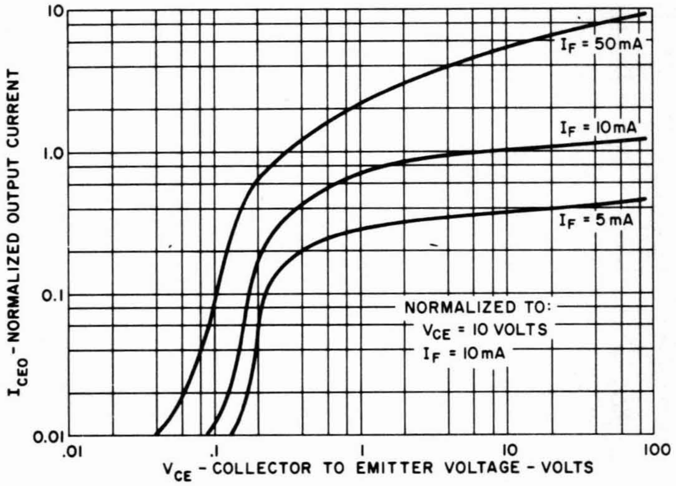
1. OUTPUT CURRENT VS INPUT CURRENT



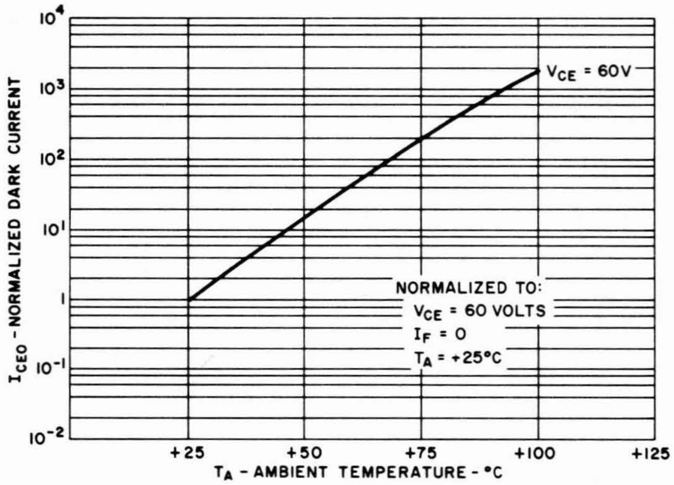
2. OUTPUT CURRENT VS TEMPERATURE



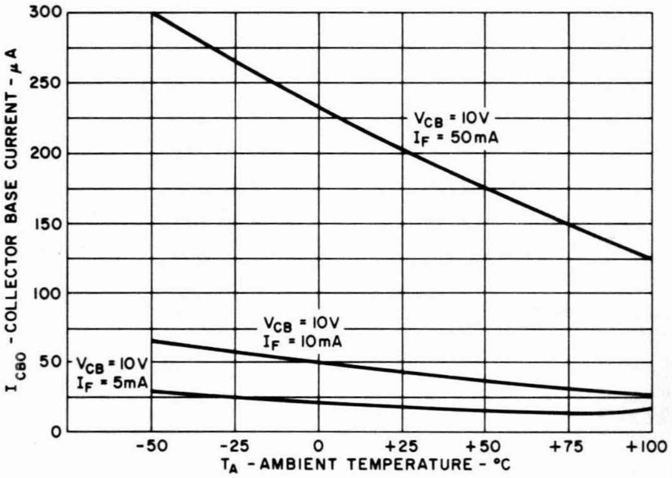
3. INPUT CHARACTERISTICS



4. OUTPUT CHARACTERISTICS



5. NORMALIZED DARK CURRENT VS TEMPERATURE

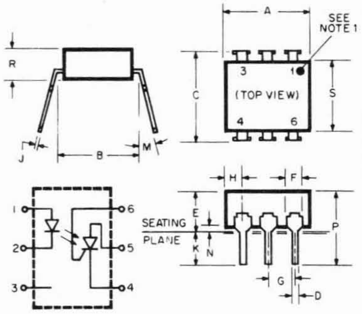


6. COLLECTOR BASE CURRENT VS TEMPERATURE

Photon Coupled Isolator 4N39, 4N40

Ga As Infrared Emitting Diode & Light Activated SCR

The General Electric 4N39 and 4N40 consist of a gallium arsenide, infrared emitting diode coupled with a light activated silicon controlled rectifier in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings

INFRARED EMITTING DIODE		
†Power Dissipation (-55°C to 50°C)	*100	milliwatts
†Forward Current (Continuous) (-55°C to 50°C)	60	milliamps
†Forward Current (Peak) (-55°C to 50°C) (100 μsec 1% duty cycle)	1	ampere
†Reverse Voltage (-55°C to 50°C)	6	volts

*Derate 2.0mW/°C above 50°C.

PHOTO-SCR			
†Off-State and Reverse Voltage (-55°C to +100°C)	4N39	200	volts
	4N40	400	volts
†Peak Reverse Gate Voltage (-55°C to 50°C)		6	volts
†Direct On-State Current (-55°C to 50°C)		300	milliamps
†Surge (non-rep) On-State Current (-55°C to 50°C)		10	amps
†Peak Gate Current (-55°C to 50°C)		10	milliamps
†Output Power Dissipation (-55°C to 50°C)**		400	milliwatts

**Derate 8mW/°C above 50°C.

TOTAL DEVICE

†Storage Temperature Range -55°C to 150°C

†Operating Temperature Range -55°C to 100°C

†Normal Temperature Range (No Derating) -55°C to 50°C

†Soldering Temperature (1/16″ from case, 10 seconds) 260°C

†Total Device Dissipation (-55°C to 50°C), 450 milliwatts

†Linear Derating Factor (above 50°C), 9.0mW/°C

†Surge Isolation Voltage (Input to Output).
$1500V_{(peak)}$ $1060V_{(RMS)}$

†Steady-State Isolation Voltage (Input to Output).
$950V_{(peak)}$ $660V_{(RMS)}$

individual electrical characteristics (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
†Forward Voltage V_F (I_F = 10mA)	1.1	1.5	volts
†Reverse Current I_R (V_R = 3V)	–	10	microamps
Capacitance (V = 0, f = 1MHz)	50	–	picofarads

PHOTO-SCR		MIN.	MAX.	UNITS
†Peak Off-State Voltage – V_{DM}	4N39	200	–	volts
(R_{GK} = 10KΩ, T_A = 100°C)	4N40	400	–	volts
†Peak Reverse Voltage – V_{RM}	4N39	200	–	volts
(T_A = 100°C)	4N40	400	–	volts
†On-State Voltage – V_T (I_T = 300mA)		–	1.3	volts
†Off-State Current – I_D (V_D=200V, T_A=100°C, I_F=0, R_{GK}=10K)	4N39	–	50	microamps
†Off-State Current – I_D (V_D=400V, T_A=100°C, I_F=0, R_{GK}=10K)	4N40	–	150	microamps
†Reverse Current – I_R (V_R = 200V, T_A = 100°C, I_F = 0)	4N39	–	50	microamps
†Reverse Current – I_R (V_R = 400V, T_A = 100°C, I_F = 0)	4N40	–	150	microamps
†Holding Current – I_H (V_{FX} = 50V, R_{GK} = 27KΩ)		–	200	microamps

coupled electrical characteristics (25°C)

			MIN.	MAX.	UNITS
†Input Current to Trigger	V_{AK} = 50V, R_{GK} = 10KΩ	I_{FT}	–	30	milliamps
	V_{AK} = 100V, R_{GK} = 27KΩ	I_{FT}	–	14	milliamps
†Isolation Resistance (Input to Output)	V_{io} = 500V_{DC}	r_{io}	100	–	gigaohms
†Turn-On Time – V_{AK} = 50V, I_F = 30mA, R_{GK} = 10KΩ, R_L = 200Ω		t_{on}	–	50	microseconds
Coupled dv/dt, Input to Output (See Figure 13)			500	–	volts/microsec.
Input to Output Capacitance (Input to Output Voltage = 0, f = 1MHz)			–	2	picofarads

†Indicates JEDEC Registered Values.

TYPICAL CHARACTERISTICS

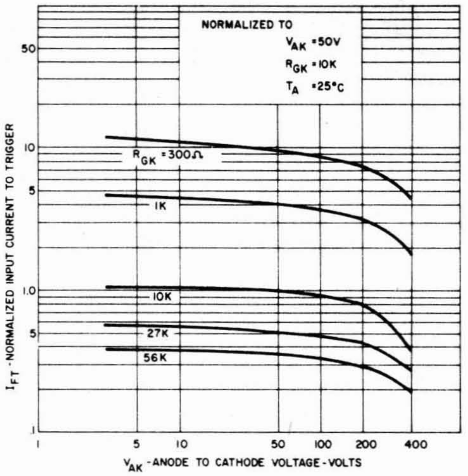


FIGURE 1. INPUT CURRENT TO TRIGGER VS. ANODE-CATHODE VOLTAGE

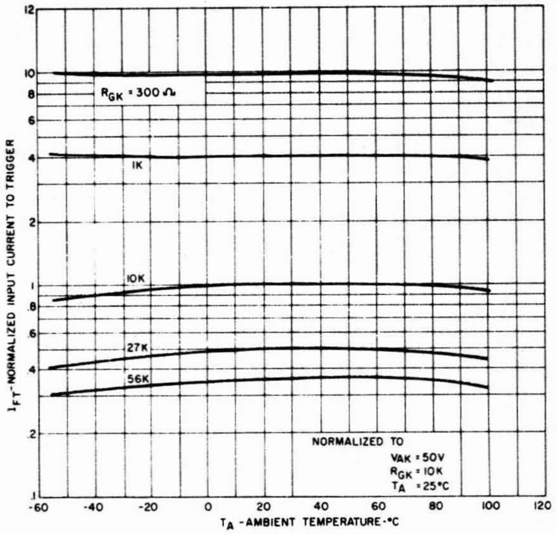


FIGURE 2. INPUT CURRENT TO TRIGGER VS. TEMPERATURE

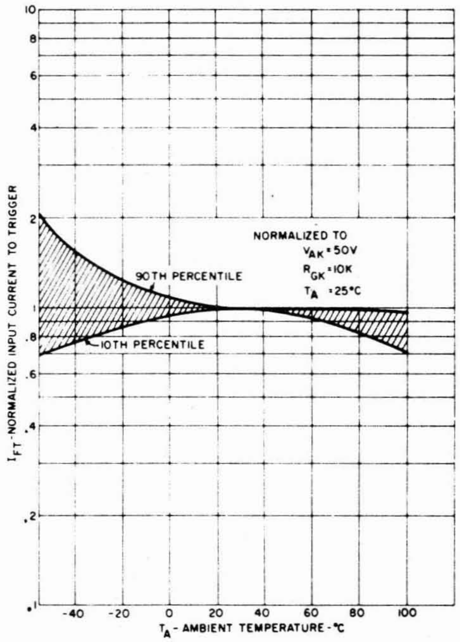


FIGURE 3. INPUT CURRENT TO TRIGGER DISTRIBUTION VS. TEMPERATURE

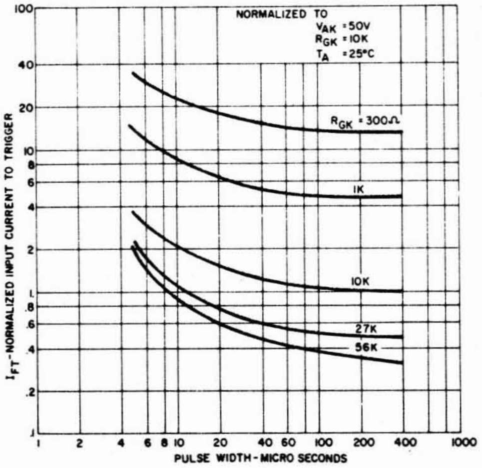


FIGURE 4. INPUT CURRENT TO TRIGGER VS. PULSE WIDTH

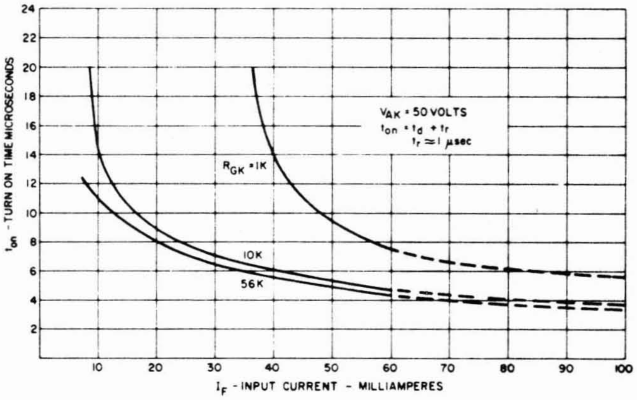


FIGURE 5. TURN-ON TIME VS. INPUT CURRENT

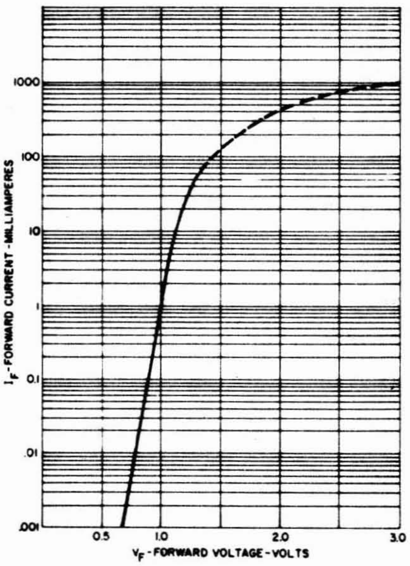


FIGURE 6. INPUT CHARACTERISTICS I_F VS. V_F

TYPICAL CHARACTERISTICS OF OUTPUT (SCR)

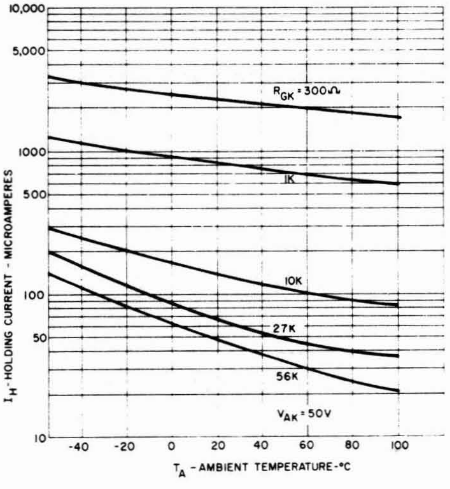


FIGURE 7. HOLDING CURRENT VS. TEMPERATURE

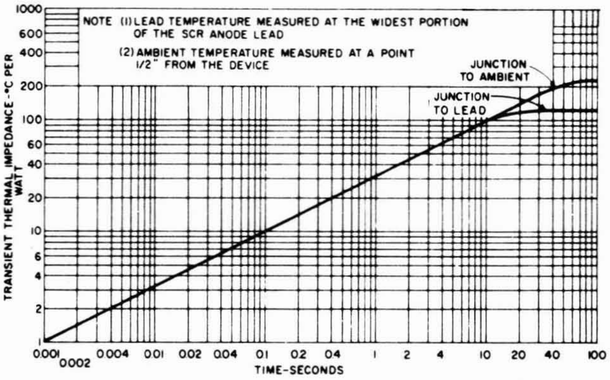


FIGURE 8. MAXIMUM TRANSIENT THERMAL IMPEDANCE

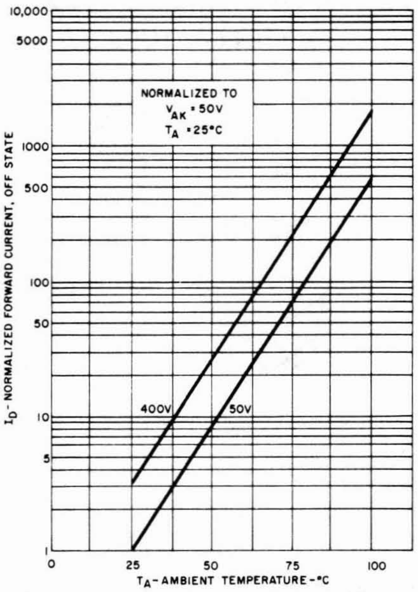


FIGURE 9. OFF-STATE FORWARD CURRENT VS. TEMPERATURE

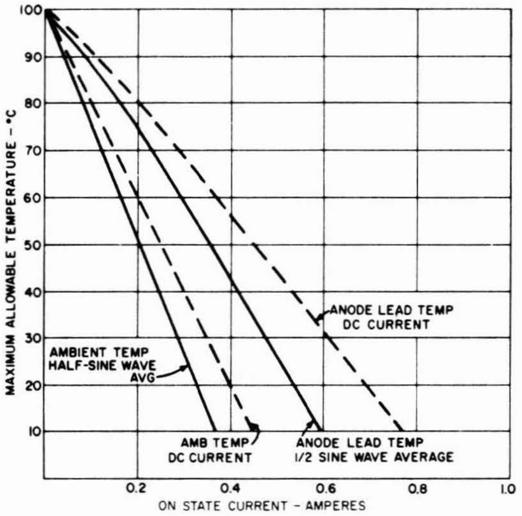


FIGURE 10. ON-STATE CURRENT VS. MAXIMUM ALLOWABLE TEMPERATURE

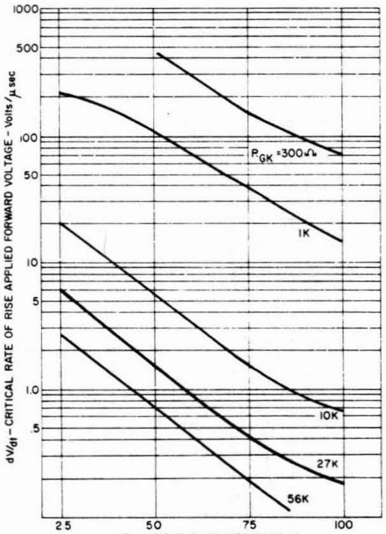


FIGURE 11. dv/dt VS. TEMPERATURE

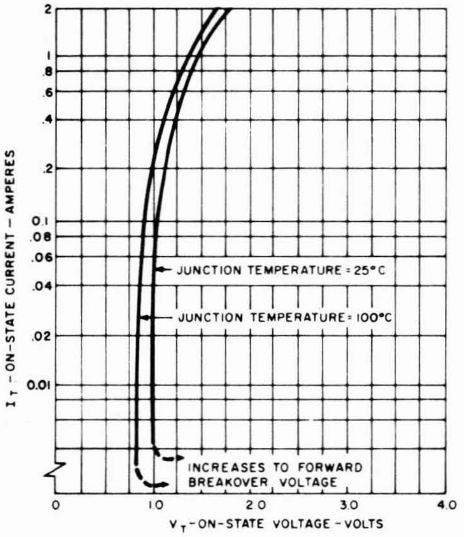
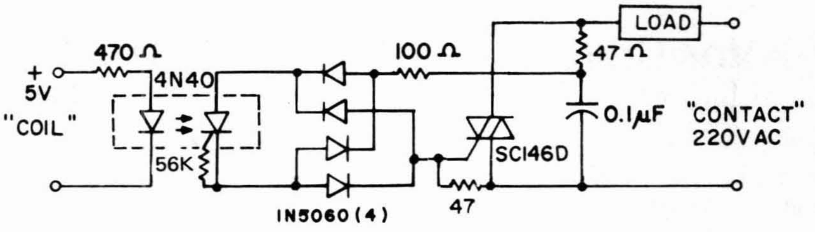


FIGURE 12. ON-STATE CHARACTERISTICS

TYPICAL APPLICATIONS

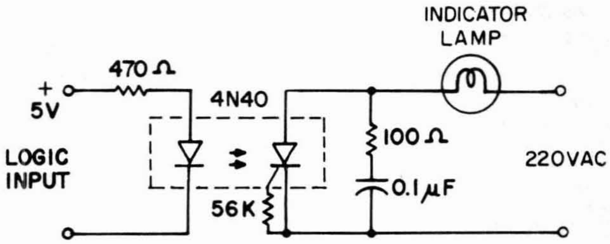
10A, T²L COMPATIBLE, SOLID STATE RELAY

Use of the 4N40 for high sensitivity, 2500V isolation capability, provides this highly reliable solid state relay design. This design is compatible with 74, 74S and 74H series T²L logic systems inputs and 220V AC loads up to 10A.



25W LOGIC INDICATOR LAMP DRIVER

The high surge capability and non-reactive input characteristics of the 4N40 allow it to directly couple, without buffers, T²L and DTL logic to indicator and alarm devices, without danger of introducing noise and logic glitches.



400V SYMMETRICAL TRANSISTOR COUPLER

Use of the high voltage PNP portion of the 4N40 provides a 400V transistor capable of conducting positive and negative signals with current transfer ratios of over 1%. This function is useful in remote instrumentation, high voltage power supplies and test equipment. Care should be taken not to exceed the 400 mW power dissipation rating when used at high voltages.

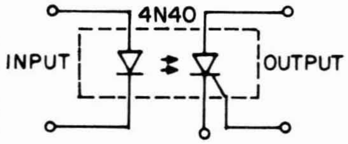
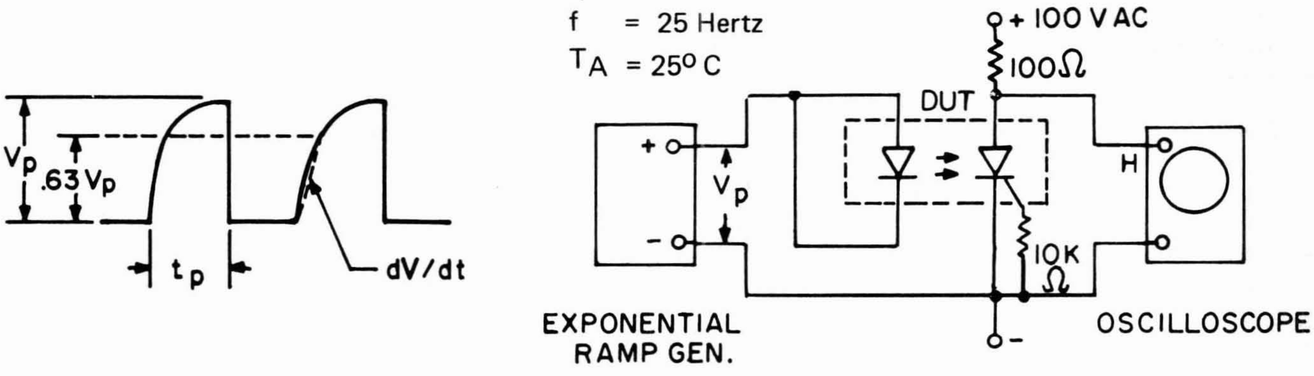


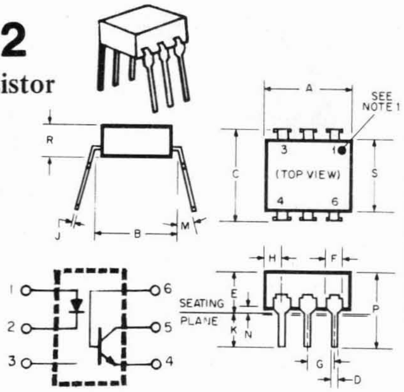
FIGURE 13
COUPLED dv/dt – TEST CIRCUIT


V_p = 800 Volts
t_p = .010 Seconds
f = 25 Hertz
T_A = 25° C

Photon Coupled Isolator H11A1, H11A2

Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric H11A1 and H11A2 are gallium arsenide infrared emitting diodes coupled with a silicon photo-transistor in a dual in-line package.



SYMBOL	INCH MIN	INCH MAX	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1 μsec 300 P Ps)	3	ampere
Reverse Voltage	3	volts

*Derate 1.33mW/°C above 25°C ambient

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{CBO}	70	volts
V_{ECO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0mW/°C above 25°C ambient

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).

H11A1	$2500V_{(peak)}$	$1770V_{(RMS)}$
H11A2	$1500V_{(peak)}$	$1060V_{(RMS)}$

Steady-State Isolation Voltage (Input to Output).

H11A1	$1500V_{(peak)}$	$1060V_{(RMS)}$
H11A2	$950V_{(peak)}$	$660V_{(RMS)}$

individual electrical characteristics (25°C)

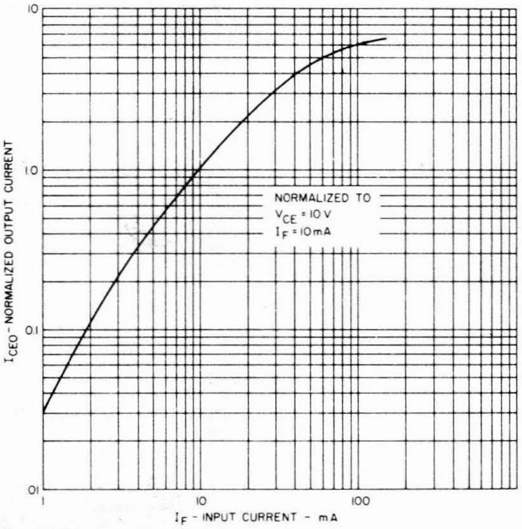
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.1	1.5	volts
Reverse Current (V_R = 3 V)	–	10	microamps
Capacitance (V = O,f = 1 MHz)	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage–$V_{(BR)CEO}$ (I_C = 10mA, I_F = O)	30	–	–	volts
Breakdown Voltage–$V_{(BR)CBO}$ (I_C = 100μA, I_F = O)	70	–	–	volts
Breakdown Voltage–$V_{(BR)ECO}$ (I_E = 100μA, I_F = O)	7	–	–	volts
Collector Dark Current–I_{CEO} (V_{CE} = 10V, I_F = O)	–	5	50	nanoamps
Capacitance (V_{CE} = 10V,f = 1MHz)	–	2	–	picofarads

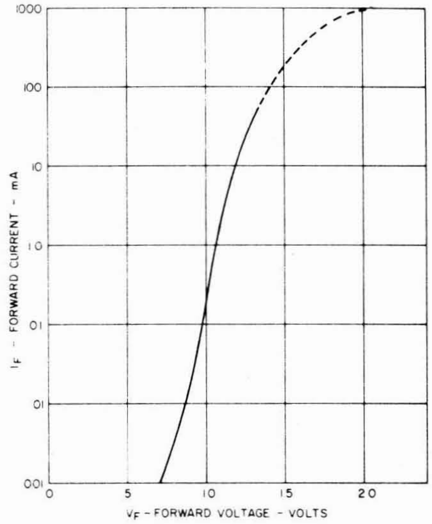
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)	H11A1	50	–	–	%
	H11A2	20	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 0.5mA)		–	0.1	0.4	volts
Isolation Resistance (Input to Output Voltage = $500V_{DC}$)		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = O,f = 1MHz)		–	–	2	picofarads
Switching Speeds:					
Rise/Fall Time (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)		–	2	–	microseconds
Rise/Fall Time (V_{CB} = 10V, I_{CB} = 50μA, R_L = 100Ω)		–	300	–	nanoseconds

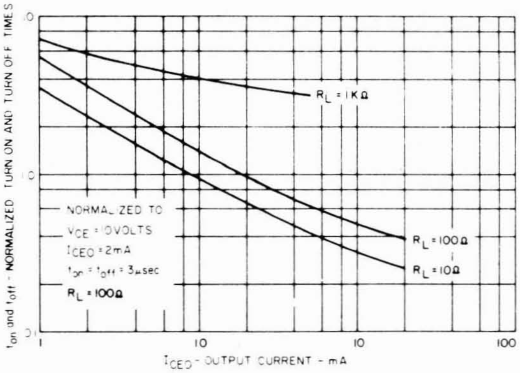
TYPICAL CHARACTERISTICS



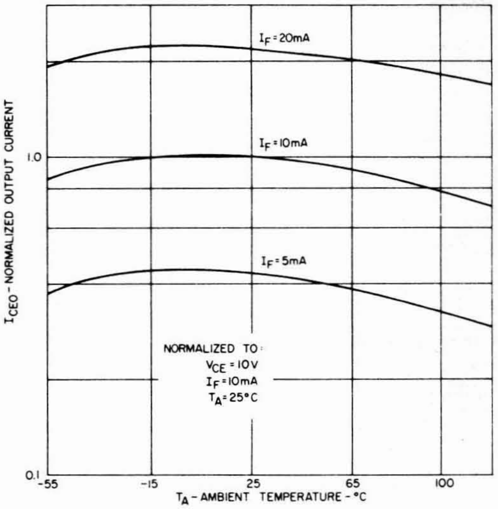
OUTPUT CURRENT VS INPUT CURRENT



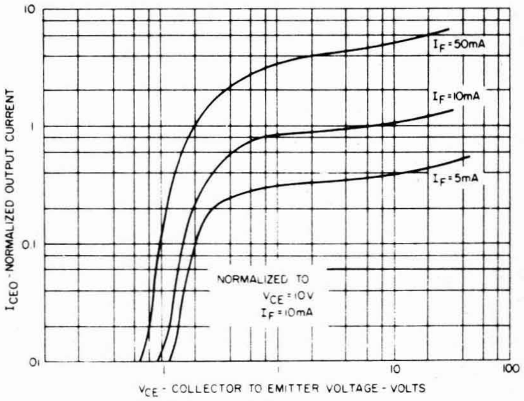
INPUT CURRENT CHARACTERISTICS



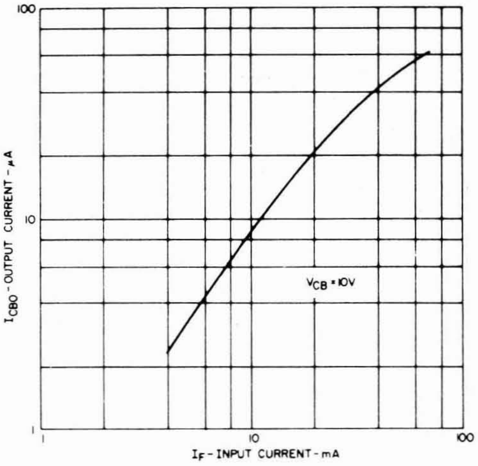
SWITCHING TIMES VS OUTPUT CURRENT



OUTPUT CURRENT VS TEMPERATURE



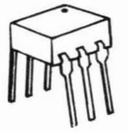
OUTPUT CHARACTERISTICS



OUTPUT CURRENT (I_{CBO}) VS INPUT CURRENT

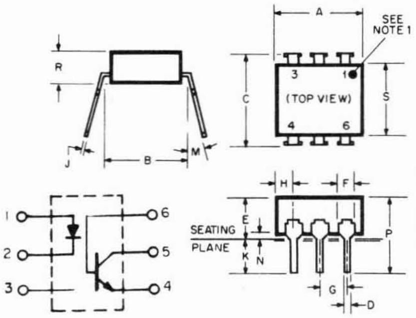
SOLID STATE OPTOELECTRONICS

Photon Coupled Isolator H11A3 , H11A4



Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric H11A3 and H11A4 are gallium arsenide, infrared emitting diodes coupled with a silicon photo-transistor in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1μsec 300 P Ps)	3	ampere
Reverse Voltage	3	volts

*Derate 1.33mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{CBO}	70	volts
V_{ECO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).

H11A3	$2500V_{(peak)}$	$1770V_{(RMS)}$
H11A4	$1500V_{(peak)}$	$1060V_{(RMS)}$

Steady-State Isolation Voltage (Input to Output).

H11A3	$1500V_{(peak)}$	$1060V_{(RMS)}$
H11A4	$950V_{(peak)}$	$660V_{(RMS)}$

individual electrical characteristics (25°C)

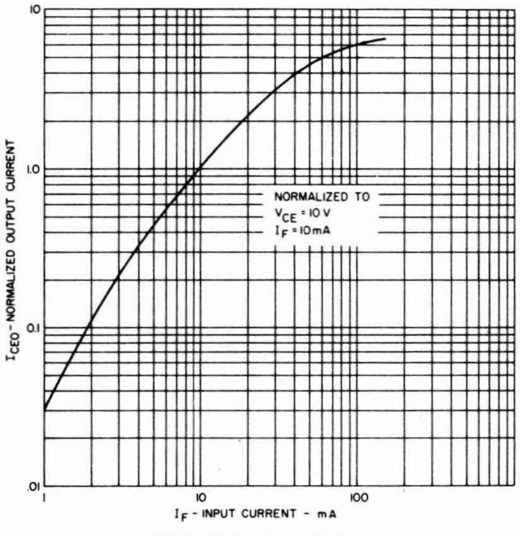
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.5	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = 0,f = 1MHz)	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	70	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = 0)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	50	nanoamps
Capacitance (V_{CE} = 10V, f = 1MHz)	–	2	–	picofarads

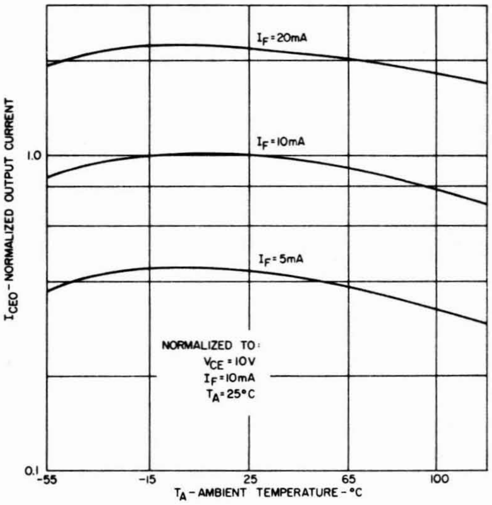
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)	H11A3	20	–	–	%
	H11A4	10	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 0.5mA)		–	0.1	0.4	volts
Isolation Resistance (Input to Output Voltage = $500V_{DC}$)		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1MHz)		–	–	2	picofarads
Switching Speeds: Rise/Fall Time (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)		–	2	–	microseconds
Rise/Fall Time (V_{CB} = 10V, I_{CB} = 50μA, R_L = 100Ω)		–	300	–	nanoseconds

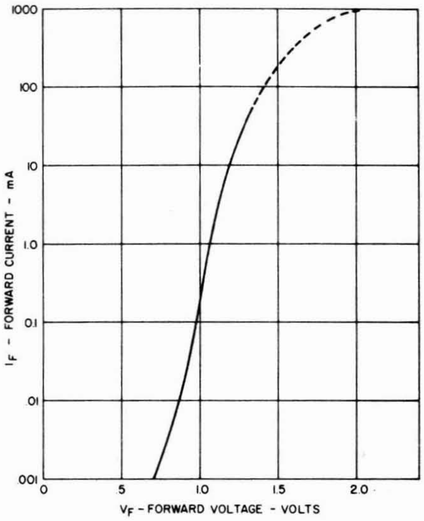
TYPICAL CHARACTERISTICS



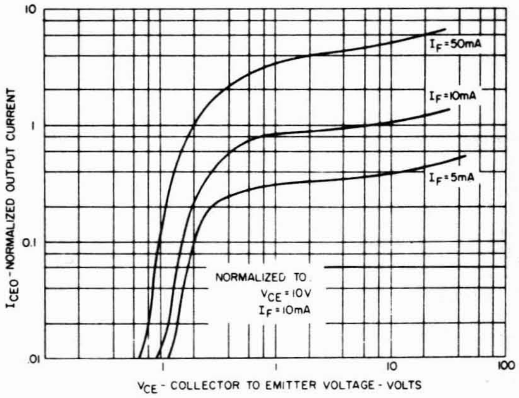
OUTPUT CURRENT VS INPUT CURRENT



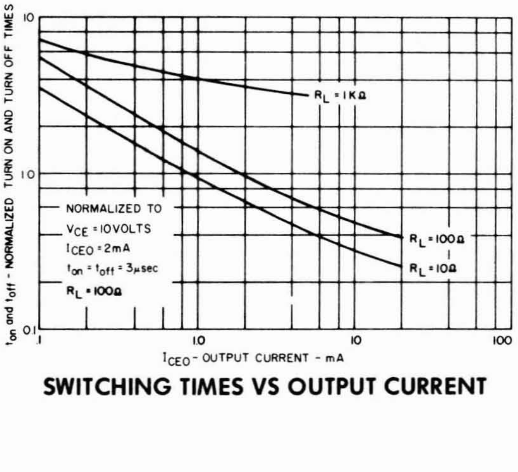
OUTPUT CURRENT VS TEMPERATURE



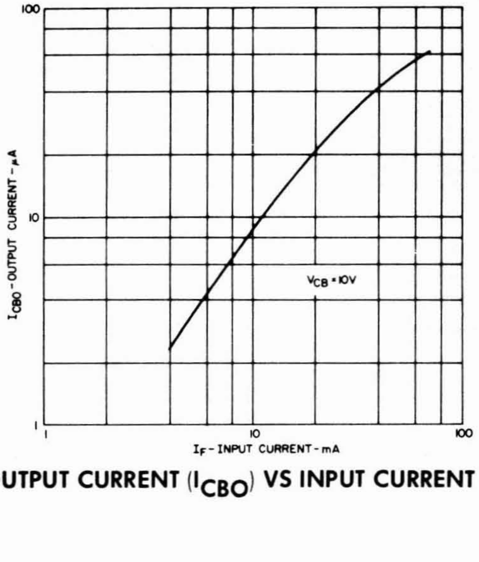
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS



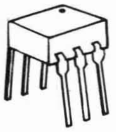
SWITCHING TIMES VS OUTPUT CURRENT



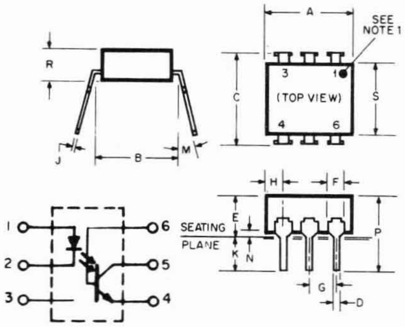
OUTPUT CURRENT (I_{CBO}) VS INPUT CURRENT

Photon Coupled Isolator H11A5

Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor



The General Electric H11A5 is a gallium arsenide, infrared emitting diode coupled with a silicon photo-transistor in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	4.70	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE

Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak)	3	ampere
(Pulse width 1μsec 300 P Ps)		
Reverse Voltage	3	volts

*Derate 1.33mW/°C above 25°C ambient.

PHOTO-TRANSISTOR

Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{CBO}	70	volts
V_{ECO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).
1500$V_{(peak)}$ 1060$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
950$V_{(peak)}$ 660$V_{(RMS)}$

individual electrical characteristics (25°C)

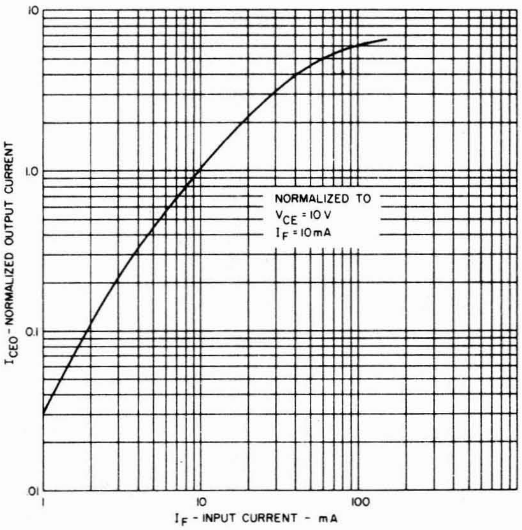
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.7	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = 0,f = 1MHz)	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	70	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = 0)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	100	nanoamps
Capacitance (V_{CE} = 10V,f = 1MHz)	–	2	–	picofarads

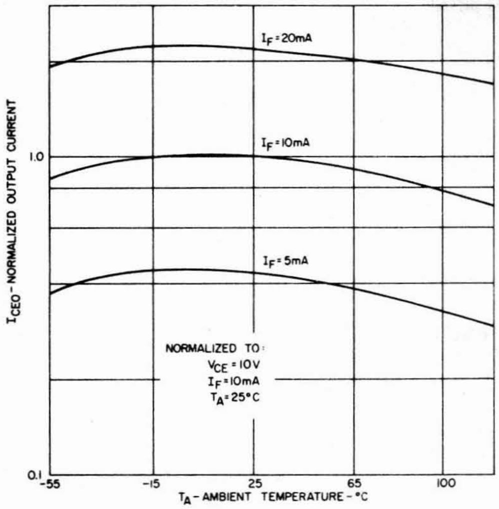
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)	30	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 0.5mA)	–	0.1	0.4	volts
Isolation Resistance (Input to Output Voltage = 500V_{DC})	100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1MHz)	–	–	2	picofarads
Switching Speeds: Rise/Fall Time (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)	–	2	–	microseconds
Rise/Fall Time (V_{CB} = 10V, I_{CB} = 50μA, R_L = 100Ω)	–	300	–	nanoseconds

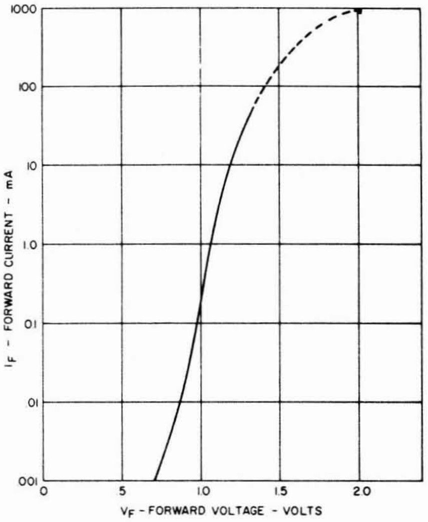
TYPICAL CHARACTERISTICS



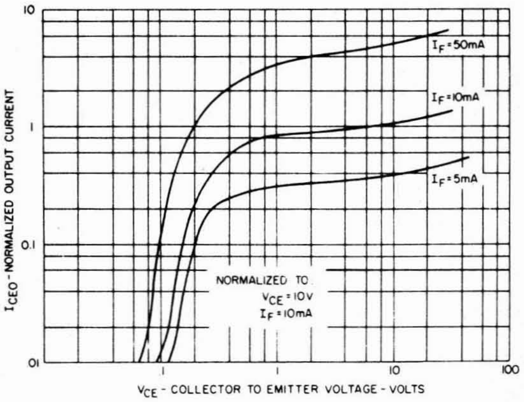
OUTPUT CURRENT VS INPUT CURRENT



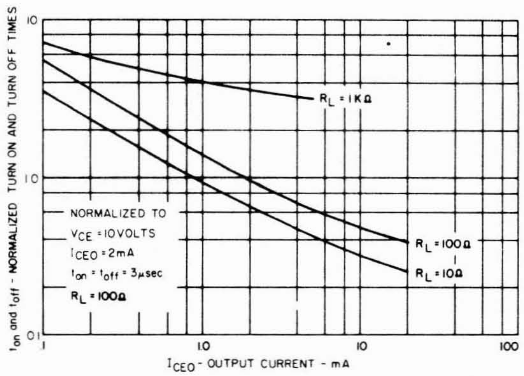
OUTPUT CURRENT VS TEMPERATURE



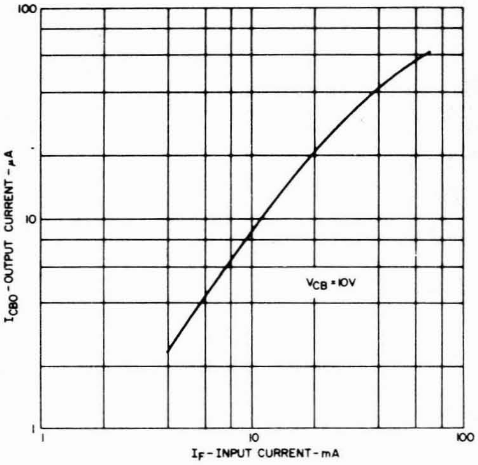
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS



SWITCHING TIMES VS OUTPUT CURRENT



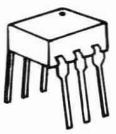
OUTPUT CURRENT (I_{CBO}) VS INPUT CURRENT

SOLID STATE OPTOELECTRONICS

PHOTON COUPLED CURRENT THRESHOLD SWITCH H11A10

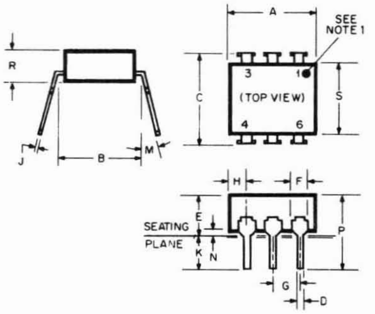
Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric H11A10 is a gallium arsenide infrared emitting diode coupled with a silicon photo transistor in a dual in-line package. It is characterized and specified with two resistors, one on the input and one on the output. This configuration provides a circuit which will detect a doubling of the input current level by registering more than a twenty to one difference in the output current over a wide temperature range.



FEATURES:

- Programmable Threshold - "off" to "on" with a 2/1 change in input current
- Glass Dielectric Isolation
- Fast Switching Speeds
- Operation over wide temperature range
- High Noise Immunity
- Covered under U.L. Component Recognition Program, reference file E51868



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE

Power Dissipation	$T_A = 25^oC$	*100	milliwatts
Power Dissipation	$T_C = 25^oC$	*100	milliwatts
Forward Current (Continuous)		50	milliamps
Forward Current (Peak) (Pulse width 1 μsec, 300 pps)		3	ampere
Reverse Voltage		6	volts

*Derate 1.33mW/°C above 25°C

PHOTO-TRANSISTOR

Power Dissipation	$T_A = 25^oC$	**300	milliwatts
Power Dissipation	$T_C = 25^oC$	***500	milliwatts

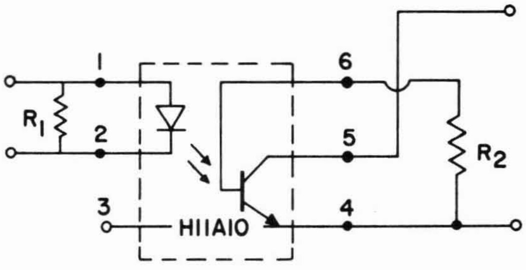
(T_C indicates collector lead temperature 1/32" from case)

V_{CEO}	30	volts
V_{CBO}	70	volts
V_{EBO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 4.0mW/°C above 25°C
***Derate 6.7mW/°C above 25°C

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Input to Output Isolation Voltage 1500V$_{(peak)}$
Surge Isolation (Input to Output)
1500V$_{(peak)}$ 1060V$_{(RMS)}$
Steady-State Isolation Voltage (Input to Output)
950V$_{(peak)}$ 660V$_{(RMS)}$



THRESHOLD SWITCH BIAS CIRCUIT ILLUSTRATION

individual electrical characteristics (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE	SYMBOL	MIN.	MAX.	UNITS	PHOTO-TRANSISTOR	SYMBOL	MIN.	TYP.	MAX.	UNITS
Forward Voltage (I_F=10mA)	V_F		1.5	volts	Breakdown Voltage (I_C=10mA, I_F=0)	$V_{(BR)CEO}$	30	–	–	volts
Reverse Current (V_R=6V)	I_R	–	10	microamps	Breakdown Voltage (I_C=100μA, I_F=0)	$V_{(BR)CBO}$	70	–	–	volts
Capacitance (V=0, f=1 MHz)	C_J		100	picofarads	Breakdown Voltage (I_E=100μA, I_F=0)	$V_{(BR)EBO}$	7	–	–	volts

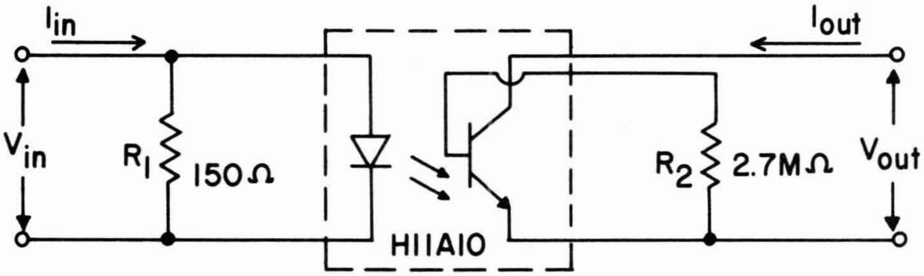


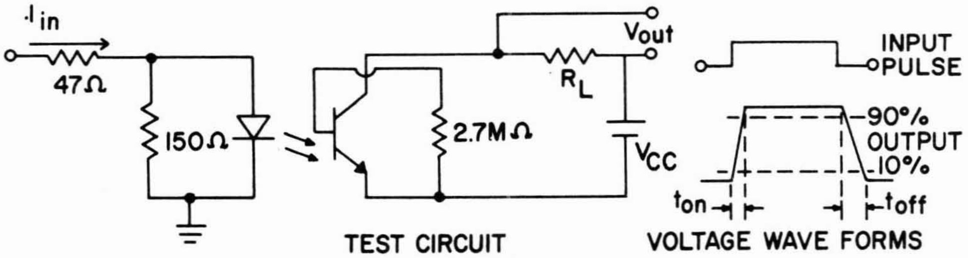
FIGURE 1

THRESHOLD CIRCUIT CHARACTERISTICS - BIAS PER FIGURE 1

(-55°C to 100°C Unless Otherwise Specified)

SYMBOL	PARAMETER/CONDITIONS	MIN.	TYP.	MAX.	UNITS
I_{out}	Output Current (V_{out}=10V, $I_{in} \leq$ 5mA, T_A=25°C)		1	50	nanoamperes
I_{out}	Output Current (V_{out}=10V, $I_{in} \leq$ 5mA, T_A=100°C)		1	50	microamperes
I_{out}/I_{in}	D.C. Current Transfer Ratio (V_{out}=10V, $I_{in} \geq$ 10mA)	10	30		percent
V_{out}	Output Saturation Voltage (I_{in}=10mA, I_{out}=0.5mA)		0.2	0.4	volts
R_{io}	Input to Output Resistance (V_{io}=500V) Note 1	100			gigaohms
t_{on}	Turn-On Time (Vcc = 10V, I_{in}=20 mA, R_L=100Ω) Figure 2		5		microseconds
t_{off}	Turn-Off Time (Vcc = 10V, I_{in}=20mA, R_L=100Ω) Figure 2		5		microseconds

Note 1: Tests of input to output isolation current resistance, and capacitance are performed with the input terminals (diode) shorted together and the output terminals (transistor) shorted together

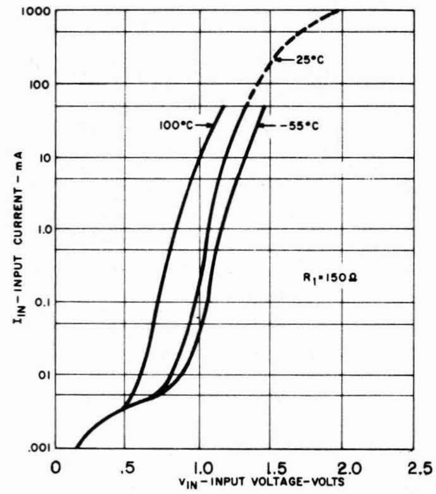


TEST CIRCUIT

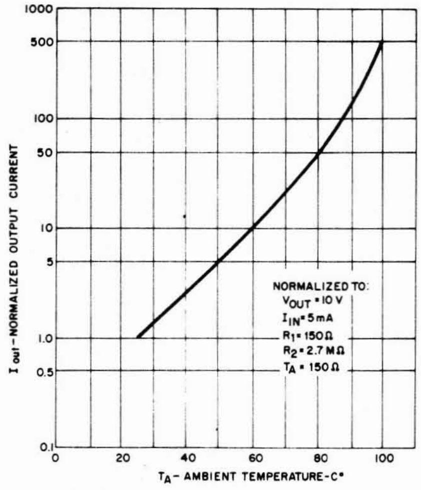
VOLTAGE WAVE FORMS

FIGURE 2

TYPICAL CHARACTERISTICS
BIASED PER FIGURE 1

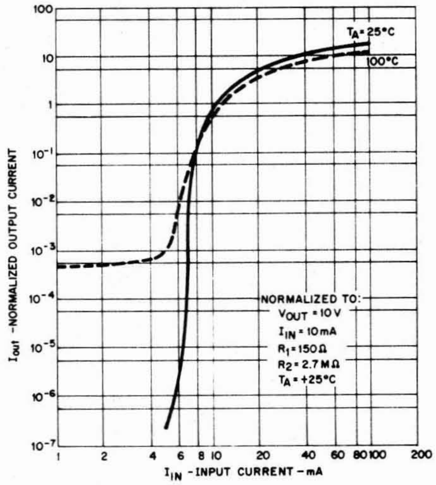


1. INPUT

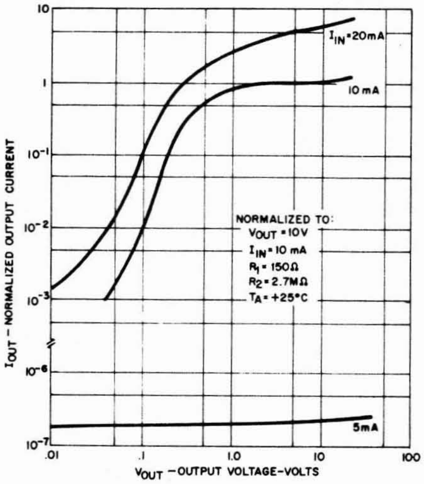


2. LEAKAGE

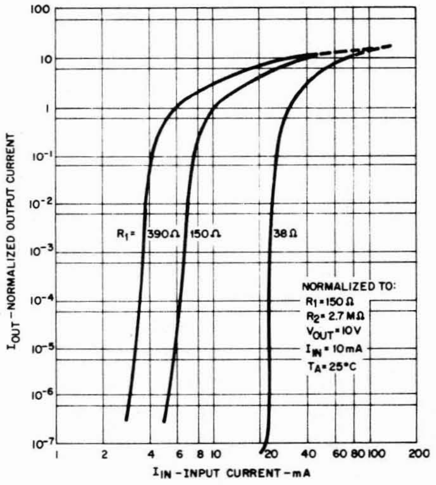
PROGRAMMING AND TRANSFER CHARACTERISTICS



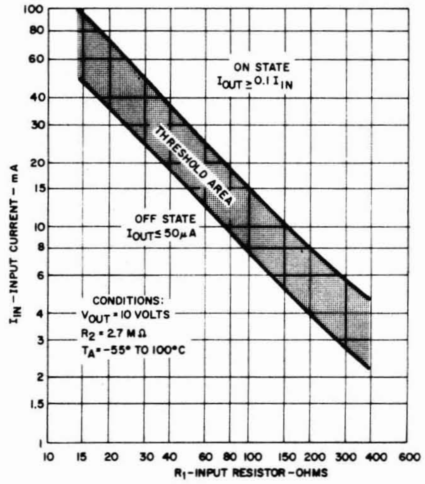
3. TEMPERATURE



4. INPUT CURRENT

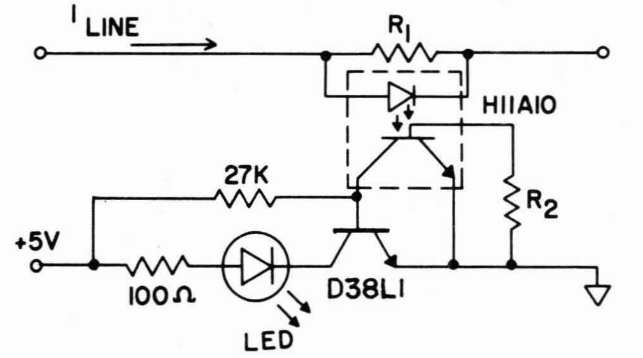


5. THRESHOLDING



6. PROGRAMMING

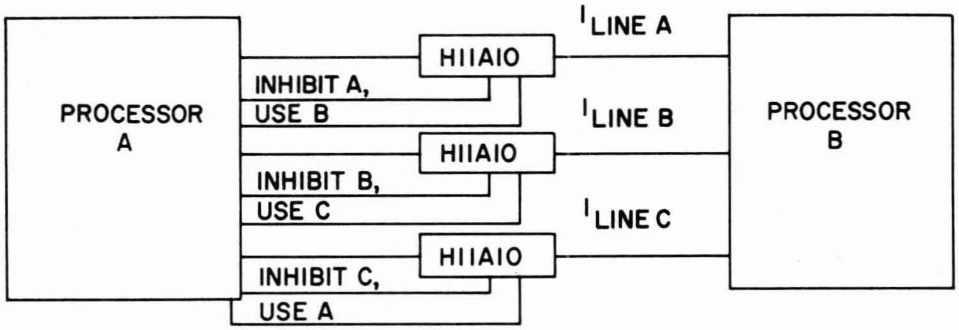
LINE CURRENT MONITORS
LINE DROPOUT ALARM LIGHT

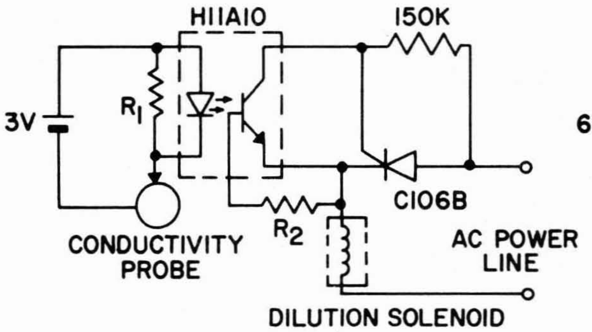


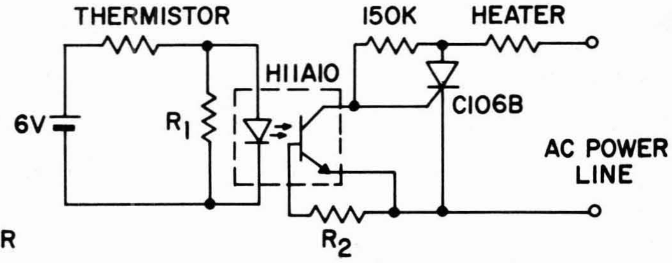
When remote line current (I_{LINE}) falls below the programmed threshold value the LED turns on, indicating loss of power to critical, isolated circuit function. Phase inversion, accomplished by replacing the D38L1 with a D34C1 PNP and interchanging the collector and emitter connections, provides an over-current alarm light.

INFORMATION FLOW DIRECTOR

To minimize lines needed to communicate between A and B, a queue system is set up using H11A10's to monitor line use and set up the queue procedures.





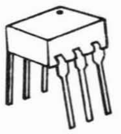


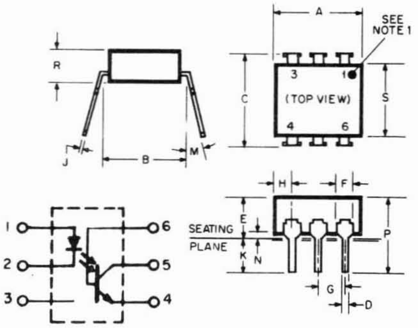
In many process control applications such as solution mixing, resistor trimming, light control and temperature control, it is advantageous to monitor conductivity with isolated low voltages and transmit this information to a power control or logic system. Low voltages are often preferred for safety, convenience or self heating considerations or to prevent ground loops and provide noise immunity. Until the advent of the H11A10 such systems were complex and costly. Using the H11A10 allows the use of simple low power circuits such as illustrated here to provide these functions. In battery operated systems, the low current thresholds of the H11A10 can considerably enhance battery life.

Photon Coupled Isolator H11A520-H11A550-H11A5100

Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric H11A520, H11A550 and H11A5100 consist of a gallium arsenide, infrared emitting diode coupled with a silicon photo-transistor in a dual in-line package.





FEATURES:

- High isolation voltage, 5000V minimum.
- General Electric unique patented glass isolation construction.
- High efficiency liquid epitaxial IRED.
- High humidiy resistant silicone encapsulation.
- Fast switching speeds.

SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE		
Power Dissipation – $T_A = 25°C$	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1 μsec, 300 pps)	3	amperes
Reverse Voltage	6	volts

*Derate 1.33mW/°C above 25°C.

PHOTO-TRANSISTOR		
Power Dissipation – $T_A = 25°C$	**300	milliwatts
V_{CEO}	30	volts
V_{CBO}	70	volts
V_{EBO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 4.0mW/°C above 25°C.

TOTAL DEVICE

Storage Temperature -55 to 150°C.
Operating Temperature -55 to 100°C.
Lead Soldering Time (at 260°C) 10 seconds.
Surge Isolation Voltage (Input to Output). See Note 2.
$5656V_{(peak)}$ $4000V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output). See Note 2.
$5000V_{(DC)}$ $3000V_{(RMS)}$

individual electrical characteristics (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE	MIN.	MAX.	UNITS
Forward Voltage – V_F (I_F = 10mA)	.8	1.5	volts
Forward Voltage – V_F (I_F = 10mA) T_A = -55°C	.9	1.7	volts
Forward Voltage – V_F (I_F = 10mA) T_A = +100°C	.7	1.4	volts
Reverse Current – I_R (V_R = 6V)	–	10	microamps
Capacitance – C_J (V = 0,f = 1MHz)	–	100	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	70	–	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ (I_E = 100μA, I_F = 0)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	50	nanoamps
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0) T_A = 100°C	–	–	500	microamps
Capacitance – C_{CE} (V_{CE} = 10V, f = 1MHz)	–	2	–	picofarads

coupled electrical characteristics (25 °C) (unless otherwise specified)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)	H11A5100	100	–	–	%
	H11A550	50	–	–	%
	H11A520	20	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 20mA, I_C = 2mA)		–	–	0.4	volts
Isolation Resistance (Input to Output Voltage = 500V_{DC}. See Note 1)		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1 MHz. See Note 1)		–	–	2.0	picofarads
Turn-On Time – t_{on} (V_{CC} = 10V, I_C = 2mA, R_L = 100Ω). (See Figure 1)		–	5	10	microseconds
Turn-Off Time – t_{off} (V_{CC} = 10V, I_C = 2mA, R_L = 100Ω). (See Figure 1)		–	5	10	microseconds

NOTE 1:

Tests of input to output isolation current resistance, and capacitance are performed with the input terminals (diode) shorted together and the output terminals (transistor) shorted together.

NOTE 2:

Surge Isolation Voltage

a. *Definition:*
This rating is used to protect against transient over-voltages generated from switching and lightning-induced surges. Devices shall be capable of withstanding this stress, a minimum of 100 times during its useful life. Ratings shall apply over entire device operating temperature range.

b. *Specification Format:*
Specification, in terms of peak and/or RMS, 60 Hz voltage, of specified duration (e.g., 5656V_{peak}/4000V_{RMS} for one second).

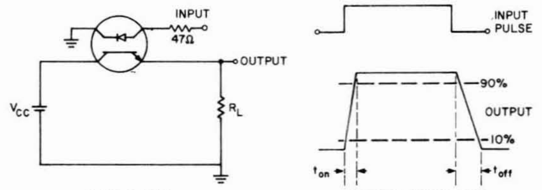
c. *Test Conditions:*
Application of full rated 60 Hz sinusoidal voltage for one second, with initial application restricted to zero voltage (i.e., zero phase), from a supply capable of sourcing 5mA at rated voltage.

Steady-State Isolation Voltage

a. *Definition:*
This rating is used to protect against a steady-state voltage which will appear across the device isolation from an electrical source during its useful life. Ratings shall apply over the entire device operating temperature range and shall be verified by a 1000 hour life test.

b. *Specification Format:*
Specified in terms of D.C. and/or RMS 60 Hz sinusoidal waveform.

c. *Test Conditions:*
Application of the full rated 60 Hz sinusoidal voltage, with initial application restricted to zero voltage (i.e., zero phase), from a supply capable of sourcing 5mA at rated voltage, for the duration of the test.

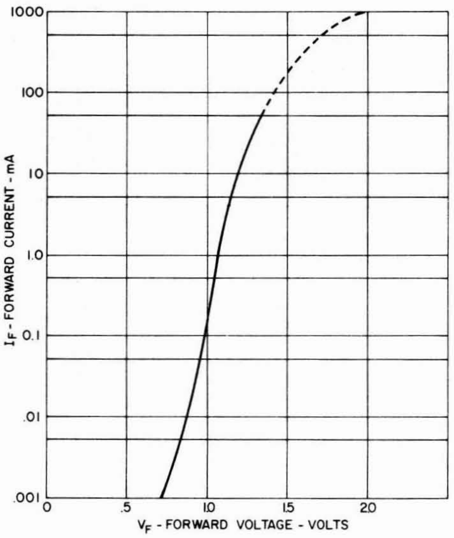


TEST CIRCUIT

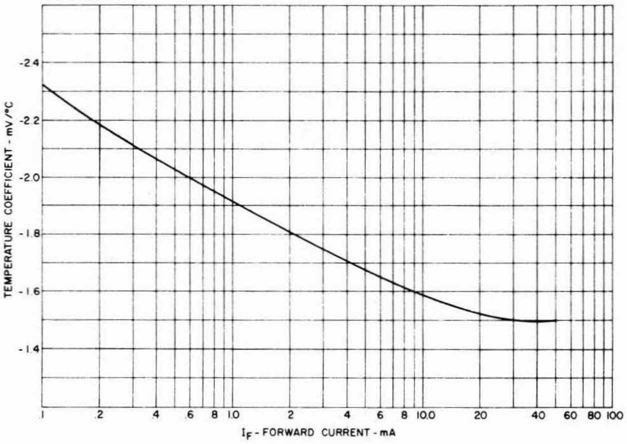
VOLTAGE WAVE FORMS

FIGURE 1: Adjust Amplitude of Input Pulse for Output (I_C) of 2mA

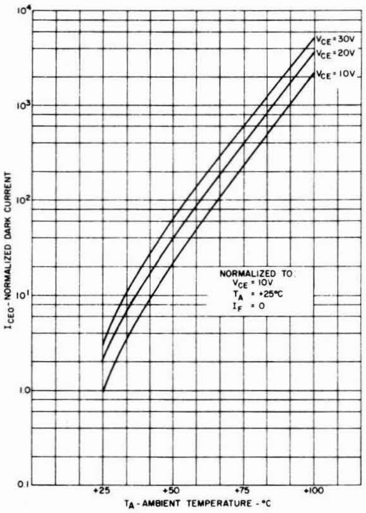
TYPICAL CHARACTERISTICS



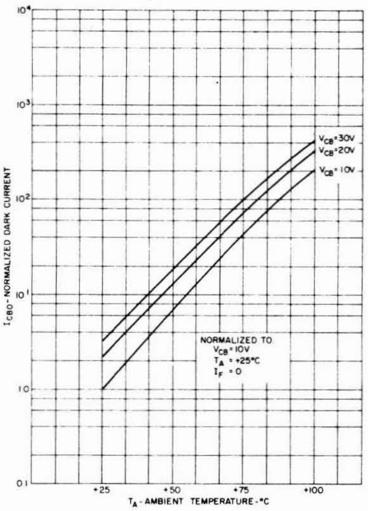
1. INPUT CHARACTERISTICS



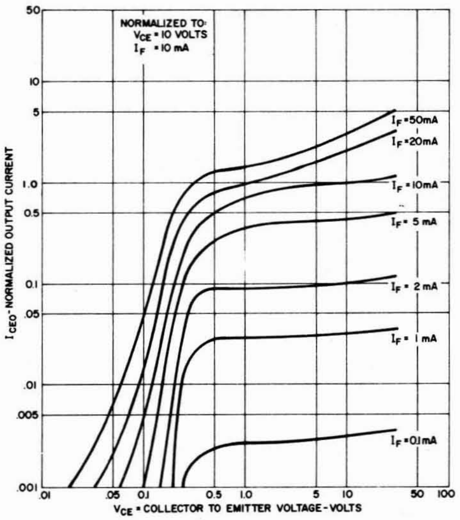
2. FORWARD CURRENT TEMPERATURE COEFFICIENT



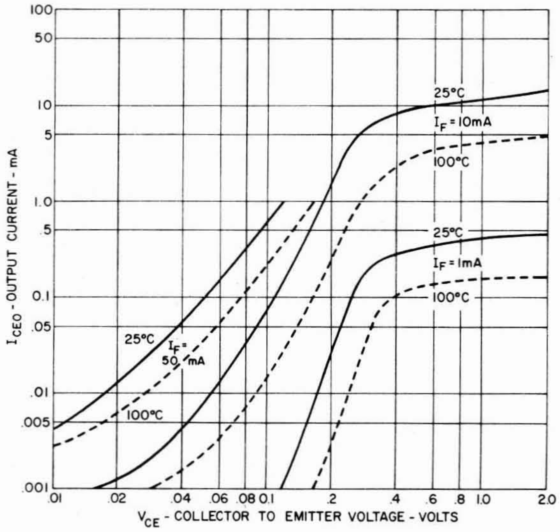
3. DARK I_{CEO} CURRENT VS. TEMPERATURE



4. I_{CBO} VS. TEMPERATURE

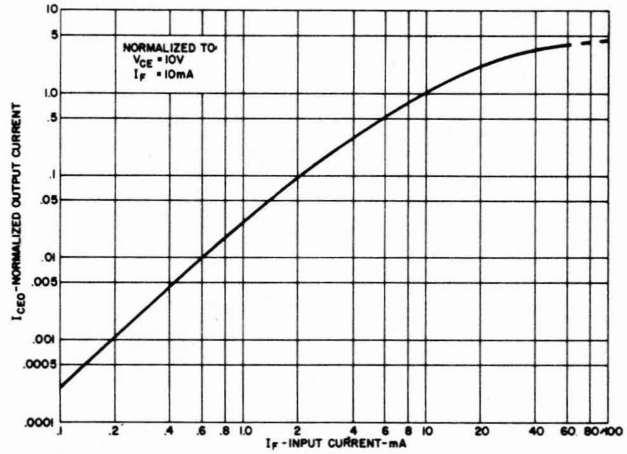


5. OUTPUT CHARACTERISTICS

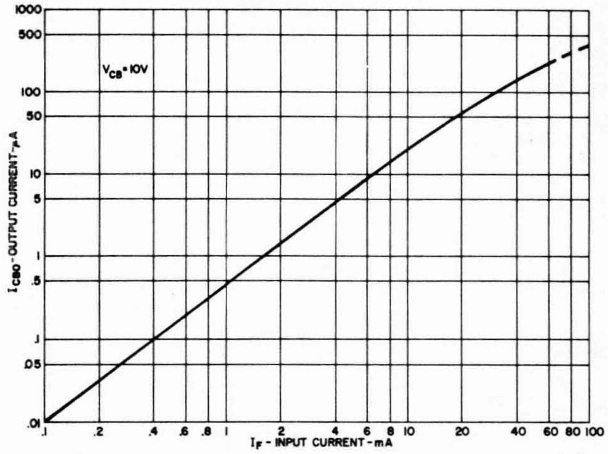


6. OUTPUT CHARACTERISTICS

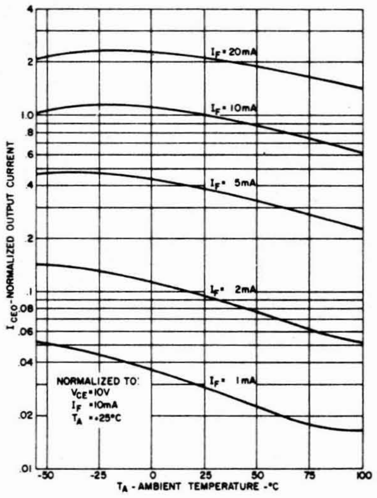
TYPICAL CHARACTERISTICS



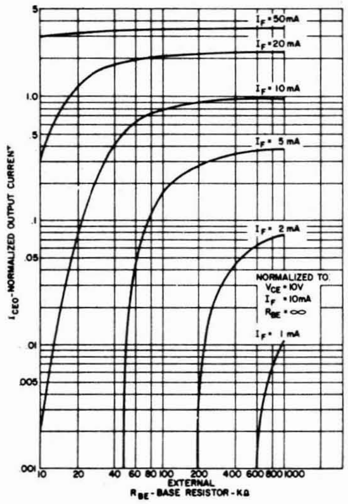
7. OUTPUT CURRENT VS. INPUT CURRENT



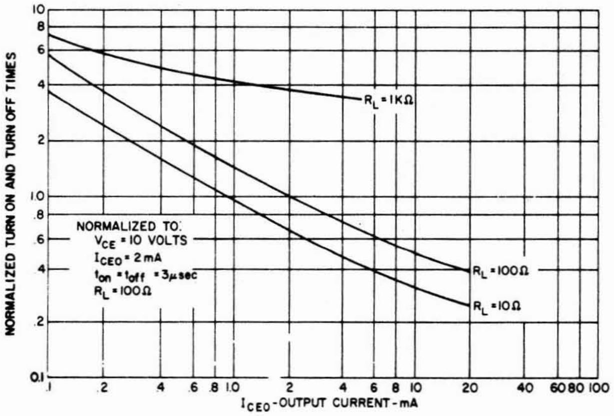
8. OUTPUT CURRENT — COLLECTOR-TO-BASE VS. INPUT CURRENT



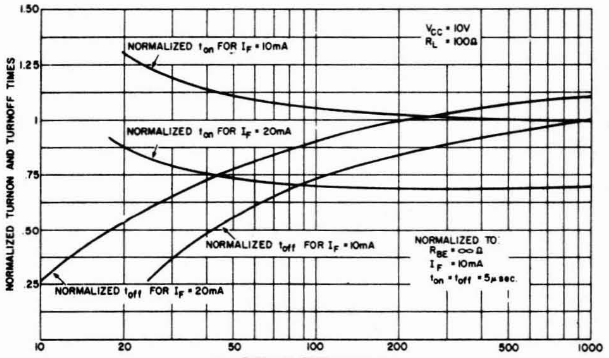
9. OUTPUT CURRENT VS. TEMPERATURE



10. OUTPUT CURRENT VS. BASE EMITTER RESISTANCE



11. SWITCHING TIMES VS. OUTPUT CURRENT



12. SWITCHING TIME VS. R_{BE}

SOLID STATE
OPTOELECTRONICS

Photon Coupled Isolator H74A1

Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

TTL Interface

The General Electric H74A1 provides logic to logic optical interfacing of TTL gates with *guaranteed* level compatibility in practical *specified* circuits. The H74A1 is a transistor output photo-coupled isolator specifically designed to eliminate ground loop cross talk and reflection problems when two distinct logic systems are coupled. It is guaranteed to couple 7400, 74H00 and 74S00 logic gates over the full TTL temperature and voltage ranges.

absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE

Power Dissipation	$T_A = 25^\circ C$	*100	milliwatts
Power Dissipation	$T_C = 25^\circ C$	*100	milliwatts
(T_C indicates collector lead temperature 1/32″ from case)			
Forward Current (Continuous)		60	milliamps
Forward Current (Peak) (Pulse width 1μsec 300 pps)		3	ampere
Reverse Voltage		6	volts

*Derate 2.2mW/°C above 25°C.

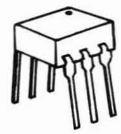
PHOTO-TRANSISTOR

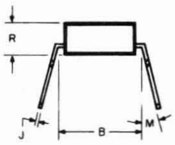
Power Dissipation	$T_A = 25^\circ C$	**300	milliwatts
Power Dissipation	$T_C = 25^\circ C$	***500	milliwatts
(T_C indicates collector lead temperature 1/32″ from case)			
V_{CEO}		15	volts
V_{CBO}		15	volts
V_{ECO}		5.5	volts
Collector Current (Continuous)		50	milliamps

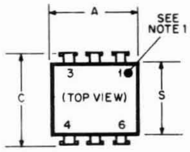
**Derate 6.7mW/°C above 25°C.
***Derate 11.1mW/°C above 25°C.

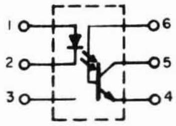
TOTAL DEVICE

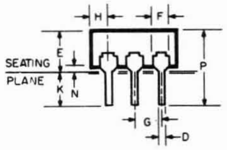
Storage Temperature -55 to 150°C
Operating Temperature 0 to 70°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output)
1500$V_{(peak)}$ 1060$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output)
950$V_{(peak)}$ 660$V_{(RMS)}$











SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

Electrical Characteristics of H74A1*

*All specifications refer to the following bias configuration (Figure 1) over the full operating temperature (0°C to 70°C) and logic supply voltage range (4.5 to 5.5V_{DC}) unless otherwise noted.

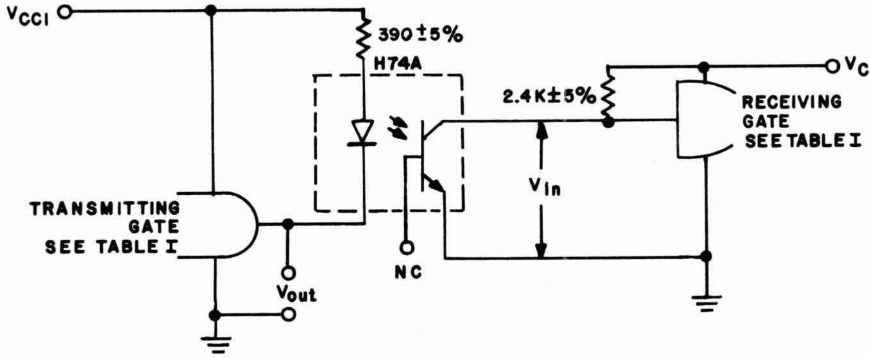


Figure 1. H74A1 BIAS CIRCUIT

V_{in} (0), Receiving Gate For $V_{OUT(0)}$ from Transmitting Gate –	0.8	V Max.
V_{in} (1), Receiving Gate for $V_{OUT(1)}$ from Transmitting Gate –	2.4	V Min.
t_p (0), Transmitting Gate to Receiving Gate Propagation Time –	20	μsec. Typ.
t_p (1), Transmitting Gate to Receiving Gate Propagation Time –	4	μsec. Typ.
Isolation Resistance (Input to Output = 500V_{DC})	100	gigaohms Min.
Input to Output Capacitance (Input to Output Voltage = O, f = 1 MHz)	2.5	pF Max.

TABLE I.

CHARACTERISTICS REQUIRED OF TTL GATES WHICH ARE TO BE INTERFACED BY H74A1

PARAMETER	TEST CONDITIONS, FIGURE 2						LIMITS		
	V_{CC}		I_{IN}		I_{SINK}		Min.	Max.	Units
	Min.	Max.	Min.	Max.	Min.	Max.			
V_{OUT} (1)	4.5V					-0.4mA	2.4		Volts
V_{OUT} (0)	4.5V				12.0mA			0.4	Volts
V_{IN} (1)		5.5V		1.0mA			2.0		Volts
V_{IN} (0)		5.5V	-1.6mA					0.8	Volts

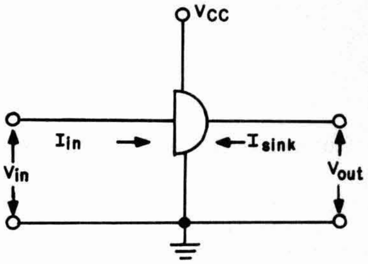
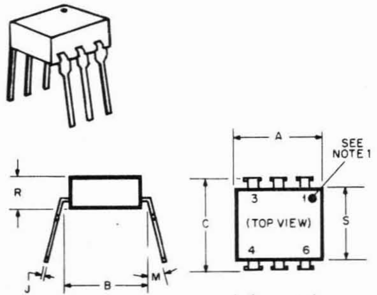


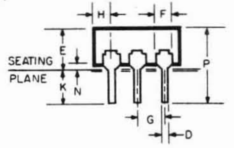
Figure 2.

SOLID STATE
OPTOELECTRONICS

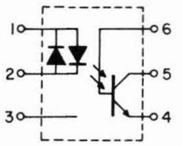
AC INPUT PHOTON COUPLED ISOLATOR H11AA1-H11AA2
Ga As Infrared Emitting Diodes & NPN Silicon Photo-Transistor

The General Electric H11AA1 and H11AA2 consist of two gallium arsenide infrared emitting diodes connected in inverse parallel and coupled with a silicon photo-transistor in a dual in-line package.





FEATURES:
- AC or polarity insensitive inputs
- Fast switching speeds
- Built-in reverse polarity input protection
- High isolation voltage
- High isolation resistance
- I/O compatible with integrated circuits



absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE

Power Dissipation	$T_A = 25^\circ C$	*100	milliwatts
Power Dissipation	$T_C = 25^\circ C$	*100	milliwatts
(T_C indicates collector lead temperature 1/32" from case)			
Input Current (RMS)		60	milliamps
Input Current (Peak)		± 1	ampere
(Pulse width 1μsec, 300 pps)			

*Derate 1.33mW/°C above 25°C

PHOTO-TRANSISTOR

Power Dissipation	$T_A = 25^\circ C$	**300	milliwatts
Power Dissipation	$T_C = 25^\circ C$	***500	milliwatts
(T_C indicates collector lead temperature 1/32" from case)			
V_{CEO}		30	volts
V_{CBO}		70	volts
V_{EBO}		5	volts
Collector Current (Continuous)		100	milliamps

**Derate 4.0mW/°C above 25°C
***Derate 6.7mW/°C above 25°C

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output)
1500$V_{(peak)}$ 1060$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output)
950$V_{(peak)}$ 660$V_{(RMS)}$

SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

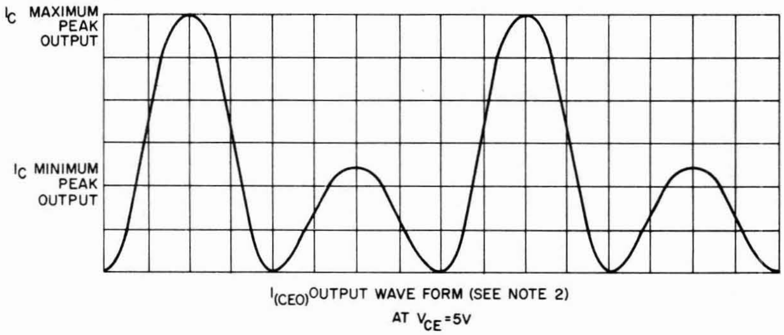
individual electrical characteristics (25 °C) (unless otherwise specified)

INFRARED EMITTING DIODE	SYMBOL	MAX.	UNITS	PHOTO-TRANSISTOR	SYMBOL	MIN.	MAX.	UNITS
Input Voltage ($I_F = \pm 10$ mA)	V_F			Breakdown Voltage ($I_C = 10$mA, $I_F = 0$)	$V_{(BR)CEO}$	30		volts
H11AA1		1.5	volts					
H11AA2		1.8	volts	Breakdown Voltage ($I_C = 100\mu$A, $I_F = 0$)	$V_{(BR)CBO}$	70		volts
Capacitance ($V = 0$, $F = 1$ MHz)	C_J	100	picofarads	Breakdown Voltage ($I_E = 100\mu$A, $I_F = 0$)	$V_{(BR)EBO}$	5		volts
				Collector Dark Current ($V_{CE} = 10$V, $I_F = 0$)	I_{CEO}			
				H11AA1			100	nanoamps
				H11AA2			200	nanoamps

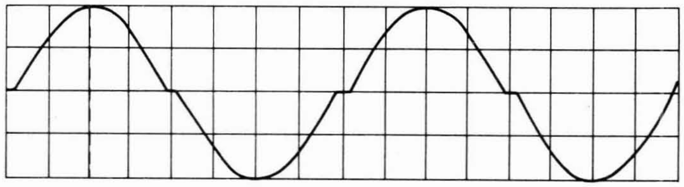
coupled electrical characteristics (25 °C) (unless otherwise specified)

	MIN.	MAX.	UNITS
Current Transfer Ratio ($V_{CE} = 10$V, $I_F = \pm 10$mA)			
H11AA1	20		percent
H11AA2	10		percent
Saturation Voltage - Collector to Emitter (I_{CEO}=0.5mA, $I_F = \pm 10$mA)		0.4	volts
Current Transfer Ratio Symmetry: $\frac{I_{CEO}(V_{CE}=10V, I_F=10mA)}{I_{CEO}(V_{CE}=10V, I_F=-10mA)}$ Note 2			
H11AA1	0.33	3.0	
Isolation Resistance (Input to Output Voltage = 500V_{DC}. See Note 1)	100		gigaohms

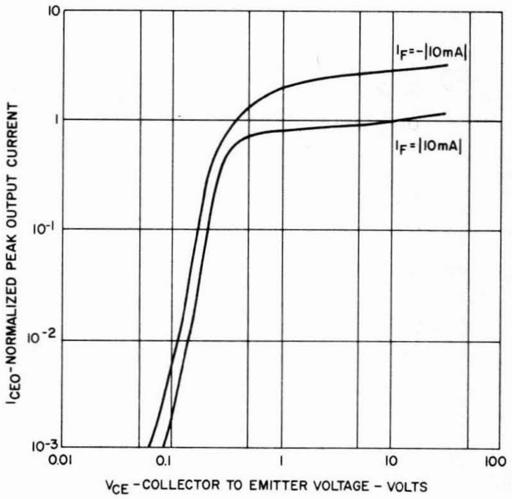
Note 1: Tests of input to output isolation current resistance, and capacitance are performed with the input terminals (diode) shorted together and the output terminals (transistor) shorted together



$I_{(CEO)}$ OUTPUT WAVE FORM (SEE NOTE 2) AT V_{CE}=5V

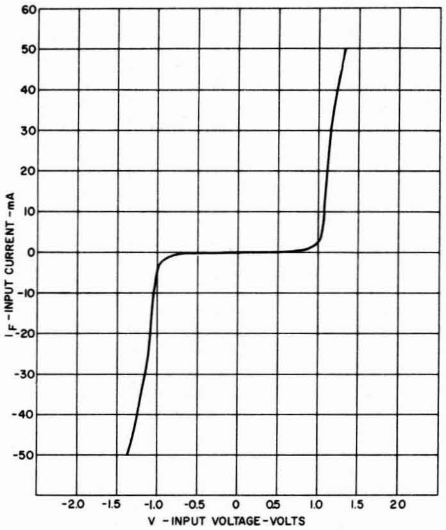


I_F INPUT WAVE FORM

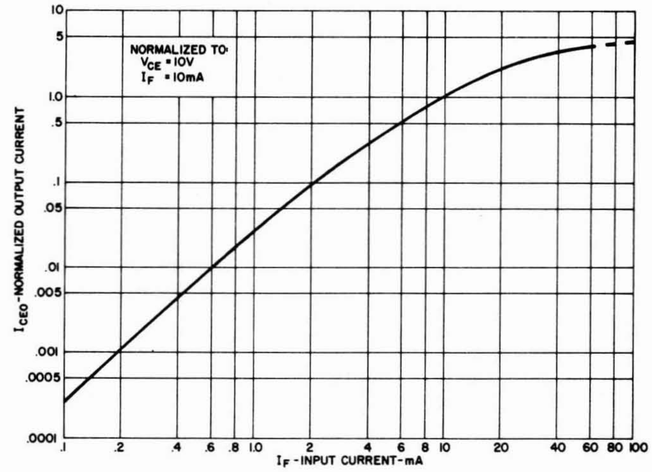


Note 2: The H11AA1 specification guarantees the maximum peak output current will be no more than three times the minimum peak output current at I_F = 10 mA

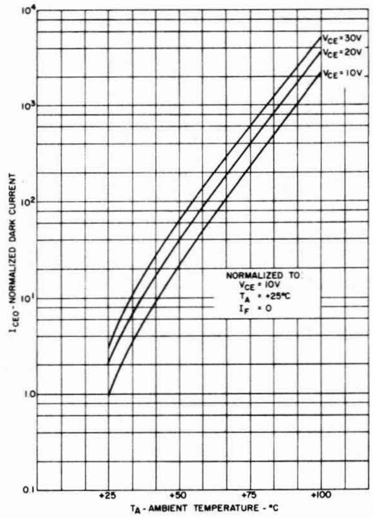
TYPICAL CHARACTERISTICS



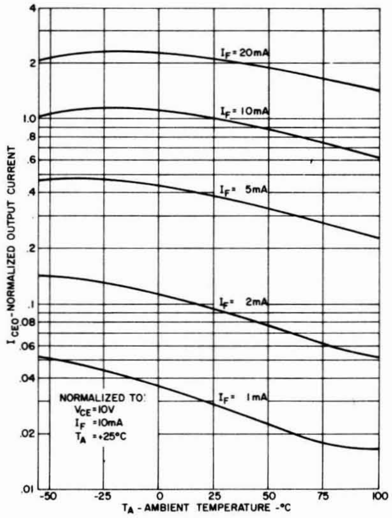
1. INPUT CHARACTERISTICS



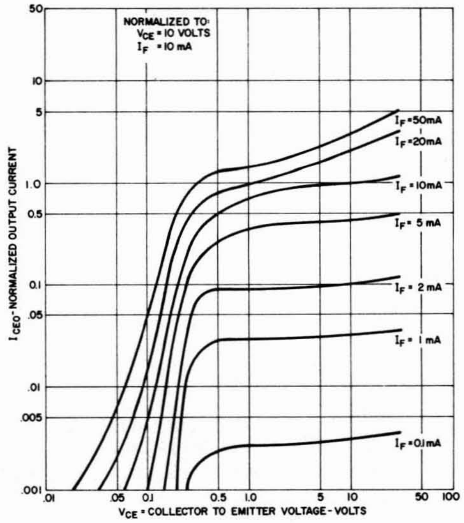
2. OUTPUT CURRENT VS INPUT CURRENT



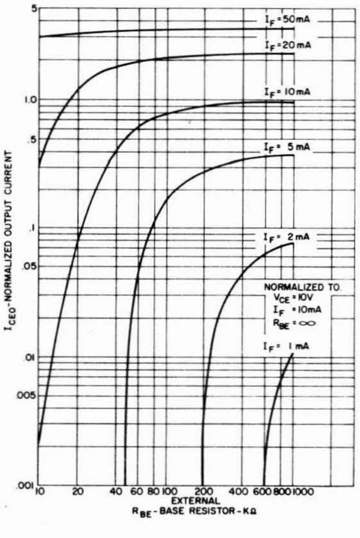
3. DARK I_{CEO} CURRENT VS TEMPERATURE



4. OUTPUT CURRENT VS TEMPERATURE

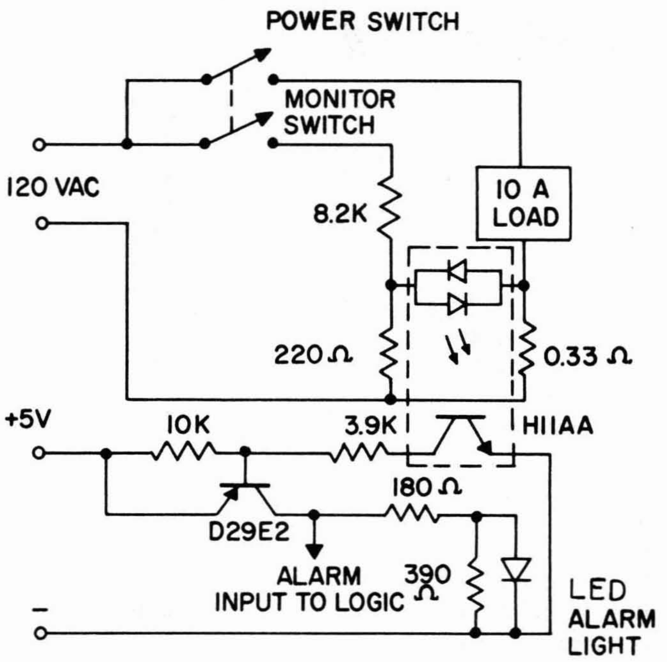


5. OUTPUT CHARACTERISTICS



6. OUTPUT CURRENT VS BASE EMITTER RESISTANCE

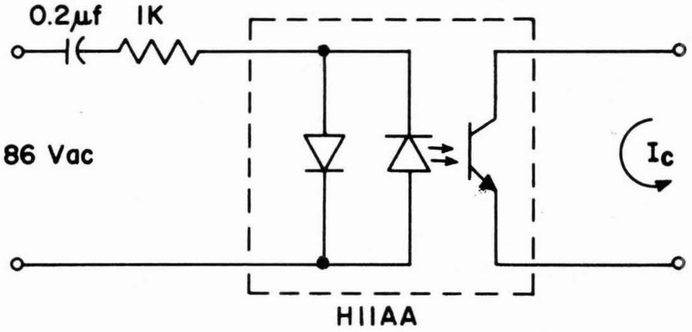
LOAD MONITOR AND ALARM



In many computer controlled systems where AC power is controlled, load dropout due to filament burnout, fusing, etc. or the opposite situation - load power when uncalled for due to switch failure can cause serious systems or safety problems. This circuit provides a simple AC power monitor which lights an alarm lamp and provides a "1" input to the computer control in either of these situations while maintaining complete electrical isolation between the logic and the power system.

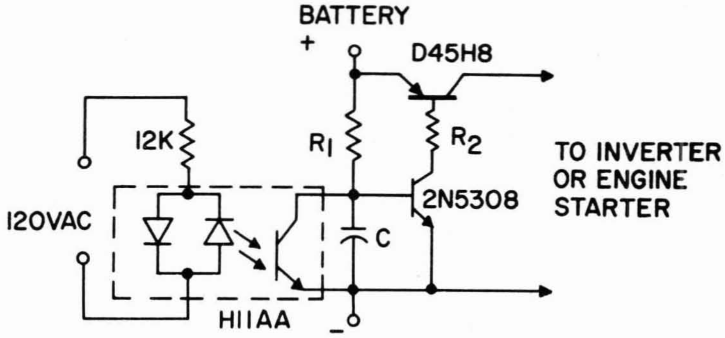
Note that for other than resistive loads, phase angle correction of the monitoring voltage divider is required.

RING DETECTOR



In many telecommunications applications it is desirable to detect the presence of a ring signal in a system without any direct electrical contact with the system. When the 86 Vac ring signal is applied, the output transistor of the H11AA is turned on indicating the presence of a ring signal in the isolated telecommunications system.

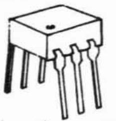
UPS SOLID STATE TURN-ON SWITCH



Interruption of the 120 VAC power line turns off the H11AA, allowing C to charge and turn on the 2N5308-D45H8 combination which activates the auxiliary power supply. This system features low standby drain, isolation to prevent ground loop problems and the capability of ignoring a fixed number of "dropped cycles" by choice of the value of C.

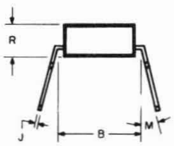
SOLID STATE
OPTOELECTRONICS

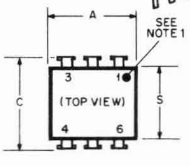
Photon Coupled Isolator H11B1,H11B2,H11B3

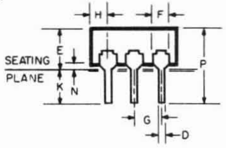


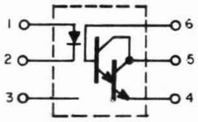
Ga As Infrared Emitting Diode & NPN Silicon Photo-Darlington Amplifier

The General Electric H11B1, H11B2 and H11B3 are gallium arsenide, infrared emitting diodes coupled with a silicon photo-darlington amplifier in a dual in-line package.









SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak)	3	ampere
(Pulse width 1 μsec 300 P Ps)		
Reverse Voltage	3	volts

*Derate 1.33mW/°C above 25°C ambient.

PHOTO-DARLINGTON		
Power Dissipation	**150	milliwatts
V_{CEO}	25	volts
V_{CBO}	30	volts
V_{ECO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds

Surge Isolation Voltage (Input to Output).

H11B1	$2500V_{(peak)}$	$1770V_{(RMS)}$
H11B2, B3	$1500V_{(peak)}$	$1060V_{(RMS)}$

Steady-State Isolation Voltage (Input to Output).

H11B1	$1500V_{(peak)}$	$1060V_{(RMS)}$
H11B2, B3	$950V_{(peak)}$	$660V_{(RMS)}$

individual electrical characteristics (25°C)

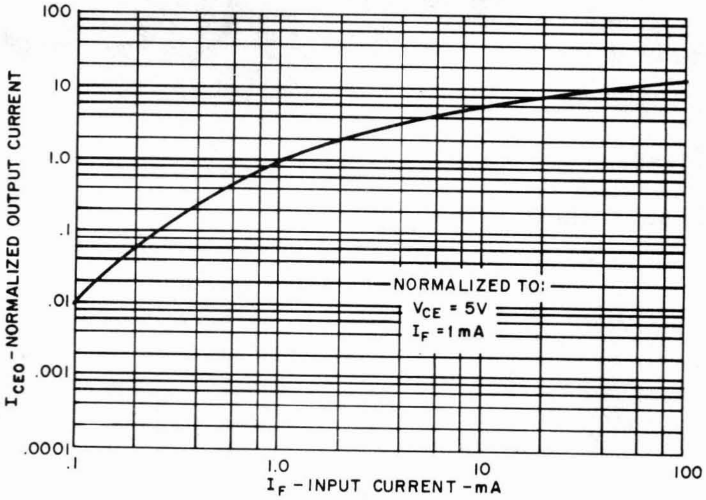
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage			
H11B1, B2 (I_F = 10mA)	1.1	1.5	volts
H11B3 (I_F = 50mA)	1.1	1.5	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = 0,f = 1MHz)	50	–	picofarads

PHOTO-DARLINGTON	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	25	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = 0)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	100	nanoamps
Capacitance (V_{CE} = 10V,f = 1MHz)	–	6	–	picofarads

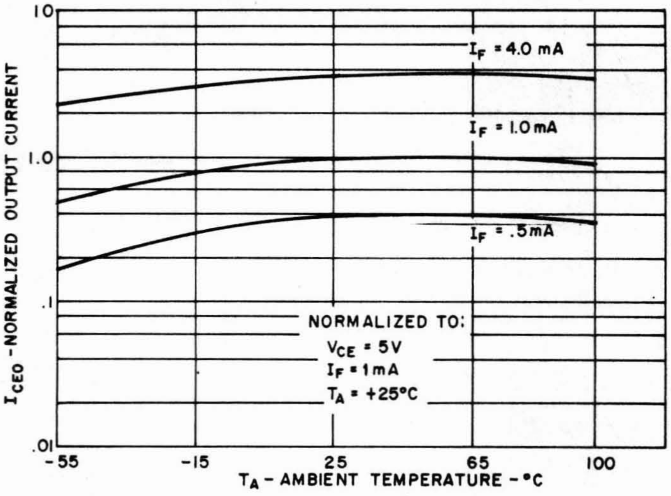
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 1mA, V_{CE} = 5V)	H11B1	500	–	–	%
	H11B2	200	–	–	%
	H11B3	100	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 1mA, I_C = 1mA)		–	0.7	1.0	volts
Isolation Resistance (Input to Output Voltage = $500V_{DC}$)		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1MHz)		–	–	2	picofarads
Switching Speeds: (V_{CE} = 10V, I_C = 10mA, R_L = 100Ω)	On-Time	–	125	–	microseconds
	Off-Time	–	100	–	microseconds

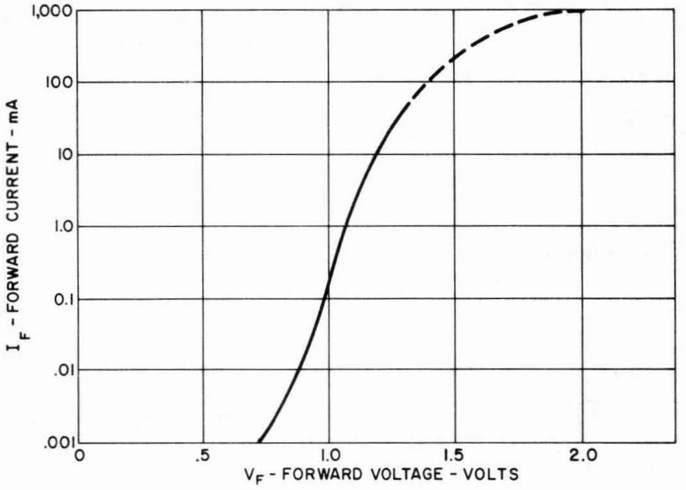
TYPICAL CHARACTERISTICS



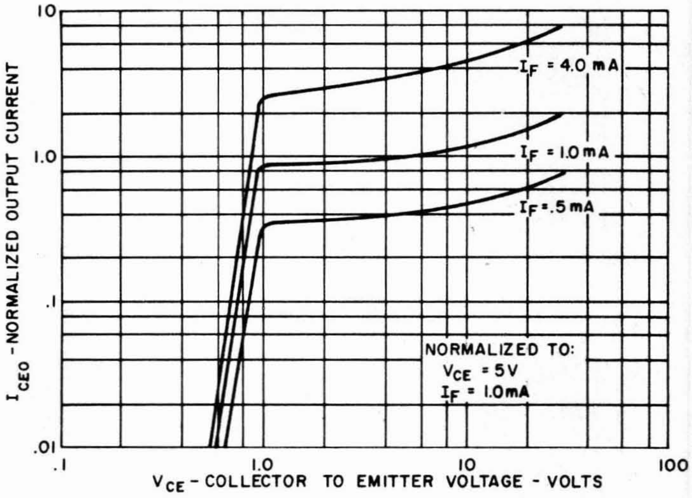
OUTPUT CURRENT VS INPUT CURRENT



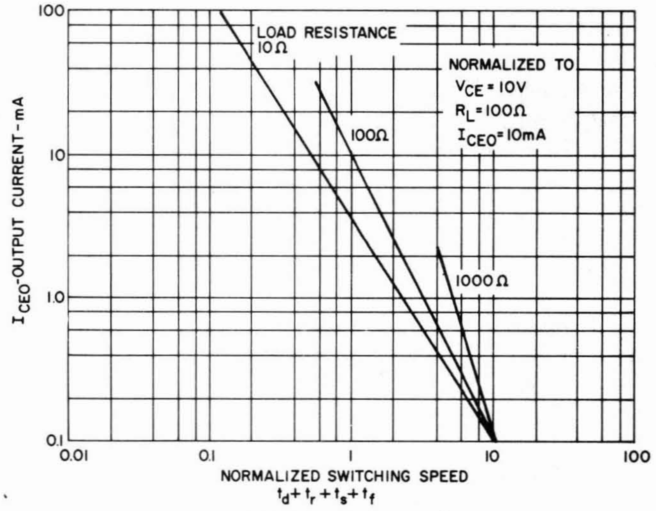
OUTPUT CURRENT VS TEMPERATURE



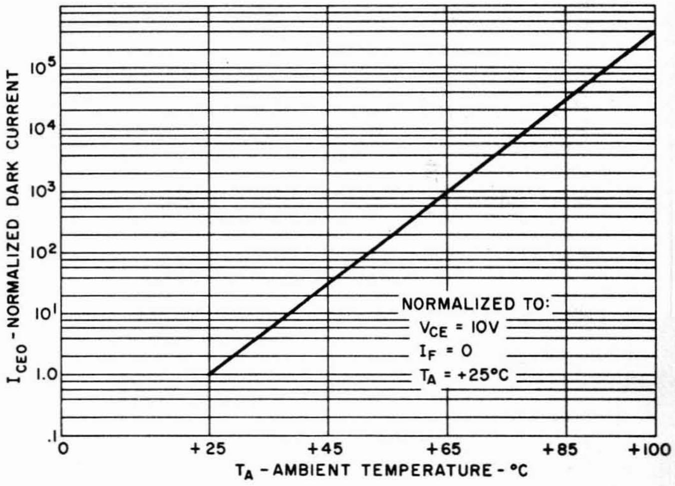
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS



SWITCHING SPEED VS OUTPUT CURRENT

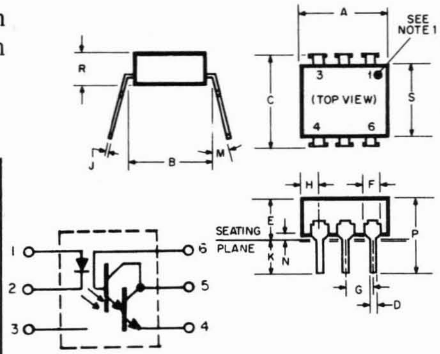


NORMALIZED DARK CURRENT VS TEMPERATURE

Photon Coupled Isolator H11B255

Ga As Infrared Emitting Diode & NPN Silicon Photo-Darlington Amplifier

The General Electric H11B255 consists of a gallium arsenide infrared emitting diode coupled with a silicon photo-darlington amplifier in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODES		
Power Dissipation	*90	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1μsec. 300 P Ps)	3	ampere
Reverse Voltage	3	volts

*Derate 1.2mW/°C above 25°C ambient.

PHOTO-DARLINGTON		
Power Dissipation	**210	milliwatts
V_{CEO}	55	volts
V_{CBO}	55	volts
V_{EBO}	8	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.8mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds.
Surge Isolation Voltage (Input to Output).
1500$V_{(peak)}$ 1060$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
950$V_{(peak)}$ 660$V_{(RMS)}$

individual electrical characteristics (25°C)

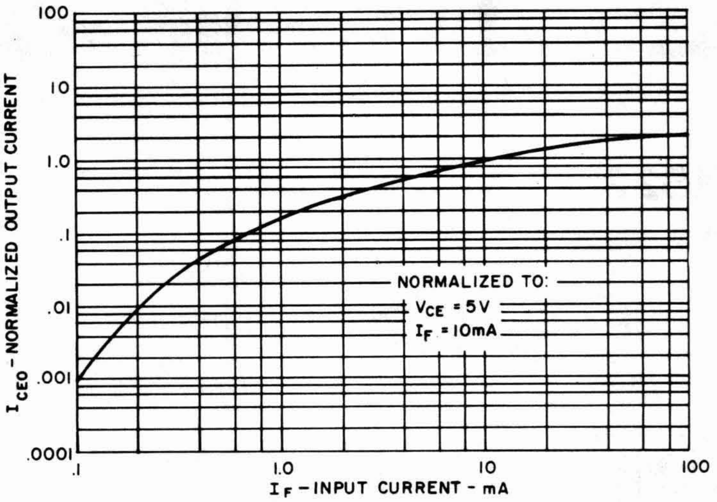
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 20mA)	1.1	1.5	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = O,f = 1 MHz)	50	–	picofarads

PHOTO-DARLINGTON	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 100μA, I_F = O)	55	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = O)	55	–	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ (I_E = 100μA, I_F = O)	8	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = O)	–	–	100	nanoamps
Capacitance (V_{CE} = 10V,f = 1 MHz)	–	2	–	picofarads

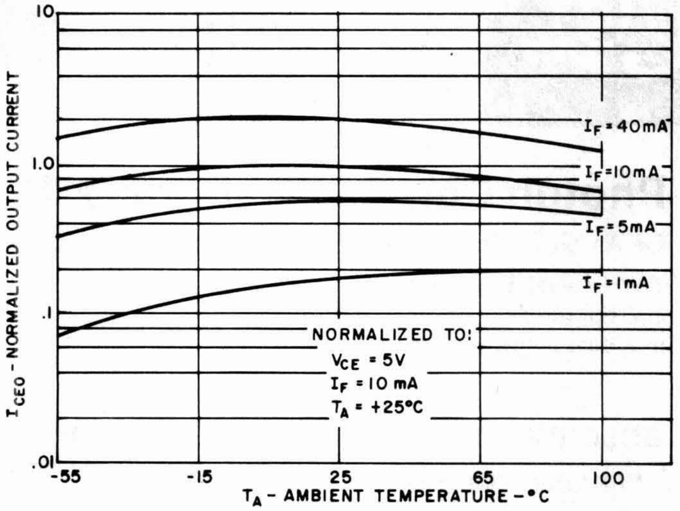
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 5V)	100	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 50mA, I_C = 50mA)	–	–	1.0	volts
Isolation Resistance (Input to Output Voltage = 500V_{DC})	100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = O,f = 1 MHz)	–	–	2	picofarads
Switching Speeds: On-Time – (V_{CE} = 10V, I_C = 10mA, R_L = 100Ω)	–	125	–	microseconds
Off-Time – (V_{CE} = 10V, I_C = 10mA, R_L = 100Ω)	–	100	–	microseconds

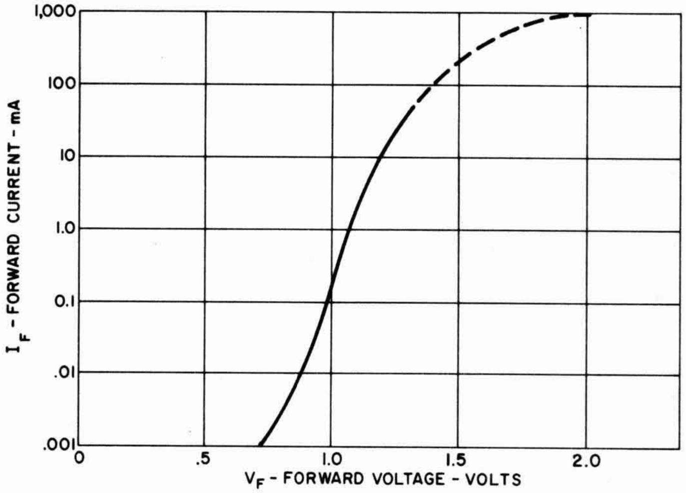
TYPICAL CHARACTERISTICS



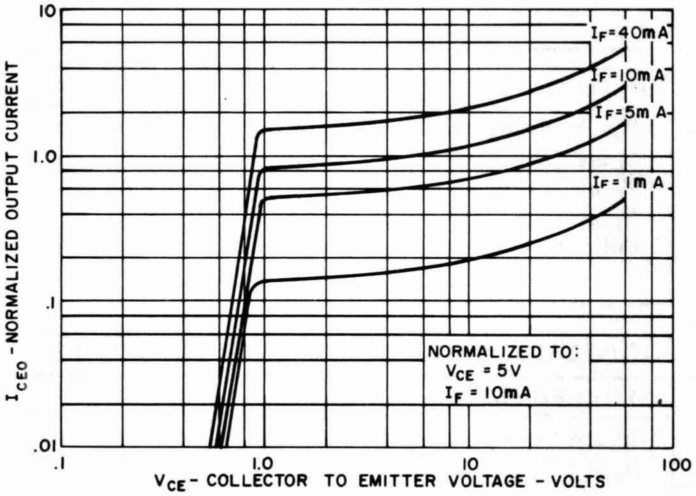
1. OUTPUT CURRENT VS. INPUT CURRENT



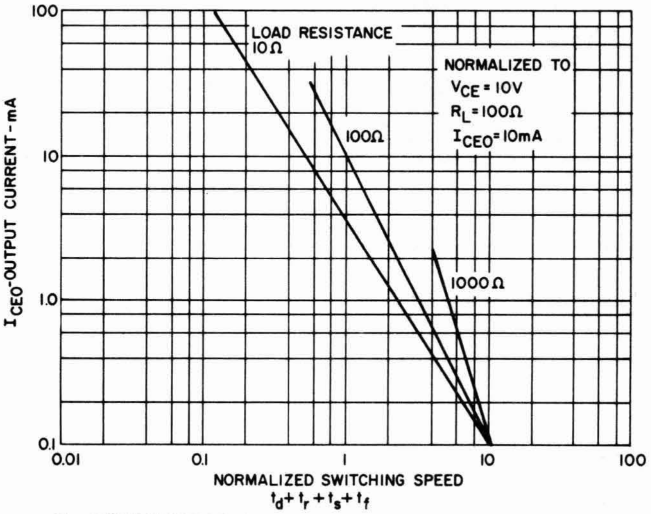
2. OUTPUT CURRENT VS. TEMPERATURE



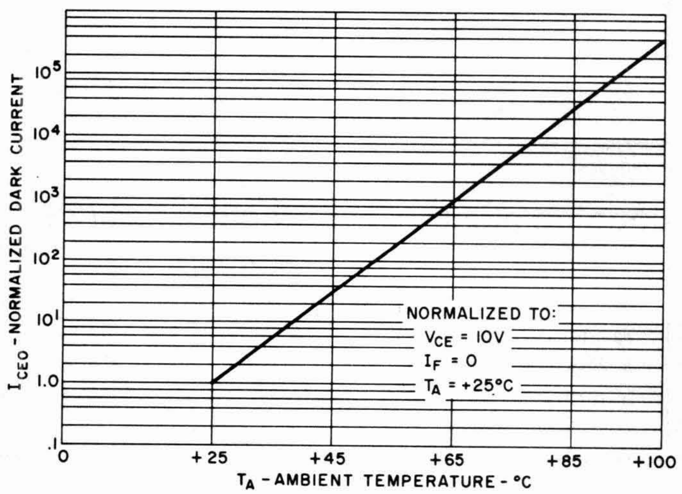
3. INPUT CHARACTERISTICS



4. OUTPUT CHARACTERISTICS



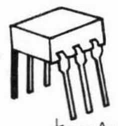
5. SWITCHING SPEED VS. OUTPUT CURRENT



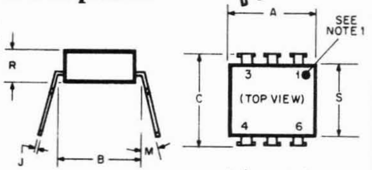
6. NORMALIZED DARK CURRENT VS. TEMPERATURE

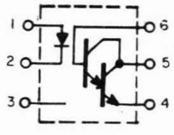
Photon Coupled Isolator H11BX522

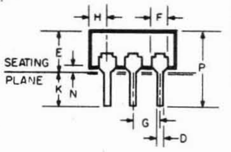
Ga As Solid State Lamp & NPN Silicon Photo-Darlington Amplifier



The General Electric H11BX522 is a gallium arsenide, infrared emitting diode coupled with a silicon photo-darlington amplifier in a dual in-line package.







SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1 μsec 300 P Ps)	3	amperes
Reverse Voltage	3	Volts

*Derate 1.33mW/° above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
V_{CEO}	25	volts
V_{CBO}	30	volts
V_{EBO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 Seconds
Surge Isolation Voltage (Input to Output).
2500$V_{(peak)}$ 1700$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output)
1500$V_{(peak)}$ 1060$V_{(RMS)}$

individual electrical characteristics (25°C)

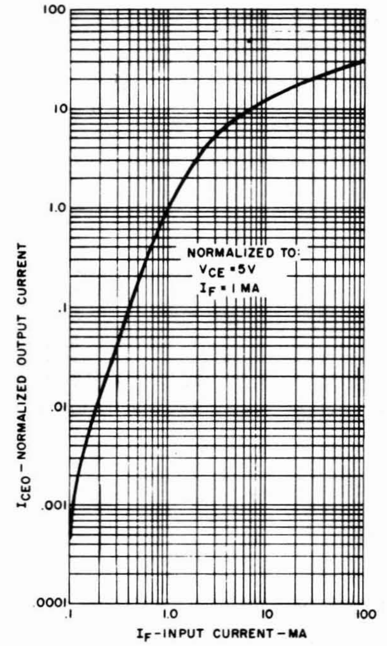
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 0.5mA)	1.0	1.15	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = 0,f = 1 MHz)	50	–	picofarads

PHOTO-DARLINGTON	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	25	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ (I_E = 100μA, I_F = 0)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 12V, R_{BE} = 7.5 M Ω, T_A = 50°C)	–	–	10	micro-amps
Capacitance Collector-Emitter – C_{CE} (V_{CE} = 10V,f = 1 MHz)	–	6	–	pico-farads

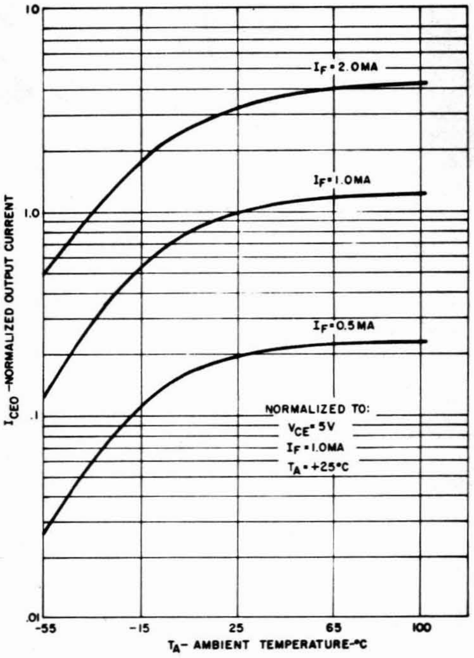
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 0.5mA, V_{CE} = 6V, R_{BE} = 7.5MΩ) -25°C → +50°C	200	–	–	%
Saturation Voltage – Collector-Emitter (I_F = 5mA, I_C = 2mA, R_{BE} = 7.5 MΩ)	–	–	1.0	Volts
Isolation Resistance (Input to Output Voltage = 500V_{DC})	–	100	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1 MHz)	–	2	–	picofarads
Switching Speeds: (I_F = 5mA, See Figure 1) t_{pr}	1	–	3	milliseconds

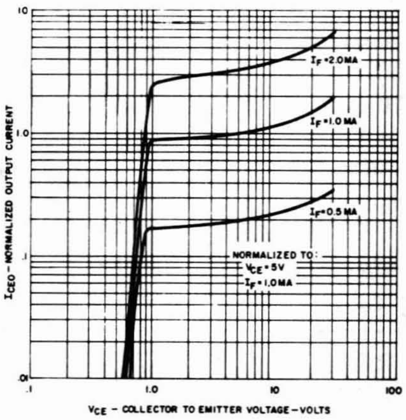
TYPICAL CHARACTERISTICS



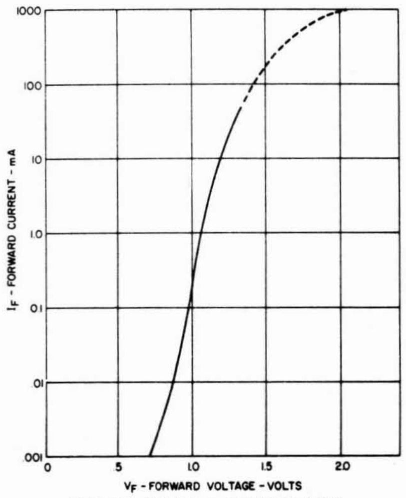
OUTPUT CURRENT VS INPUT CURRENT



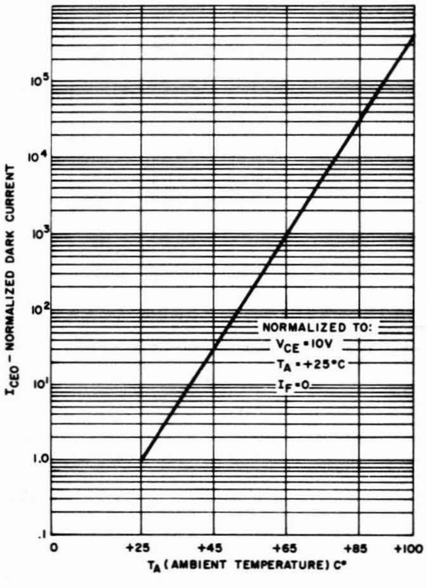
OUTPUT CURRENT VS TEMPERATURE



OUTPUT CHARACTERISTICS



INPUT CHARACTERISTICS



NORMALIZED
DARK CURRENT VS TEMPERATURE

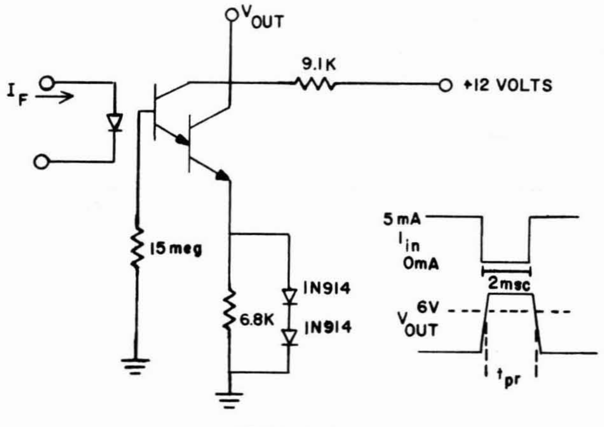
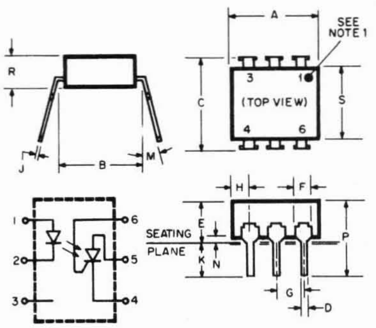


FIGURE 1.

Photon Coupled Isolator H11C1, H11C2, H11C3

Ga As Infrared Emitting Diode & Light Activated SCR

The General Electric H11C1, H11C2 and H11C3 are gallium arsenide, infrared emitting diodes coupled with light activated silicon controlled rectifiers in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE

Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak)	3	ampere
(Pulse width 1 μsec 300 P Ps)		
Reverse Voltage	6	volts

*Derate 1.33 mW/°C above 25°C ambient.

PHOTO-SCR

Peak Forward Voltage	200	volts
RMS Forward Current	300	milliamps
Forward Current (Peak)	10	amperes
(100μsec 1% duty cycle)		
Surge Current (10m sec)	5	amperes
Reverse Gate Voltage	6	volts
Power Dissipation (25°C Ambient)	** 400	milliwatts
Power Dissipation (25°C Case)	***1000	milliwatts

**Derate 5.3mW/°C above 25°C ambient.
***Derate 13.3mW/°C above 25°C case.

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).

H11C1	2500$V_{(peak)}$	1770$V_{(RMS)}$
H11C2	2100$V_{(peak)}$	1500$V_{(RMS)}$
H11C3	2100$V_{(peak)}$	1500$V_{(RMS)}$

Steady-State Isolation Voltage (Input to Output).

H11C1	1500$V_{(peak)}$	1060$V_{(RMS)}$
H11C2	1260$V_{(peak)}$	890$V_{(RMS)}$
H11C3	1260$V_{(peak)}$	890$V_{(RMS)}$

individual electrical characteristics (25°C)

INFRARED EMITTING DIODE		TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	V_F	1.2	1.5	volts
Reverse Current (V_R = 3V)	I_R	–	10	microamps
Capacitance (V = 0,f = 1MHz)	C_J	50	–	picofarads

PHOTO-SCR	MIN.	TYP.	MAX.	UNITS
Peak Off-State Voltage – V_{DM} (R_{GK} = 10KΩ, 100°C)	200	–	–	volts
Peak Reverse Voltage – V_{RM} (R_{GK} = 10KΩ, 100°C)	200	–	–	volts
On-State Voltage – V_{TM} (I_{TM} = .3 amp)	–	1.1	1.3	volts
Off-State Current – I_{DM} (V_{DM} = 200V, T_A = 100°C)	–	–	50	microamps
Reverse Current – I_{RM} (V_{RM} = 200V, T_A = 100°C)	–	–	50	microamps
Capacitance (Anode-Gate)	–	20	–	picofarads
V=0V,f=1MHz(Gate-Cathode)	–	350	–	picofarads

coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
Input Current to Trigger (V_{AK} = 50V, R_{GK} = 10KΩ)	H11C1, C2	–	–	20	milliamps
	H11C3	–	–	30	milliamps
Input Current to Trigger (V_{AK} = 100V, R_{GK} = 27KΩ)	H11C1, C2	–	–	11	milliamps
	H11C3	–	–	14	milliamps
Isolation Resistance (Input to Output Voltage = 500V_{DC})		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1MHz)		–	–	2	picofarads
Coupled dV/dt, Input to Output (See Figure 13)		500	–	–	volts/μsec

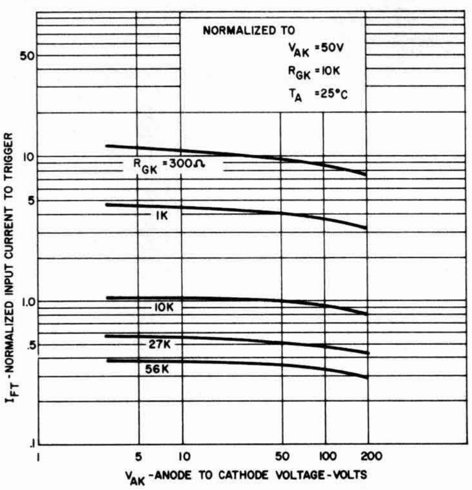


FIGURE 1. INPUT CURRENT TO TRIGGER VS ANODE-CATHODE VOLTAGE

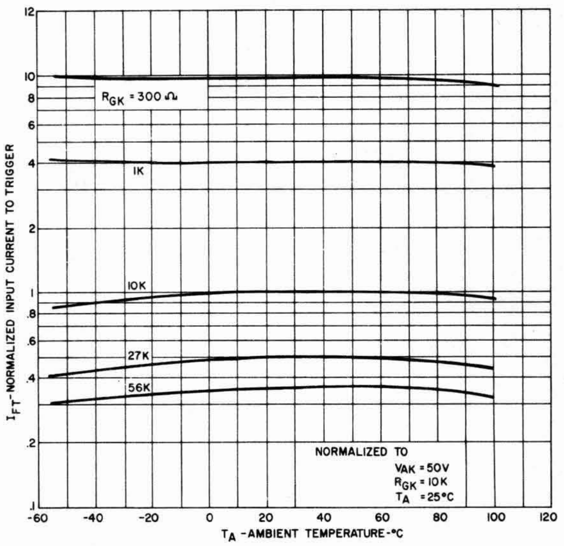


FIGURE 2. INPUT CURRENT TO TRIGGER VS TEMPERATURE

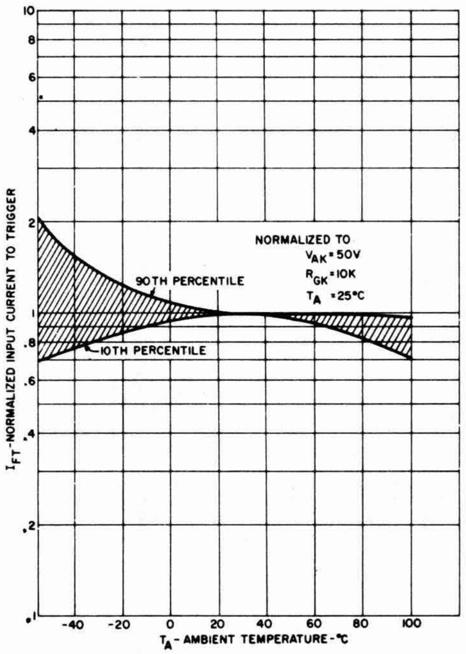


FIGURE 3. INPUT CURRENT TO TRIGGER DISTRIBUTION VS TEMPERATURE

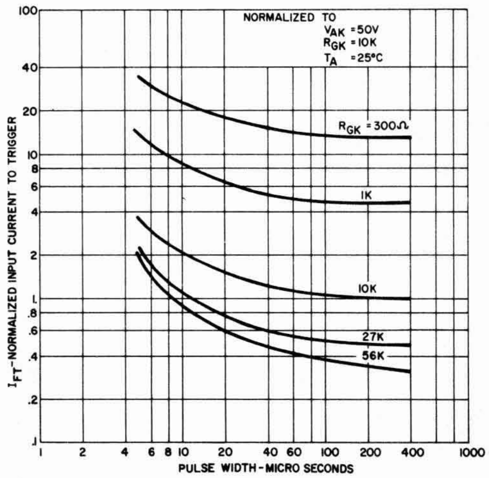
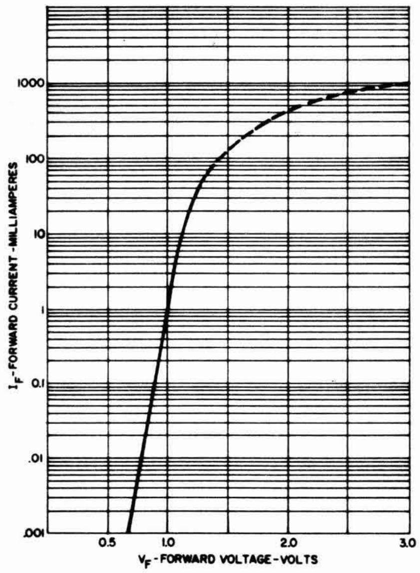


FIGURE 4. INPUT CURRENT TO TRIGGER VS PULSE WIDTH



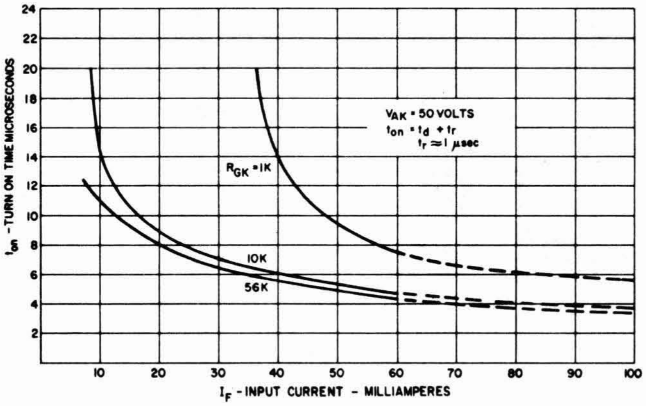


FIGURE 5. TURN ON TIME VS INPUT CURRENT

FIGURE 6. INPUT CHARACTERISTICS I_F VS V_F

TYPICAL CHARACTERISTICS OF OUTPUT (SCR)

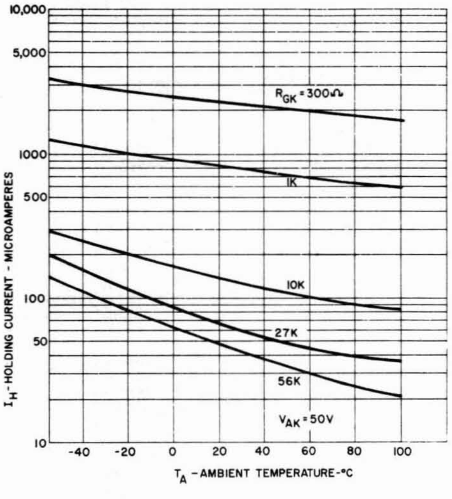


FIGURE 7. HOLDING CURRENT VS TEMPERATURE

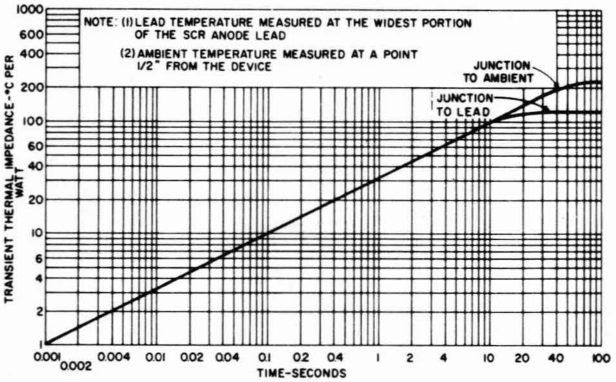


FIGURE 8. MAXIMUM TRANSIENT THERMAL IMPEDANCE

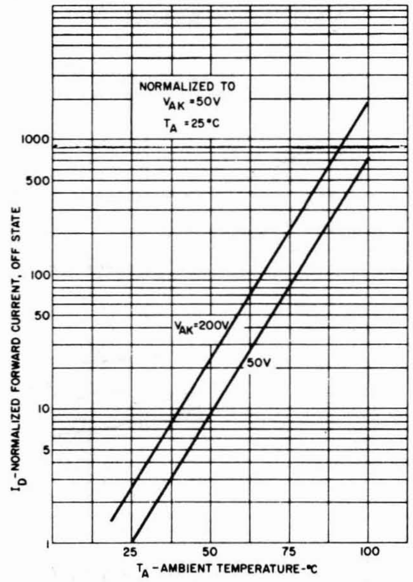


FIGURE 9. OFF STATE FORWARD CURRENT VS TEMPERATURE

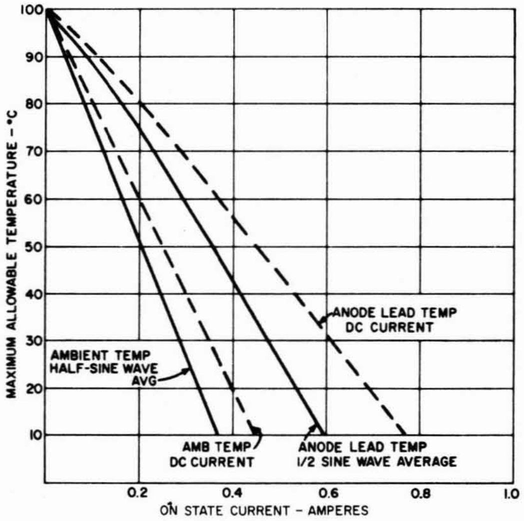


FIGURE 10. ON STATE CURRENT VS MAXIMUM ALLOWABLE TEMPERATURE

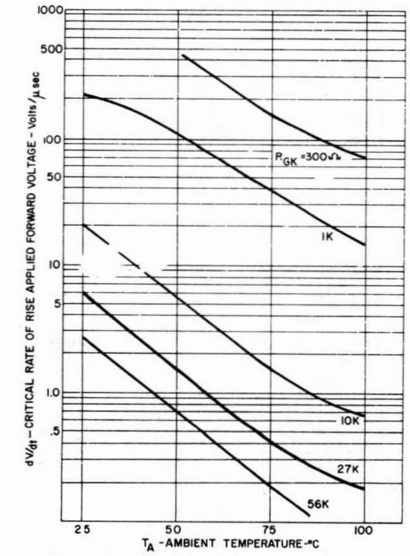


FIGURE 11. dV/dt VS TEMPERATURE

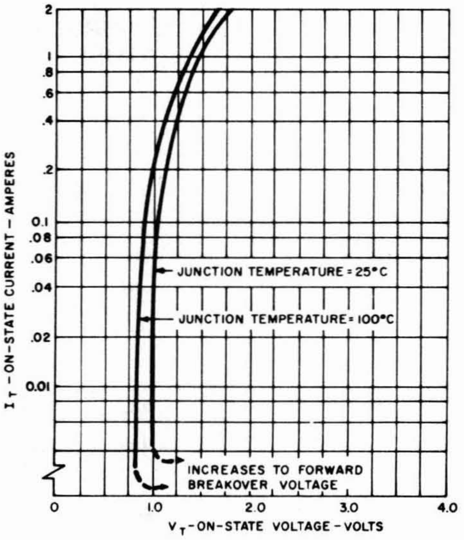
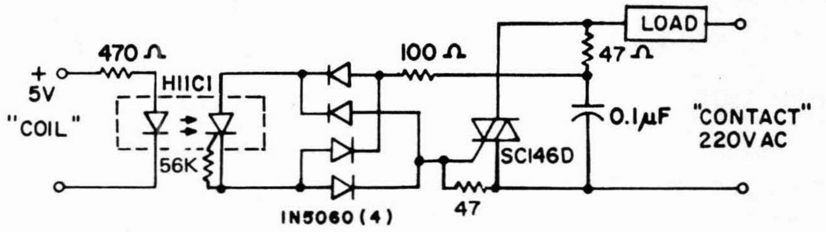


FIGURE 12. ON-STATE CHARACTERISTICS

TYPICAL APPLICATIONS

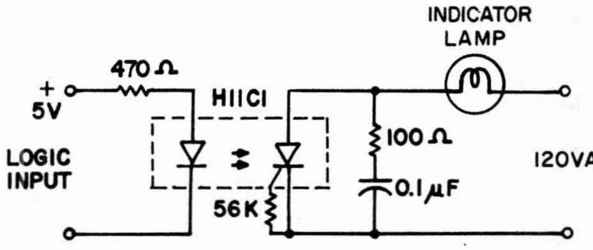
10A, T²L COMPATABLE, SOLID STATE RELAY

Use of the H11C1 for high sensitivity, 2500 v isolation capability, provides this highly reliable solid state relay design. This design is compatable with 74, 74S and 74H series T²L logic systems inputs and 120VAC loads up to 10 A.



25W LOGIC INDICATOR LAMP DRIVER

The high surge capability and non-reactive input characteristics of the H11C allow it to directly couple, without buffers, T²L and DTL logic to indicator and alarm devices, without danger of introducing noise and logic glitches.



200V SYMMETRICAL TRANSISTOR COUPLER

Use of the high voltage PNP portion of the H11C provides a 200V transistor capable of conducting positive and negative signals with current transfer ratios of over 1%. This function is useful in remote instrumentation, high voltage power supplys and test equipment. Care should be taken not to exceed the H11C 400 mW power dissipation rating when used at high voltages.

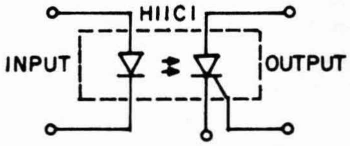
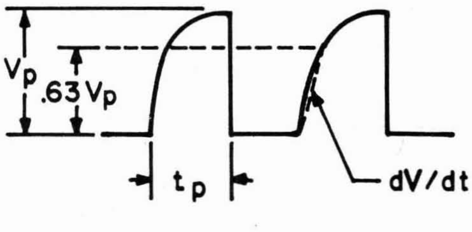
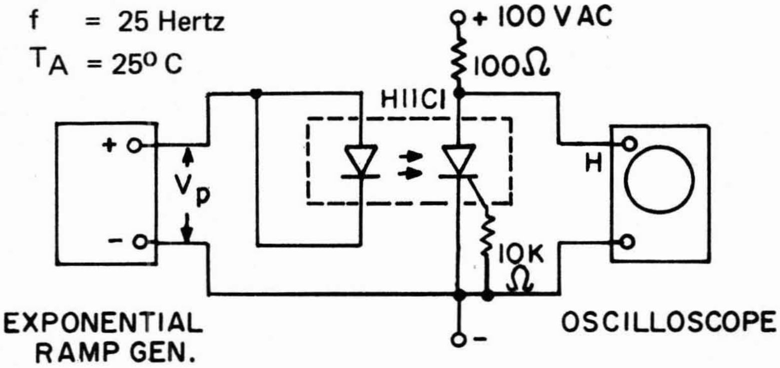


FIGURE 13
COUPLED dV/dt – TEST CIRCUIT

V_p = 800 Volts
t_p =.010 Seconds
f = 25 Hertz
T_A = 25° C





SOLID STATE
OPTOELECTRONICS

Photon Coupled Isolator H11C4 , H11C5 , H11C6

Ga As Infrared Emitting Diode & Light Activated SCR

The General Electric H11C4, H11C5 and H11C6 are gallium arsenide, infrared emitting diodes coupled with light activated silicon controlled rectifiers in a dual in-line package.

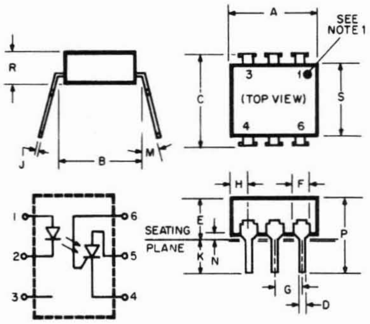
absolute maximum ratings: (25 °C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1μsec 300 P Ps)	3	ampere
Reverse Voltage	6	volts

*Derate 1.33mW/°C above 25°C ambient.

PHOTO – SCR		
Peak Forward Voltage	400	volts
RMS Forward Current	300	milliamps
Forward Current (Peak) (100μsec 1% duty cycle)	10	amperes
Surge Current (10m sec)	5	amperes
Reverse Gate Voltage	6	volts
Power Dissipation (25°C Ambient)	** 400	milliwatts
Power Dissipation (25°C Case)	***1000	milliwatts

**Derate 5.3mW/°C above 25°C ambient.
***Derate 13.3mW/°C above 25°C case.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).

H11C4	$2500V_{(peak)}$	$1770V_{(RMS)}$
H11C5	$2100V_{(peak)}$	$1500V_{(RMS)}$
H11C6	$2100V_{(peak)}$	$1500V_{(RMS)}$

Steady-State Isolation Voltage (Input to Output).

H11C4	$1500V_{(peak)}$	$1060V_{(RMS)}$
H11C5	$1260V_{(peak)}$	$890V_{(RMS)}$
H11C6	$1260V_{(peak)}$	$890V_{(RMS)}$

individual electrical characteristics (25 °C)

INFRARED EMITTING DIODE		TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	V_F	1.2	1.5	volts
Reverse Current (V_R = 3V)	I_R	–	10	microamps
Capacitance (V = O,f = 1MHz)	C_J	50	–	picofarads

PHOTO – SCR	MIN.	TYP.	MAX.	UNITS
Peak Off-State Voltage – V_{DM} (R_{GK} = 10KΩ, 100°C)	400	–	–	volts
Peak Reverse Voltage – V_{RM} (R_{GK} = 10KΩ, 100°C)	400	–	–	volts
On-State Voltage – V_{TM} (I_{TM} = .3 amp)	–	1.1	1.3	volts
Off-State Current – I_{DM} (V_{DM} = 400V, T_A = 100°C)	–	–	150	microamps
Reverse Current – I_{RM} (V_{RM} = 400V, T_A = 100°C)	–	–	150	microamps
Capacitance (Anode-Gate)	–	20	–	picofarads
V=0V,f=1MHz (Gate-Cathode)	–	350	–	picofarads

coupled electrical characteristics (25 °C)

		MIN.	TYP.	MAX.	UNITS
Input Current to Trigger (V_{AK} = 50V, R_{GK} = 10KΩ)	H11C4, C5	–	–	20	milliamps
	H11C6	–	–	30	milliamps
Input Current to Trigger (V_{AK} = 100 V, R_{GK} = 27KΩ)	H11C4, C5	–	–	11	milliamps
	H11C6	–	–	14	milliamps
Isolation Resistance (Input to Output Voltage = 500V_{DC})		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = O,f = 1MHz)		–	–	2	picofarads
Coupled dv/dt, Input to Output (See Figure 13)		500	–	–	volts/μsec

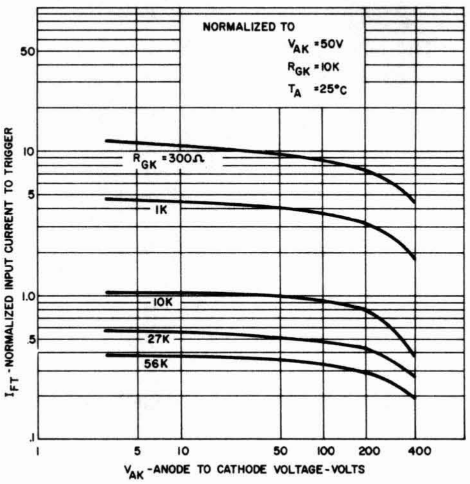


FIGURE 1. INPUT CURRENT TO TRIGGER VS. ANODE-CATHODE VOLTAGE

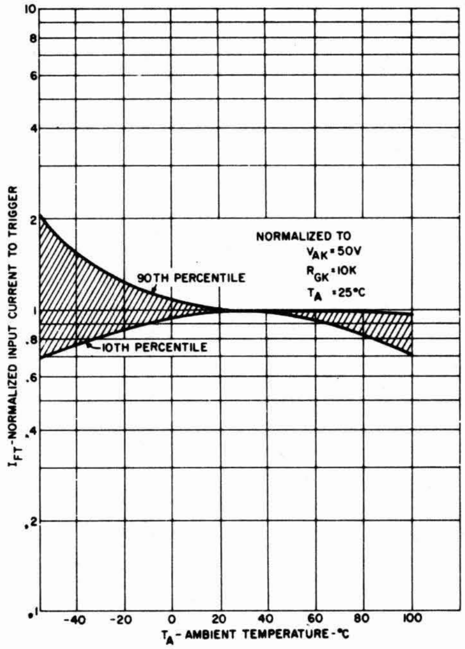


FIGURE 3. INPUT CURRENT TO TRIGGER DISTRIBUTION VS. TEMPERATURE

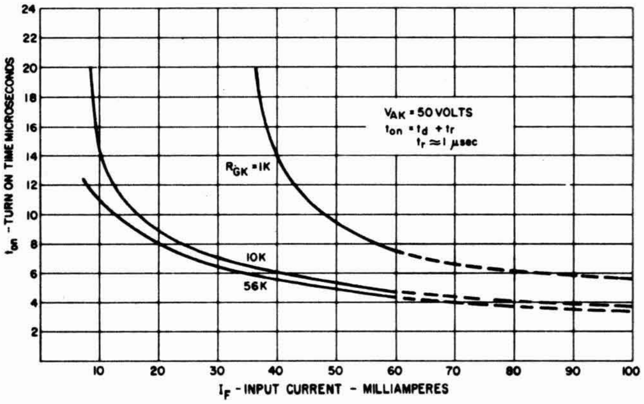


FIGURE 5. TURN-ON TIME VS. INPUT CURRENT

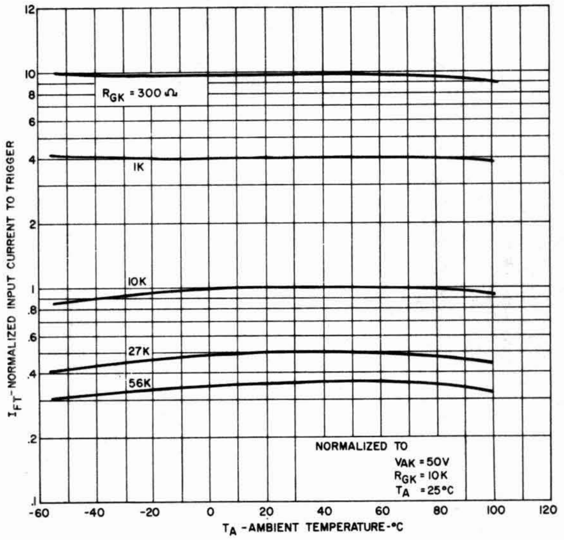


FIGURE 2. INPUT CURRENT TO TRIGGER VS. TEMPERATURE

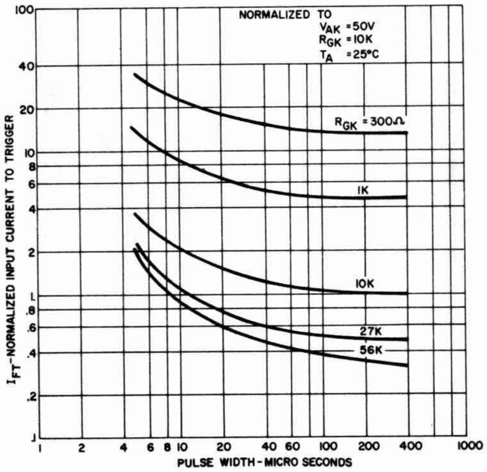


FIGURE 4. INPUT CURRENT TO TRIGGER VS. PULSE WIDTH

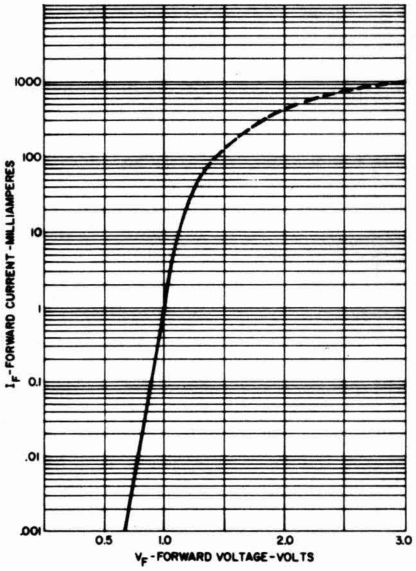


FIGURE 6. INPUT CHARACTERISTICS I_F VS. V_F

TYPICAL CHARACTERISTICS OF OUTPUT (SCR)

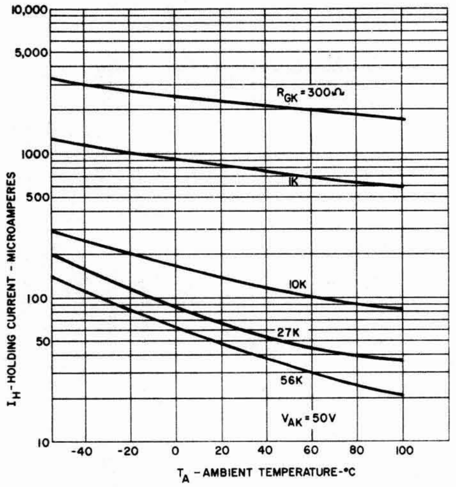


FIGURE 7. HOLDING CURRENT VS. TEMPERATURE

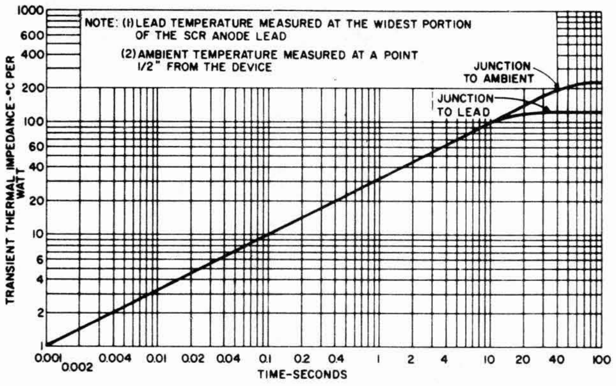


FIGURE 8. MAXIMUM TRANSIENT THERMAL IMPEDANCE

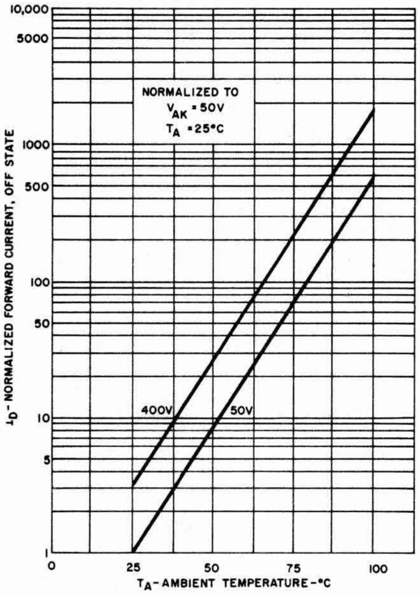


FIGURE 9. OFF-STATE FORWARD CURRENT VS. TEMPERATURE

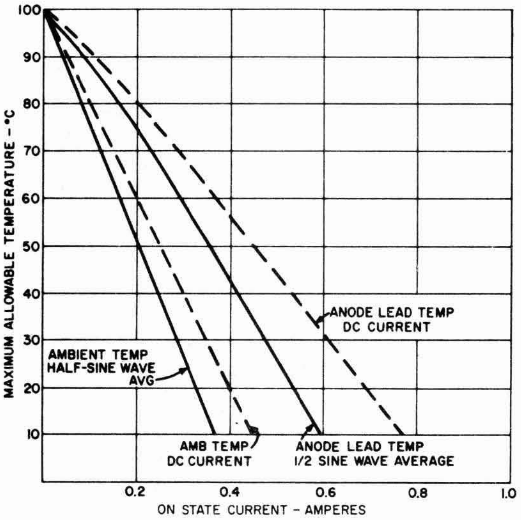


FIGURE 10. ON-STATE CURRENT VS. MAXIMUM ALLOWABLE TEMPERATURE

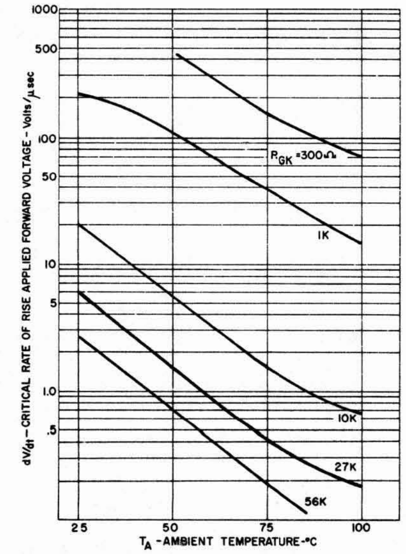


FIGURE 11. dv/dt VS. TEMPERATURE

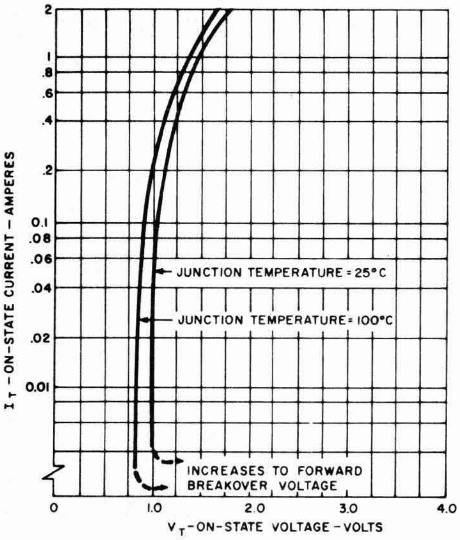
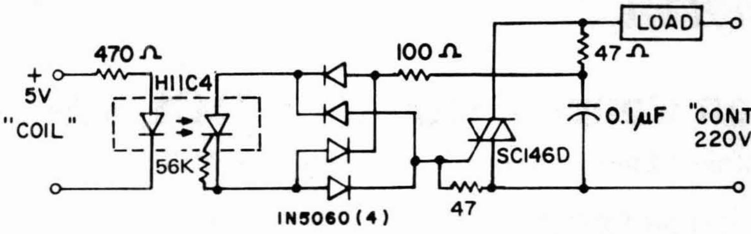


FIGURE 12. ON-STATE CHARACTERISTICS

TYPICAL APPLICATIONS

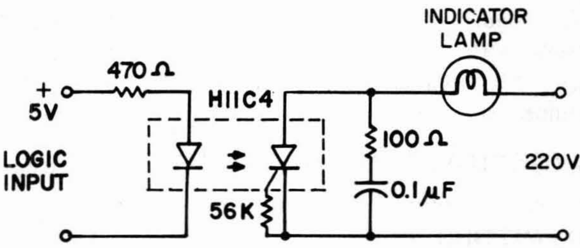
10A, T^2L COMPATIBLE, SOLID STATE RELAY

Use of the H11C4 for high sensitivity, 2500V isolation capability, provides this highly reliable solid state relay design. This design is compatible with 74, 74S and 74H series T^2L logic systems inputs and 220V AC loads up to 10A.



25W LOGIC INDICATOR LAMP DRIVER

The high surge capability and non-reactive input characteristics of the H11C allow it to directly couple, without buffers, T^2L and DTL logic to indicator and alarm devices, without danger of introducing noise and logic glitches.



400V SYMMETRICAL TRANSISTOR COUPLER

Use of the high voltage PNP portion of the H11C provides a 400V transistor capable of conducting positive and negative signals with current transfer ratios of over 1%. This function is useful in remote instrumentation, high voltage power supplies and test equipment. Care should be taken not to exceed the H11C 400 mW power dissipation rating when used at high voltages.

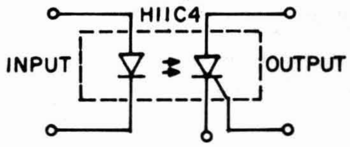
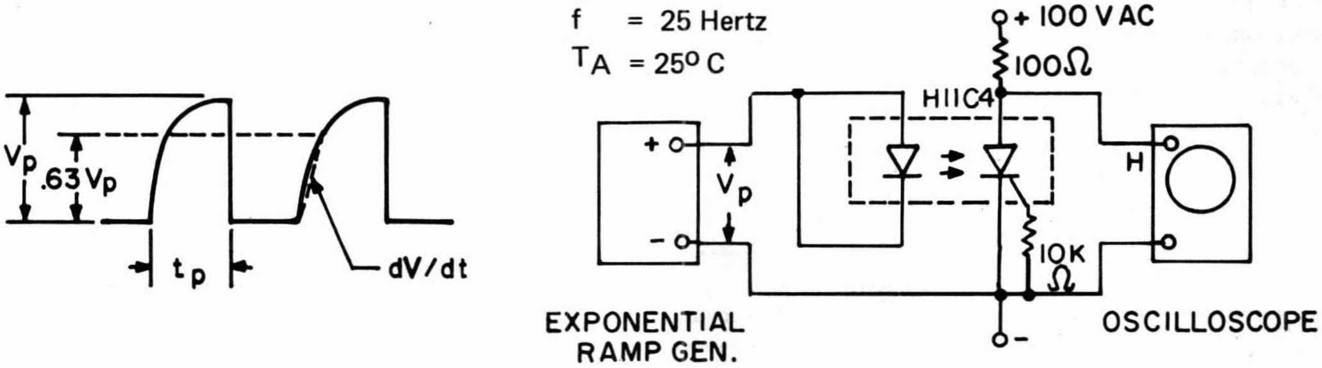


FIGURE 13
COUPLED dv/dt – TEST CIRCUIT

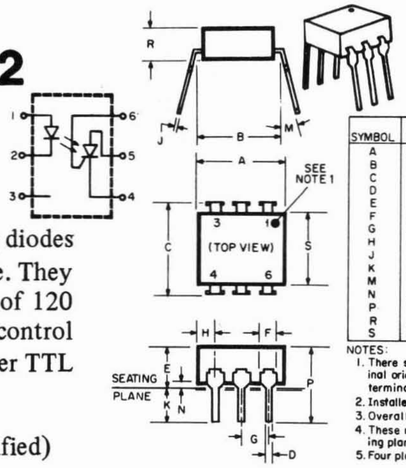
V_p = 800 Volts
t_p =.010 Seconds
f = 25 Hertz
T_A = 25° C



Photon Coupled Isolator H74C1, H74C2

Ga As Infrared Emitting Diode & Light Activated SCR

TTL Interface



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

The General Electric H74C1 and H74C2 are gallium arsenide infrared emitting diodes coupled with light activated silicon controlled rectifiers in a dual in-line package. They are specifically designed to operate from TTL logic inputs and allow control of 120 or 240V_{AC} power with 7400, 74H00 and 74S00 series logic gates. It can also control up to 400V_{DC} power circuits. They are guaranteed and specified to operate over TTL voltage and temperature ranges using standard tolerance components.

absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE

Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak 100μsec 1% duty cycle)	1	ampere
Reverse Voltage	6	volts

*Derate 1.33 mW/°C above 25°C ambient.

PHOTO – SCR

Peak Forward Voltage		
H74C1	200	volts
H74C2	400	volts
RMS Forward Current	300	milliamps
Forward Current (Peak, 100μsec 1% duty cycle)	10	amperes
Surge Current (10 msec)	5	amperes
Reverse Gate Voltage	6	volts
Power Dissipation (25°C Ambient)	** 400	milliwatts
Power Dissipation (25°C Case)	***1000	milliwatts

**Derate 5.3 mW/°C above 25°C ambient.
***Derate 13.3 mW/°C above 25°C case.

electrical characteristics of H74C*

*All specifications refer to the following bias configuration (Figure 1) over the full operating temperature (0°C to 70°C) and logic supply voltage range (4.5 to 5.5V_{DC}) unless otherwise noted.

SCR Leakage, Logic Gate $V_{OUT(1)}$, Both Directions	50	μA Max.
SCR Drop, Anode Positive, Logic Gate $V_{OUT(0)}$, I_{TM} = 250mA	1.3	V Max.
Coupled dv/dt to Trigger, V_{DC} to V_{AC} (25°)	500	V/μsec. Min.
Capacitance (Input to Output Voltage = 0, f = 1 MHz)	2	pF Max.
Isolation Resistance (Input to Output Voltage = 500V_{DC})	100	Gigaohms Min.
Turn-On Time of SCR; $V_{OUT(0)}$, Input to Output (25°C)	200	μsec. Max.

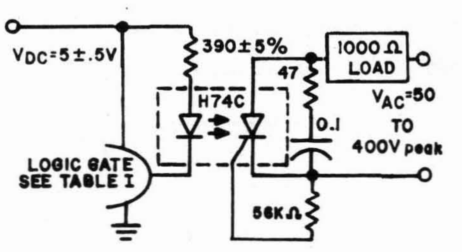


Figure 1. H74C BIAS CIRCUIT

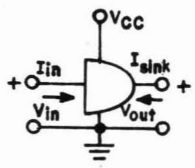


Figure 2.

absolute maximum ratings – total device

SCR Current	See Figure 4
Operating Temperature Range	0°C to 70°C
Operating Voltage Range, V_{DC}	4.5 to 5.5V_{DC}
Operating Voltage Range, H74C1	50 to 200 V_{pk}
Operating Voltage Range, H74C2	50 to 400 V_{pk}
Storage Temperature Range	-55°C to 150°C
Lead Soldering Time (at 260°C)	10 sec. Max.
Surge Isolation Voltage (Input to Output) 1500 $V_{(peak)}$	1060V_{RMS}
Steady-State Isolation Voltage (Input to Output) 950 $V_{(peak)}$	660V_{RMS}

TABLE 1. Characteristics required of TTL gate which is to be interfaced with H74C.

PARAMETER	TEST CONDITIONS, FIGURE 2						LIMITS		
	V_{CC}		I_{IN}		I_{SINK}		MIN.	MAX.	UNITS
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.			
V_{OUT} (1)	4.5V					-0.4mA	2.4		Volts
V_{OUT} (0)	4.5V				12.0mA			0.4	Volts

TYPICAL CHARACTERISTICS OF OUTPUT (SCR)

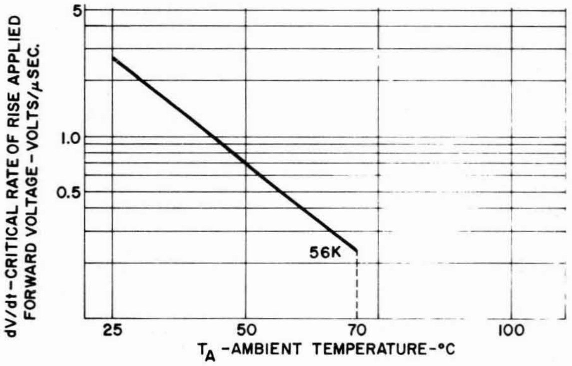


FIGURE 1. dv/dt VS. TEMPERATURE

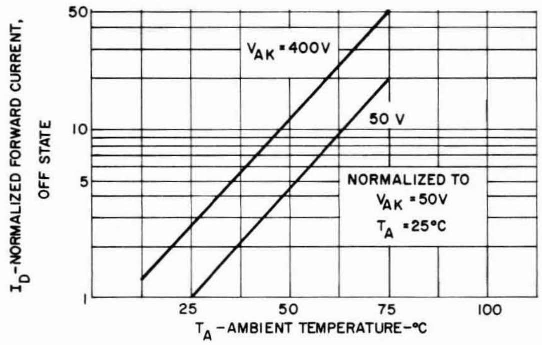


FIGURE 3. OFF-STATE FORWARD CURRENT VS. TEMPERATURE

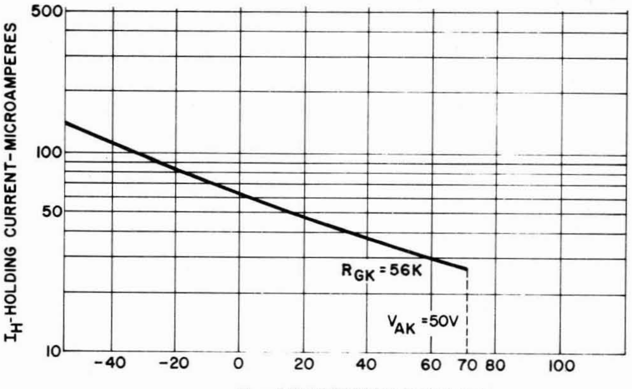


FIGURE 5. HOLDING CURRENT VS. TEMPERATURE

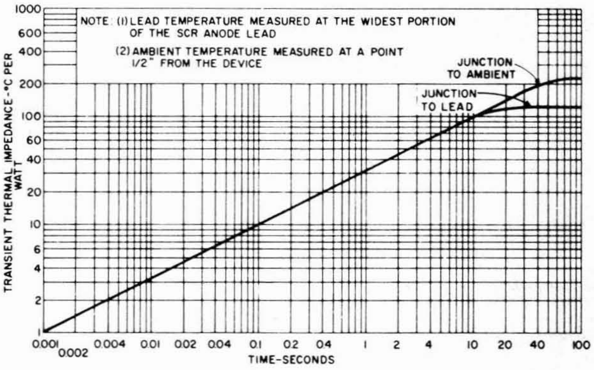


FIGURE 2. MAXIMUM TRANSIENT THERMAL IMPEDANCE

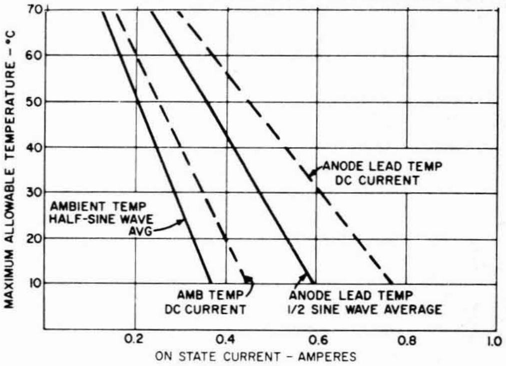


FIGURE 4. ON-STATE CURRENT VS. MAXIMUM ALLOWABLE TEMPERATURE

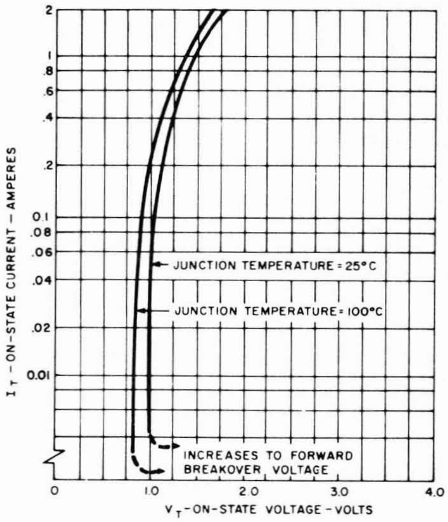
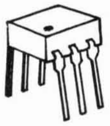


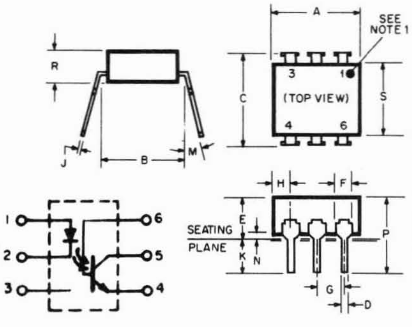
FIGURE 6. ON-STATE CHARACTERISTICS

Photon Coupled Isolator H11D1-H11D4

Ga As Infrared Emitting Diode & NPN Silicon High Voltage Photo-Transistor



The General Electric H11D1-H11D4 are gallium arsenide, infrared emitting diodes coupled with silicon high voltage photo-transistors in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
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M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
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NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
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4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1μsec 300 P Ps)	3	ampere
Reverse Voltage	6	volts

*Derate 1.33mW/°C above 25°C ambient.

PHOTO-TRANSISTOR	H11D1-D2	H11D3-D4	
Power Dissipation	**300	**300	milliwatts
V_{CER}	300	200	volts
V_{CBO}	300	200	volts
V_{ECO}	7	7	volts
Collector Current (Continuous)	100	100	milliamps

**Derate 4.0mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 150°C

Operating Temperature -55 to 100°C

Lead Soldering Time (at 260°C) 10 seconds.

Surge Isolation Voltage (Input to Output).

H11D1	$2500V_{(peak)}$	$1770V_{(RMS)}$
H11D2, D3, D4	$1500V_{(peak)}$	$1060V_{(RMS)}$

Steady-State Isolation Voltage (Input to Output).

H11D1	$1500V_{(peak)}$	$1060V_{(RMS)}$
H11D2, D3, D4	$950V_{(peak)}$	$660V_{(RMS)}$

individual electrical characteristics (25°C)

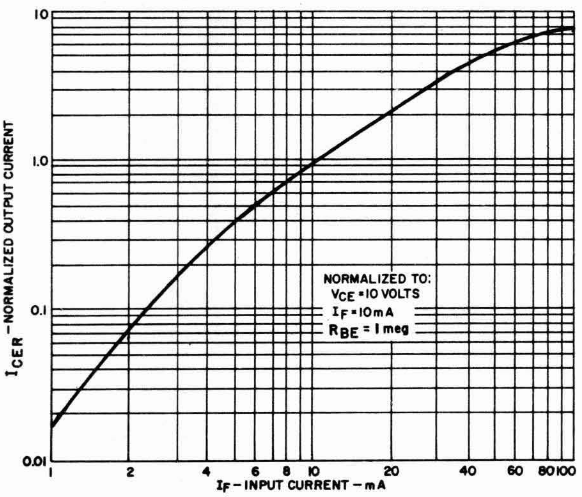
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.5	volts
Reverse Current (V_R = 6V)	–	10	microamps
Capacitance (V = 0,f = 1MHz)	50	–	picofarads

PHOTO-TRANSISTOR		MIN.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CER}$	D1,2	300	–	volts
(I_C = 1mA; I_F = 0, R_{BE} = 1 meg)	D3,4	200	–	volts
Breakdown Voltage – $V_{(BR)CBO}$	D1,2	300	–	volts
(I_C = 100μA; I_F = 0)	D3,4	200	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ (I_E = 100μA; I_F = 0)		7	–	volts
Collector Dark Current – I_{CER}, R_{BE} = 1 meg.				
(V_{CE}=200V; I_F=0; T_A= 25°C)	D1,2	–	100	nanoamps
(V_{CE}=200V; I_F=0; T_A=100°C)	D1,2	–	250	microamps
(V_{CE}=100V; I_F=0; T_A= 25°C)	D3,4	–	100	nanoamps
(V_{CE}=100V; I_F=0; T_A=100°C)	D3,4	–	250	microamps

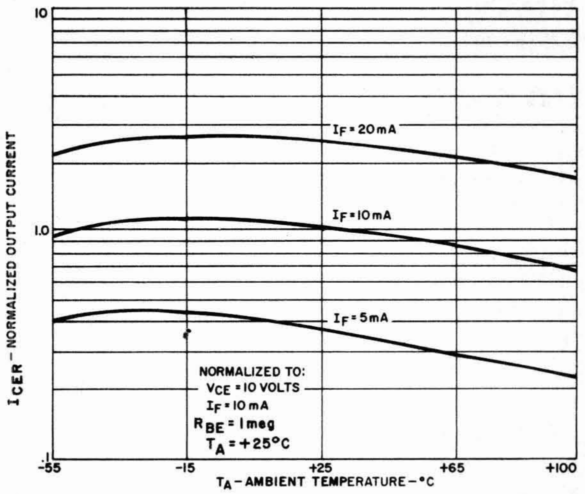
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V, R_{BE} = 1 meg)	H11D1, D2, D3	20	–	–	%
	H11D4	10	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 0.5mA, R_{BE} = 1 meg)		–	0.1	0.4	volts
Isolation Resistance (Input to Output Voltage = $500V_{DC}$)		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f =1MHz)		–	–	2	picofarads
Switching Speeds: Turn-On Time – (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)		–	5	–	microseconds
Turn-Off Time – (V_{CB} = 10V, I_{CE} = 2mA, R_L = 100Ω)		–	5	–	microseconds

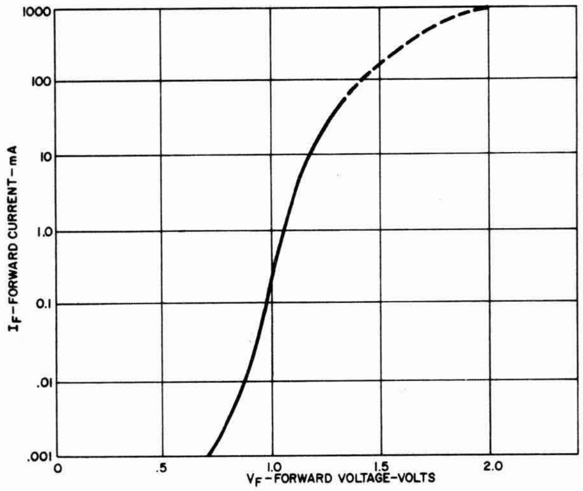
TYPICAL CHARACTERISTICS



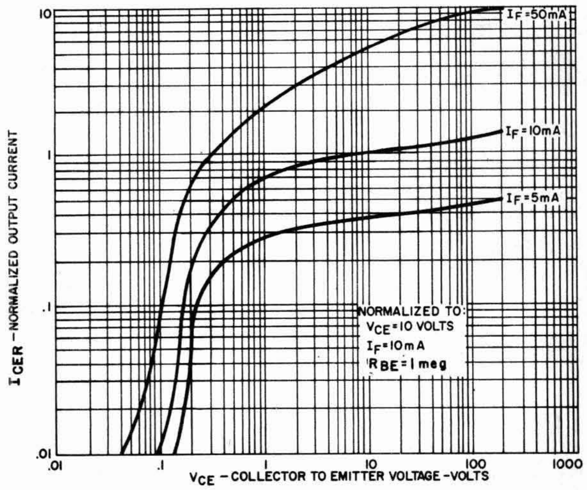
1. OUTPUT CURRENT VS INPUT CURRENT



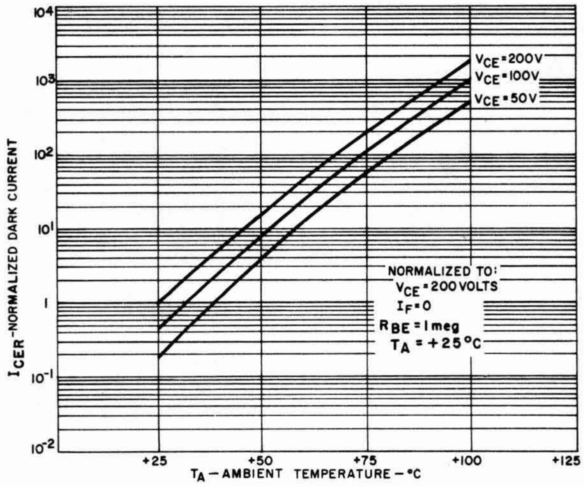
2. OUTPUT CURRENT VS. TEMPERATURE



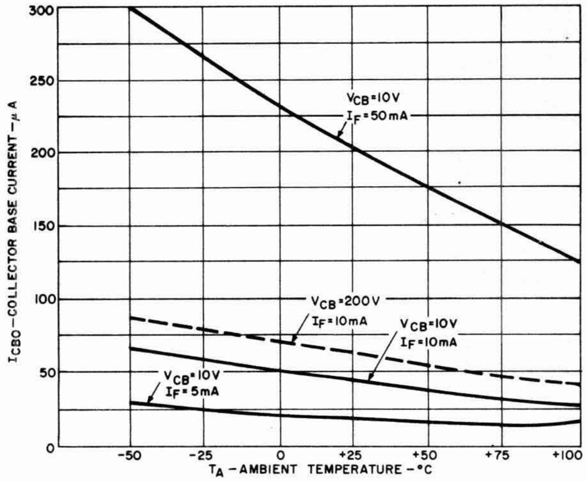
3. INPUT CHARACTERISTICS



4. OUTPUT CHARACTERISTICS



5. NORMALIZED DARK CURRENT VS. TEMPERATURE

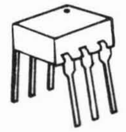


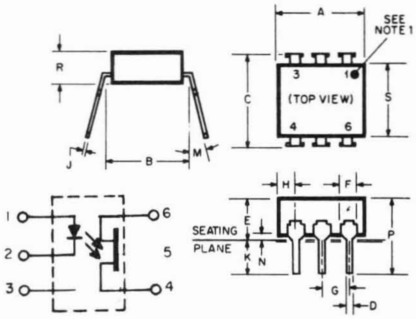
6. COLLECTOR BASE CURRENT VS. TEMPERATURE

H11F1, H11F2, H11F3

Photon Coupled Bilateral Analog FET

The General Electric H11F family consists of a gallium arsenide infrared emitting diode coupled to a symmetrical bilateral silicon photo detector. The detector is electrically isolated from the input and performs like an ideal isolated FET designed for distortion-free control of low level A.C. and D.C. analog signals.





SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		4
M		15°		15°	
N	.015		.381		4
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.
6. Pin 5 is substrate do not connect.

FEATURES:

As a Remote Variable Resistor –

- ⩽ 100Ω to ⩾ 300M Ω
- ⩾ 99.9% Linearity
- ⩽ 15 pF Shunt Capacitance
- ⩾ 100G Ω I/O Isolation Resistance

As An Analog Signal Switch –

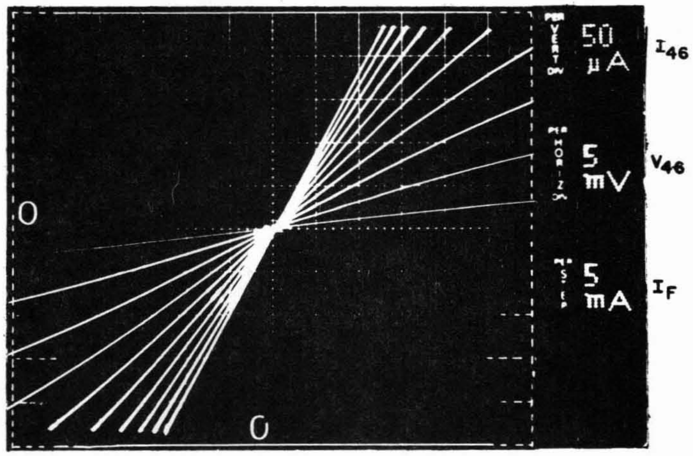
- Extremely Low Offset Voltage
- 60V pk-pk Signal Capability
- No Charge Injection or Latchup
- t_{on}, t_{off} ⩽ 15μsec.

Absolute Maximum Ratings: (25°C Unless Otherwise Specified)

INFRARED EMITTING DIODE		
Power Dissipation	T_A = 25°C	*150 milliwatts
Forward Current (Continuous)		60 milliamps
Forward Current (Peak) (Pulse Width 100μsec 100 pps)		500 milliamps
Forward Current (Peak) (Pulse Width 1μsec 300 pps)		3 amps
Reverse Voltage		6 volts
*Derate 2.0 mW/°C above 25°C.		

PHOTO DETECTOR		
Power Dissipation	T_A = 25°C	**300 milliwatts
Breakdown Voltage		
H11F1 – H11F2		± 30 volts
H11F3		± 15 volts
Detector Current (Continuous)		±100 milliamps
**Derate 4.0 mW/°C above 25°C.		

TOTAL DEVICE		
Storage Temperature		-55 to +150°C
Operating Temperature		-55 to +100°C
Lead Soldering Time (at 260°C),		10 Seconds
Surge Isolation Voltage (Input to Output)		
H11F1–H11F2	2500 $V_{(peak)}$	1770 $V_{(RMS)}$
H11F3	1500 $V_{(peak)}$	1060 $V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output)		
H11F1–H11F2	1500 $V_{(peak)}$	1060 $V_{(RMS)}$
H11F3	1000 $V_{(peak)}$	700 $V_{(RMS)}$



TYPICAL LOW LEVEL OUTPUT CHARACTERISTIC

Individual Electrical Characteristics: (25°C Unless Otherwise Specified)

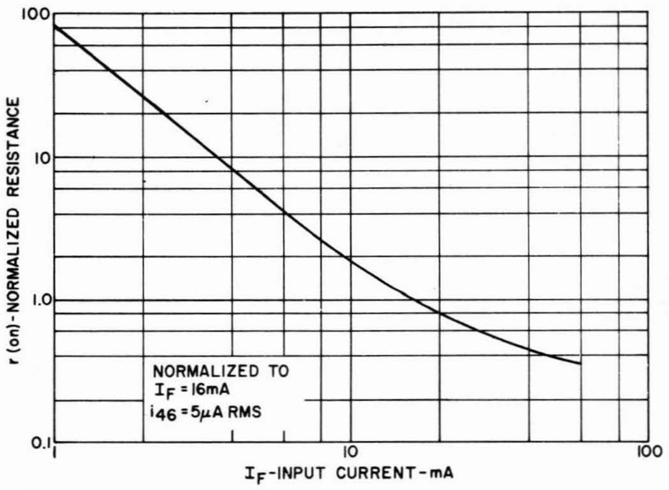
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 16 mA)	1.1	1.75	volts
Reverse Current (V_R = 6V)	–	10	microamps
Capacitance (V = 0, f = 1 MHz)	50	–	picofarads

PHOTO-DETECTOR (Either Polarity)	MIN.	MAX.	UNITS
Breakdown Voltage–$V_{(BR)\ 46}$ (I_{46} = 10μA; I_F = 0) – F1,2	30	–	volts
– F3	15	–	volts
Off-State Dark Current – I_{46} (V_{46}=15V;I_F=0;T_A= 25°C)	–	50	nanoamps
(V_{46}=15V;I_F=0;T_A=100°C)	–	50	microamps
Off-State Resistance – r_{46} (V_{46} = 15V; I_F = 0)	300	–	megohms
Capacitance – C_{46} (V_{46} = 0, I_F = 0, f = 1 MHz)	–	15	picofarads

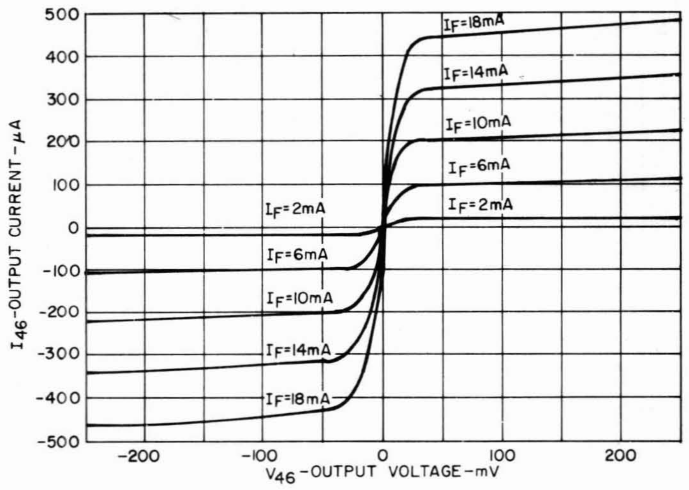
Coupled Electrical Characteristics: (25°C)

		MIN.	TYP.	MAX.	UNITS
On-State Resistance – r_{46} (I_F = 16mA, I_{46} = 100μA)	H11F1	–	–	200	ohms
	H11F2	–	–	330	ohms
	H11F3	–	–	470	ohms
On-State Resistance – r_{46} (I_F = 16 mA, I_{64} = 100μA)	H11F1	–	–	200	ohms
	H11F2	–	–	330	ohms
	H11F3	–	–	470	ohms
Isolation Resistance (Input to Output) (V_{10} = 500V)		100	–	–	gigohms
Input to Output Capacitance (V_{10} = 0,*f* = 1 MHz)		–	–	2.5	picofarads
Turn-On Time – t_{on} (I_F = 16mA, R_L = 50Ω, V_{46} = 5V)		–	–	15	microseconds
Turn-Off Time – t_{off} (I_F = 16mA, R_L = 50Ω, V_{46} = 5V)		–	–	15	microseconds
Resistance, Non-Linearity and Asymmetry (I_F = 16mA, i_{46} = 25μA RMS, f = 1 KHz)		–	–	0.1	percent

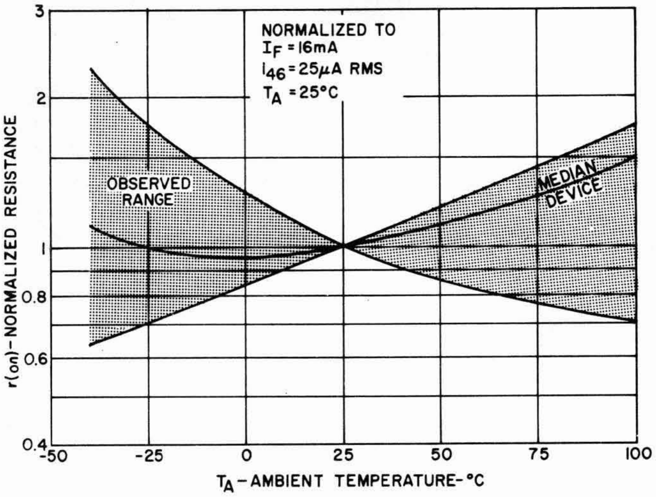
TYPICAL CHARACTERISTICS (25°C) – EITHER POLARITY



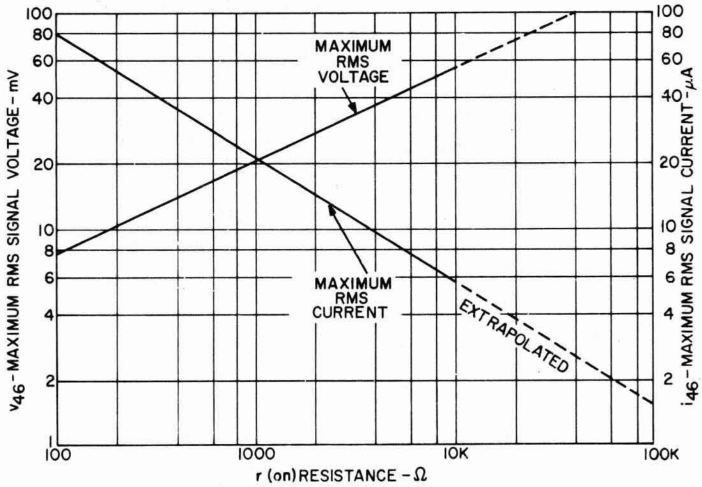
1. RESISTANCE VS. INPUT CURRENT



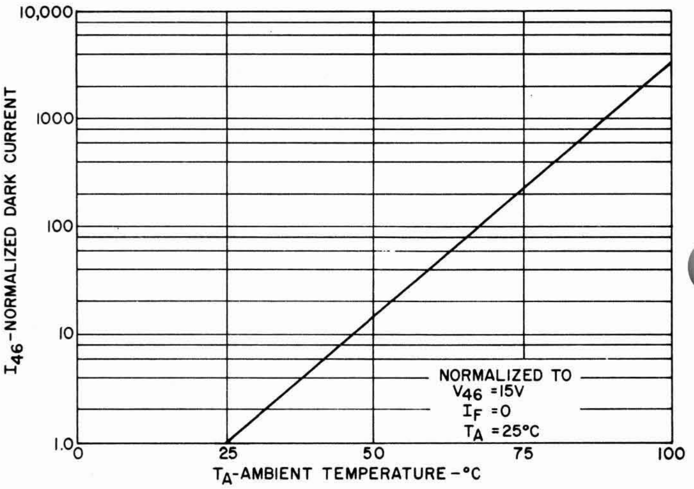
2. OUTPUT CHARACTERISTICS



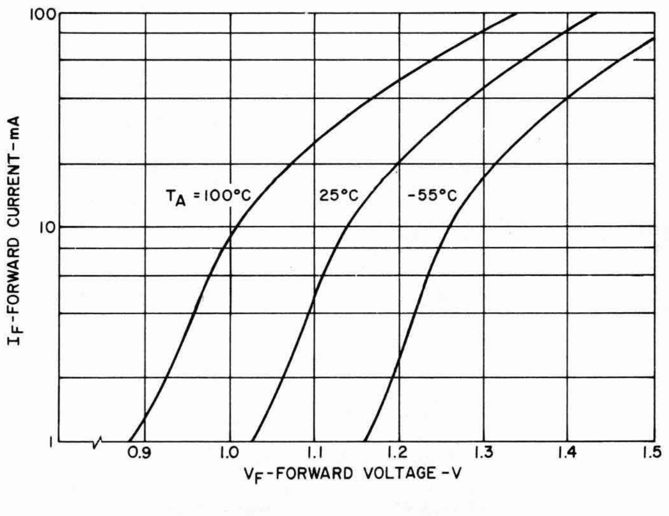
3. RESISTANCE VS. TEMPERATURE



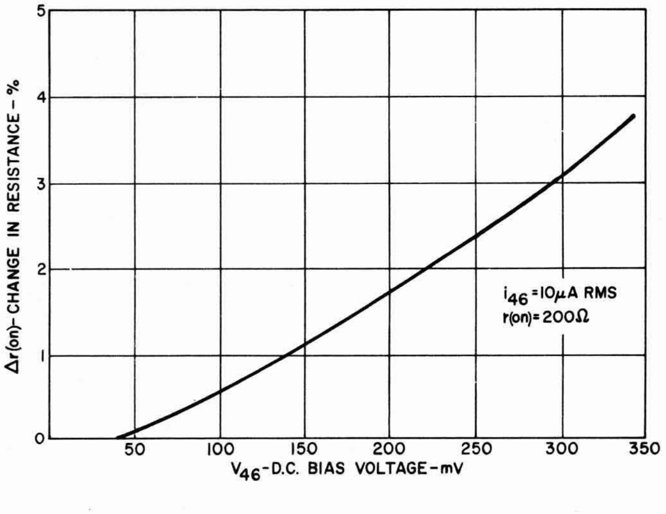
4. REGION OF LINEAR RESISTANCE



5. OFF-STATE CURRENT VS. TEMPERATURE



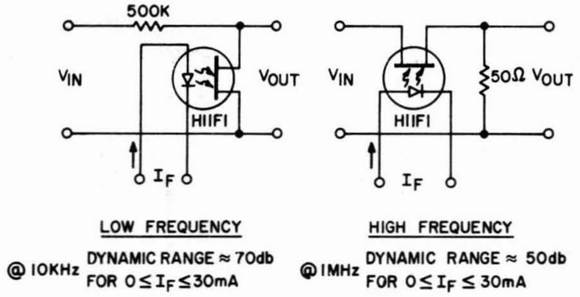
6. FORWARD VOLTAGE VS. FORWARD CURRENT



7. RESISTIVE NON-LINEARITY VS. D.C. BIAS

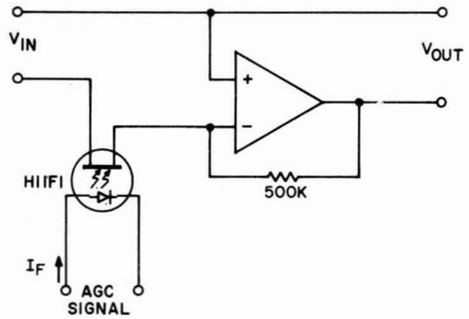
AS A VARIABLE RESISTOR

ISOLATED VARIABLE ATTENUATORS



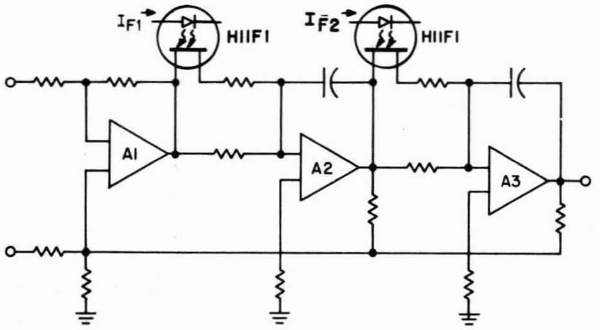
Distortion free attenuation of low level A.C. signals is accomplished by varying the IRED current, I_F. Note the wide dynamic range and absence of coupling capacitors; D.C. level shifting or parasitic feedback to the controlling function.

AUTOMATIC GAIN CONTROL



This simple circuit provides over 70db of stable gain control for an AGC signal range of from 0 to 30mA. This basic circuit can be used to provide programmable fade and attack for electronic music and can be modified with six components to a high performance compression amplifier.

ACTIVE FILTER FINE TUNING/BAND SWITCHING

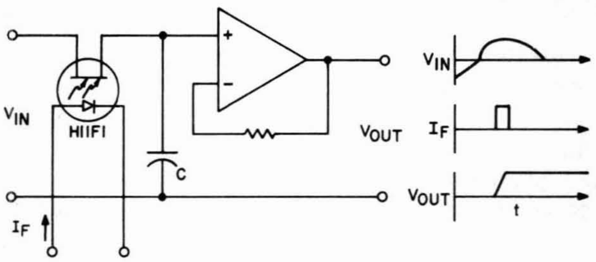


I_{F1} ADJUSTS f_1, I_{F2} ADJUSTS f_2

The linearity of resistance and the low offset voltage of the H11F allows the remote tuning or band-switching of active filters without switching glitches or distortion. This schematic illustrates the concept, with current to the H11F1 IRED's controlling the filter's transfer characteristic.

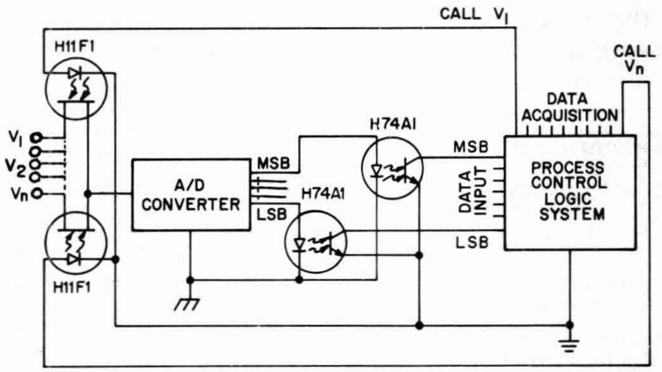
AS AN ANALOG SIGNAL SWITCH

ISOLATED SAMPLE AND HOLD CIRCUIT



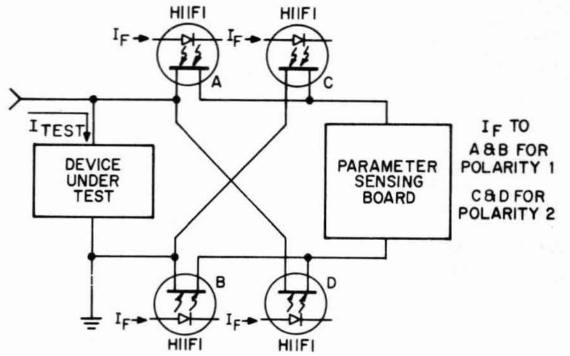
Accuracy and range are improved over conventional FET switches because the H11F has no charge injection from the control signal. The H11F also provides switching of either polarity input signal up to 30V magnitude.

MULTIPLEXED, OPTICALLY-ISOLATED A/D CONVERSION



The optical isolation, linearity and low offset voltage of the H11F allows the remote multiplexing of low level analog signals from such transducers as thermocouplers, Hall effect devices, strain gauges, etc. to a single A/D converter.

TEST EQUIPMENT – KELVIN CONTACT POLARITY



In many test equipment designs the auto polarity function uses reed relay contacts to switch the Kelvin Contact polarity. These reeds are normally one of the highest maintenance cost items due to sticking contacts and mechanical problems. The totally solid-state H11F eliminates these troubles while providing faster switching.

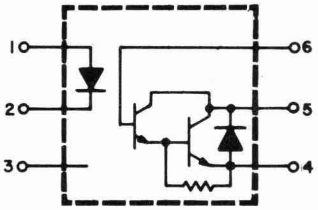
55.130 3/79

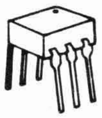
Supersedes 55.130 1/79

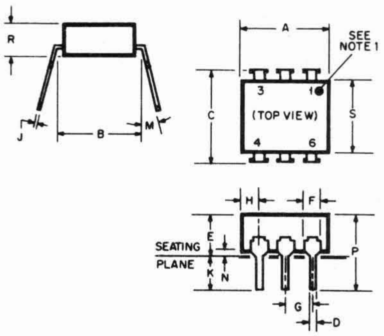
Photon Coupled Isolator H11G1 - H11G2

Ga As Infrared Emitting Diode & NPN Silicon Darlington Connected Phototransistor

The General Electric H11G series consists of a gallium arsenide, infrared emitting diode coupled with a silicon, darlington connected, phototransistor which has an integral base-emitter resistor to optimize switching speeds and elevated temperature characteristics.







SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	.762	REF.	2
C		.340		.864	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		.953	
R	.100	.185	2.57	.470	
S	.225	.280	5.71	7.12	

NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE

Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak)		
(Pulse width 300 μsec, 2% Duty Cycle)	0.5	amperes
(Pulse width 1 μsec, 300 Hz)	3	amperes
Reverse Voltage	6	volts

*Derate 1.33 mW/°C above 25°C ambient.

DARLINGTON CONNECTED PHOTO-TRANSISTOR

Power Dissipation	**150	milliwatts
V_{CEO} – H11G1	100	volts
– H11G2	80	volts
V_{CBO} – H11G1	100	volts
– H11G2	80	volts
V_{EBO}	7	volts
Collector Current (Continuous) – Forward	150	milliamps
Collector Current (Continuous) – Reverse	10	milliamps

**Derate 2.0 mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55°C to +150°C

Operating Temperature -55°C to +100°C

Lead Soldering Time (at 260°C) 10 seconds

Surge Isolation Voltage (Input to Output)

3535 $V_{(peak)}$ 2500 $V_{(RMS)}$

Steady-State Isolation Voltage (Input to Output)

2125 $V_{(peak)}$ 1500 $V_{(RMS)}$

individual electrical characteristics:(25°C)

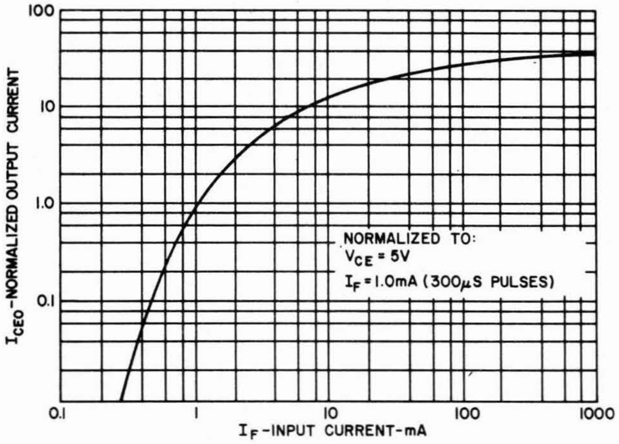
EMITTER	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.1	1.5	volts
Reverse Current (V_R = 3 V)	–	10	microamps
Capacitance (V = 0, f = 1 MHz)	50	–	picofarads

DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$				
(I_C = 1.0 mA, I_F = 0) – H11G1	100	–	–	volts
– H11G2	80	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$				
(I_C = 100 μA, I_F = 0) – H11G1	100	–	–	volts
– H11G2	80	–	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ (I_E = 100 μA, I_F = 0)	7	–	–	volts
Collector Dark Current – I_{CEO}				
(V_{CE} = 80 V, I_F = 0) – H11G1	–	–	100	nanoamps
(V_{CE} = 60 V, I_F = 0) – H11G2	–	–	100	nanoamps
(V_{CE} = 80 V, I_F = 0, T_A = 80°C) – H11G1	–	–	100	microamps
(V_{CE} = 60 V, I_F = 0, T_A = 80°C) – H11G2	–	–	100	microamps
Capacitance (V_{CE} = 10 V, f = 1 MHz)	–	6	–	picofarads

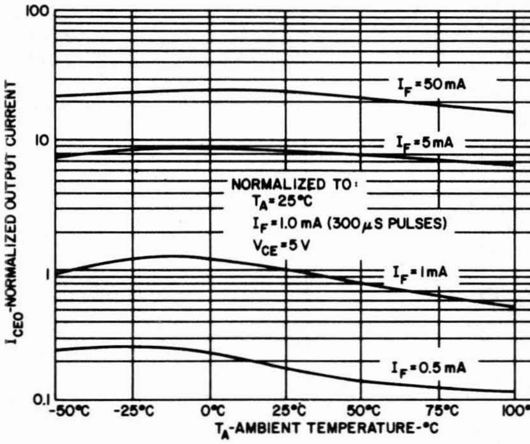
coupled electrical characteristics:(25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio – (I_F = 10 mA, V_{CE} = 1 V)	1000	–	–	%
– (I_F = 1 mA, V_{CE} = 5 V)	500	–	–	%
Saturation Voltage – Collector to Emitter – (I_F = 1 mA, I_C = 1 mA)	–	0.75	1.0	volts
– (I_F = 16 mA, I_C = 50 mA)	–	0.85	1.0	volts
Isolation Resistance (Input to Output Voltage = 500 V_{DC})	100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0, f = 1 MHz)	–	–	2	picofarads
Switching Speeds:				
On-Time – (V_{CE} = 5 V, R_L = 100Ω, I_F = 10 mA)	–	5	–	microseconds
Off-Time – (Pulse width ≤300 µsec, f ≤ 30 Hz)	–	100	–	microseconds

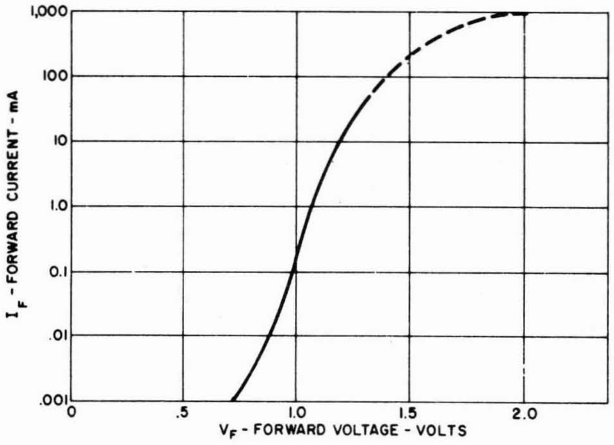
TYPICAL CHARACTERISTICS



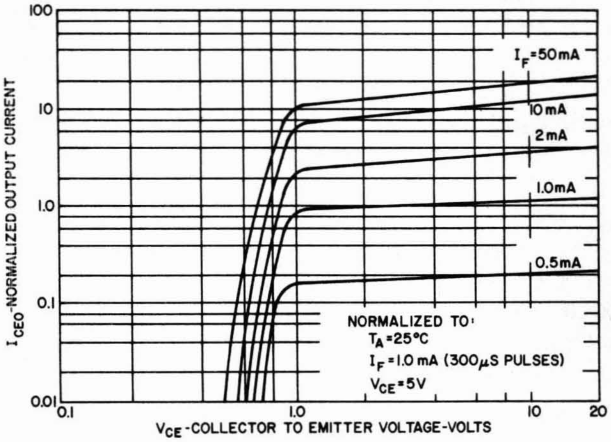
OUTPUT VS. INPUT CURRENT



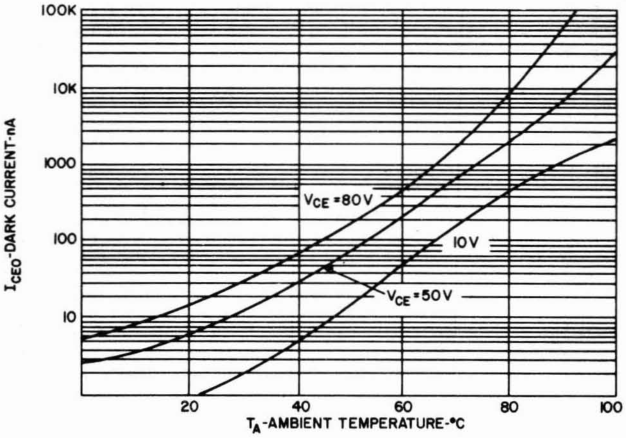
OUTPUT VS. TEMPERATURE



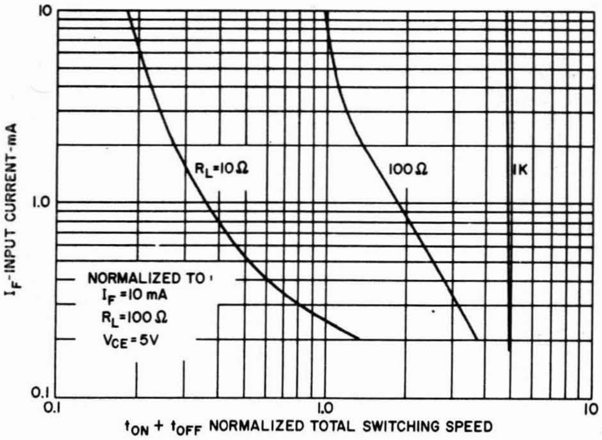
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS



DARK CURRENT



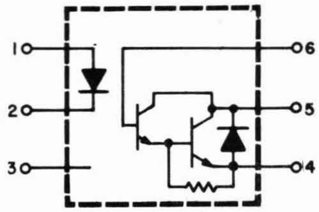
SWITCHING SPEED

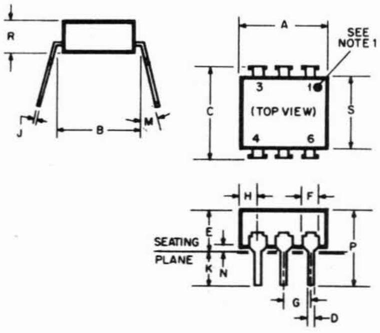
Photon Coupled Isolator H11G3

55.131 3/79
Supersedes 55.131 1/79

Ga As Infrared Emitting Diode & NPN Silicon Darlington Connected Phototransistor

The General Electric H11G series consists of a gallium arsenide, infrared emitting diode coupled with a silicon, darlington connected, phototransistor which has an integral base-emitter resistor to optimize switching speeds and elevated temperature characteristics.





SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	.762	REF.	2
C		.340		.864	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		.953	
R	.100	.185	2.57	.470	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak)		
(Pulse width 300 μsec, 2% Duty Cycle)	0.5	amperes
(Pulse width 1 μsec, 300 Hz)	3	amperes
Reverse Voltage	6	volts

*Derate 1.33 mW/°C above 25°C ambient.

DARLINGTON CONNECTED PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
V_{CEO}	55	volts
V_{CBO}	55	volts
V_{EBO}	7	volts
Collector Current (Continuous) – Forward	100	milliamps
Collector Current (Continuous) – Reverse	10	milliamps

**Derate 2.0 mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55°C to +150°C
Operating Temperature -55°C to +100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output)
2125 $V_{(peak)}$ 1500 $V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output)
1275 $V_{(peak)}$ 900 $V_{(RMS)}$

individual electrical characteristics:(25°C)

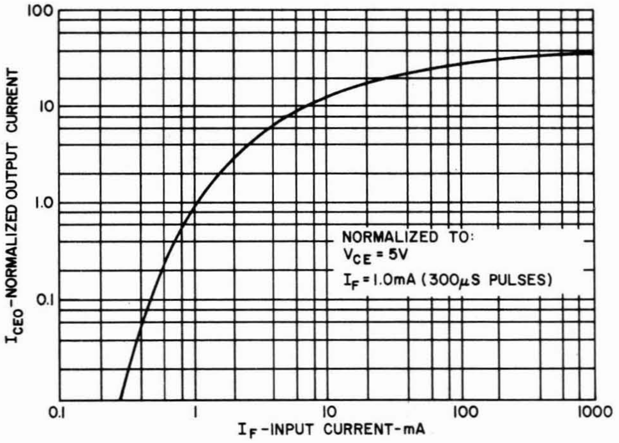
EMITTER	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.1	1.5	volts
Reverse Current (V_R = 3 V)	–	10	microamps
Capacitance (V = 0, f = 1 MHz)	50	–	picofarads

DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 1.0 mA, I_F = 0)	55	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100 μA, I_F = 0)	55	–	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ (I_E = 100 μA, I_F = 0)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 30 V, I_F = 0)	–	5	100	nanoamps
Capacitance (V_{CE} = 10 V, f = 1 MHz)	–	6	–	picofarads

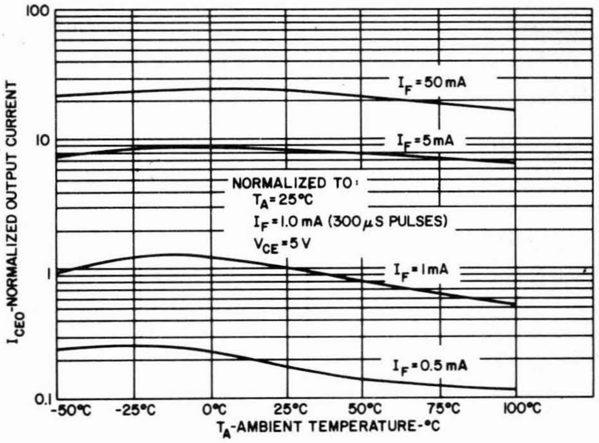
coupled electrical characteristics:(25 °C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 1 mA, V_{CE} = 5 V)	200	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 20 mA, I_C = 50 mA)	–	0.85	1.2	volts
Isolation Resistance (Input to Output Voltage = 500 V_{DC})	100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1 MHz)	–	–	2	picofarads
Switching Speeds:				
On-Time – (V_{CE} = 5 V, R_L = 100Ω, I_F = 10 mA)	–	5	–	microseconds
Off-Time – (Pulse width ⩽ 300 μsec, f ⩽ 30 Hz)	–	100	–	microseconds

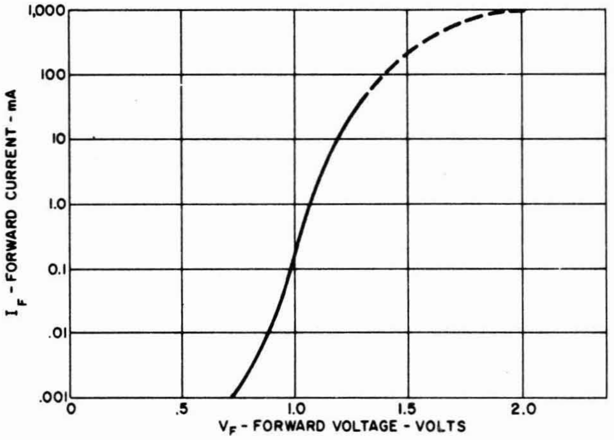
TYPICAL CHARACTERISTICS



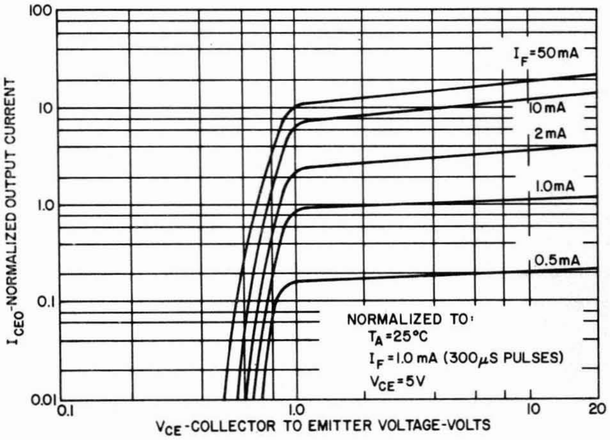
OUTPUT VS. INPUT CURRENT



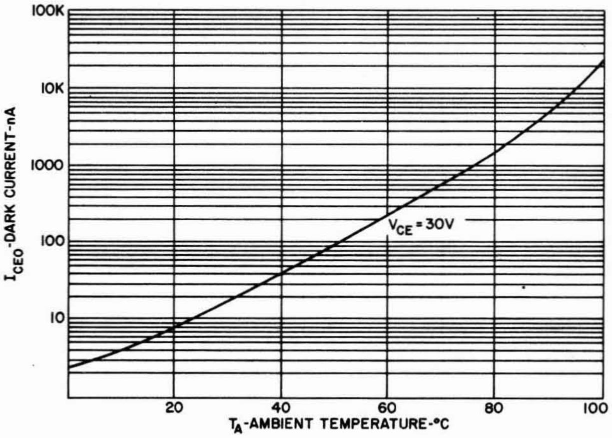
OUTPUT VS. TEMPERATURE



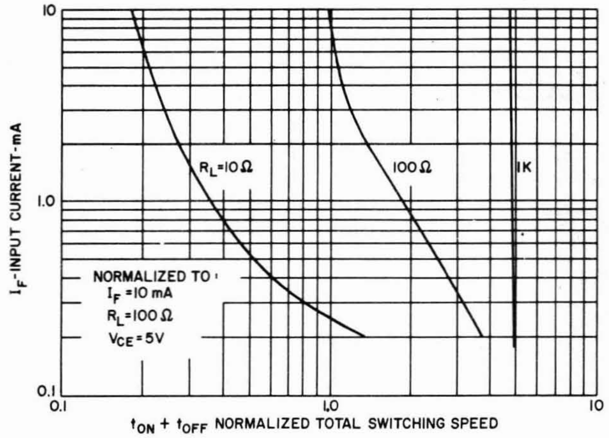
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS

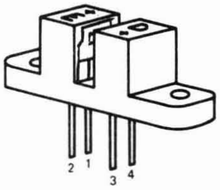


DARK CURRENT



SWITCHING SPEED

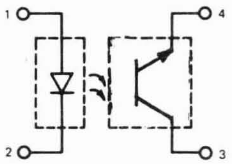
Photon Coupled Interrupter Module H13A1,H13A2

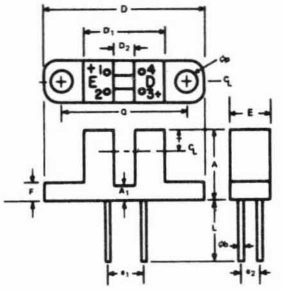


The General Electric H13A1 and H13A2 are gallium arsenide infrared emitting diodes coupled with a silicon photo-transistor in a plastic housing. The gap in the housing provides a means of interrupting the signal with tape, cards, shaft encoders, or other opaque material, switching the output transistor from an "ON" into an "OFF" state.

FEATURES:

- Low cost, plastic module
- Non-contact switching
- Fast switching speeds
- Solid state reliability
- I/O compatible with integrated circuits





SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	.390	.400	9.91	10.16	
A_1	.075	.085	1.91	2.16	
φb	.016	.019	.407	.482	1
D	.954	.984	24.24	24.99	
D_1	.475	.495	12.07	12.57	
D_2	.120	.130	3.05	3.30	
e_1	.205	.235	5.21	5.96	
e_2	.090	.110	2.29	2.79	
E		.250		6.35	
F	.095	.105	2.42	2.66	
L	.300		7.62		1
φp	.120	.130	3.05	3.30	
Q	.745	.755	18.93	19.17	
T	.110 NOM.		2.79 NOM.		2

NOTES:

1. Four leads. Lead diameter controlled between .050" (1.27 MM) from the seating plane and the end of the leads.
2. The sensing area falls within a .060" (1.52 MM) square on this centerline.

absolute maximum ratings: (25°C) (unless otherwise specified)

Storage and Operating Temperature -55° to 85°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (peak, 100μs, 1% duty cycle)	1	amp
Reverse Voltage	3	volts

*Derate 1.67mW/°C above 25°C ambient

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
Collector Current (Continuous)	100	milliamps
V_{CEO}	30	volts
V_{ECO}	5	volts

**Derate 2.5mW/°C above 25°C ambient

individual electrical characteristics (25°C)

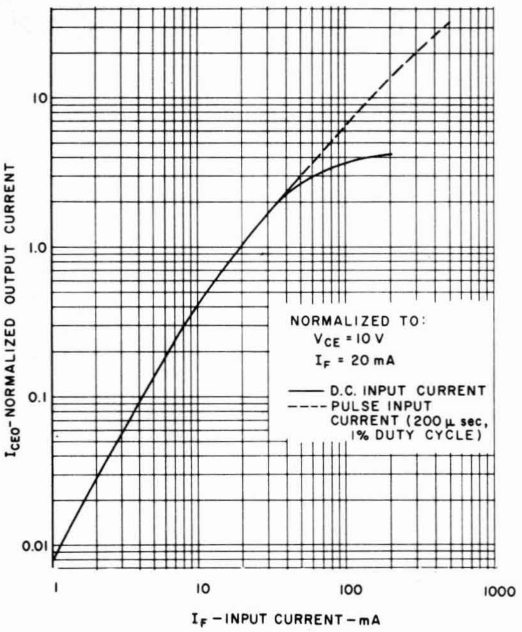
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.2	1.7	volts
Reverse Current (V_R = 2V)	–	10	μamps
Capacitance (V= 0, f = 1MHz)	150	–	pf

PHOTO-TRANSISTOR	MIN.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ (I_C = 10 mA)	30	–	volts
Breakdown Voltage $V_{(BR)ECO}$ (I_E = 100μA)	5	–	volts
Collector Dark Current I_{CEO} (V_{CE} = 10V, I_F =0, H=0)	–	100	nA

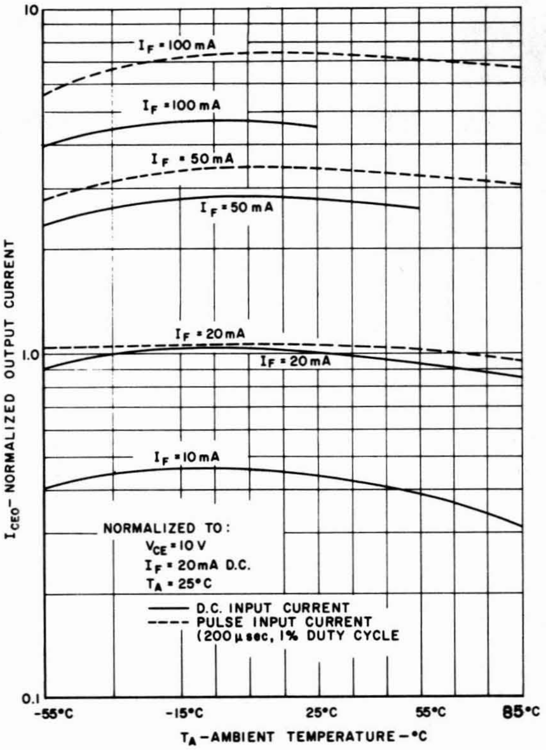
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
Output Current (I_F = 20 mA, V_{CE} = 10V)	H13A1	200	400	–	μamps
	H13A2	50	–	–	μamps
Saturation Voltage (I_F = 20 mA, I_C = 25μA)		–	0.2	0.4	volts
Switching Speeds (V_{CE} = 10V, I_C = 2 mA, R_L = 100Ω)					
On Time ($t_d + t_r$)		–	5	–	μsecs
Off Time ($t_s + t_f$)		–	5	–	μsecs

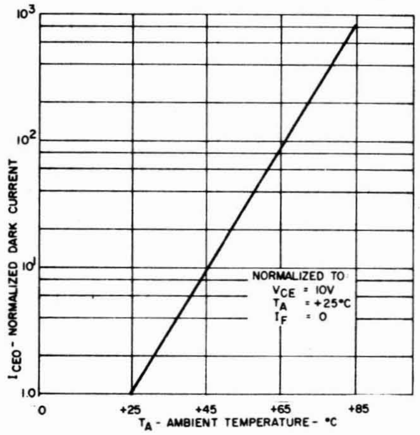
TYPICAL CHARACTERISTICS



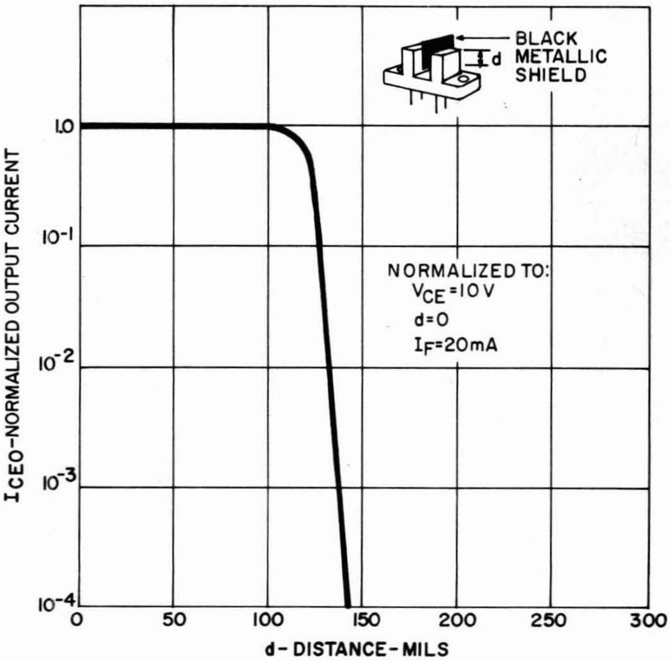
OUTPUT CURRENT VS INPUT CURRENT



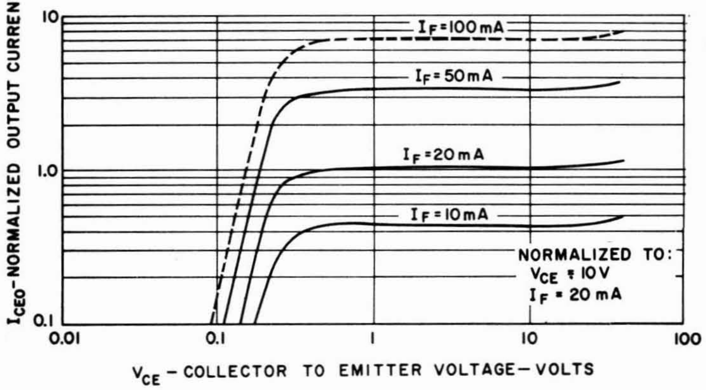
OUTPUT CURRENT VS TEMPERATURE



NORMALIZED DARK CURRENT VS TEMPERATURE

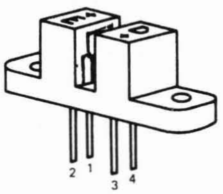


OUTPUT CURRENT VS SHIELD DISTANCE



OUTPUT CHARACTERISTICS

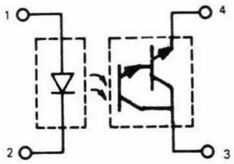
Photon Coupled Interrupter Module H13B1,H13B2

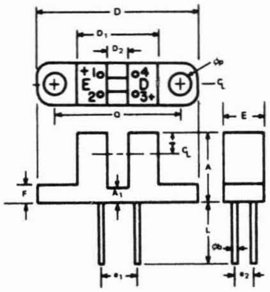


The General Electric H13B1 and H13B2 are gallium arsenide infrared emitting diodes coupled with a silicon photo-darlington in a plastic housing. The gap in the housing provides a means of interrupting the signal with tape, cards, shaft encoders, or other opaque material, switching the output transistor from an "ON" into an "OFF" state.

FEATURES:

- Low cost, plastic module
- Non-contact switching
- Solid state reliability
- I/O compatible with integrated circuits





SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	.390	.400	9.91	10.16	
A_1	.075	.085	1.91	2.15	
ϕb	.016	.019	.407	.482	1
D	.954	.984	24.24	24.99	
D_1	.475	.495	12.07	12.57	
D_2	.120	.130	3.05	3.30	
e_1	.205	.235	5.21	5.96	
e_2	.090	.110	2.29	2.79	
E		.250		6.35	
F	.095	.105	2.42	2.66	
L	.300		7.62		1
ϕp	.120	.130	3.05	3.30	
Q	.745	.755	18.93	19.17	
T	.110 NOM.		2.79 NOM.		2

NOTES:

1. Four leads. Lead diameter controlled between .060" (1.27 MM) from the seating plane and the end of the leads.
2. The sensing area falls within a .060" (1.52 MM) square on this centerline.

absolute maximum ratings: (25°C) (unless otherwise specified)

Storage and Operating Temperature -55° to 85°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (peak, 100 μs, 1% duty cycle)	1	amp
Reverse Voltage	3	volts

*Derate 1.67mW/°C above 25°C ambient

PHOTO-DARLINGTON		
Power Dissipation	**150	milliwatts
Collector Current (Continuous)	100	milliamps
V_{CEO}	25	volts
V_{ECO}	7	volts

**Derate 2.5mW/°C above 25°C ambient

individual electrical characteristics (25°C)

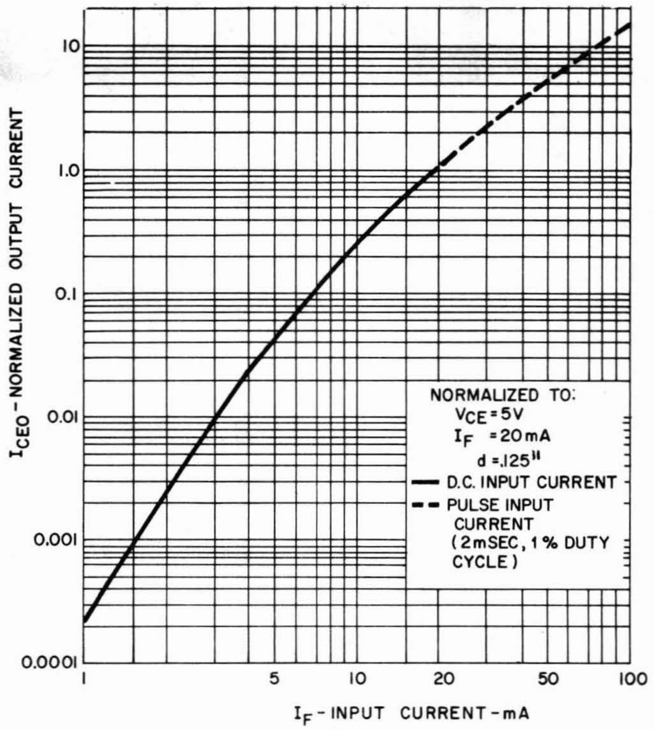
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.2	1.7	volts
Reverse Current (V_R = 2V)	–	10	μamps
Capacitance (V = O, f = 1MHz)	150	–	pf

PHOTO-DARLINGTON	MIN.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ (I_C = 10 mA)	25	–	volts
Breakdown Voltage $V_{(BR)ECO}$ (I_E = 100μA)	7	–	volts
Collector Dark Current I_{CEO} (V_{CE} = 10V, I_F= O, H = O)	–	100	nA

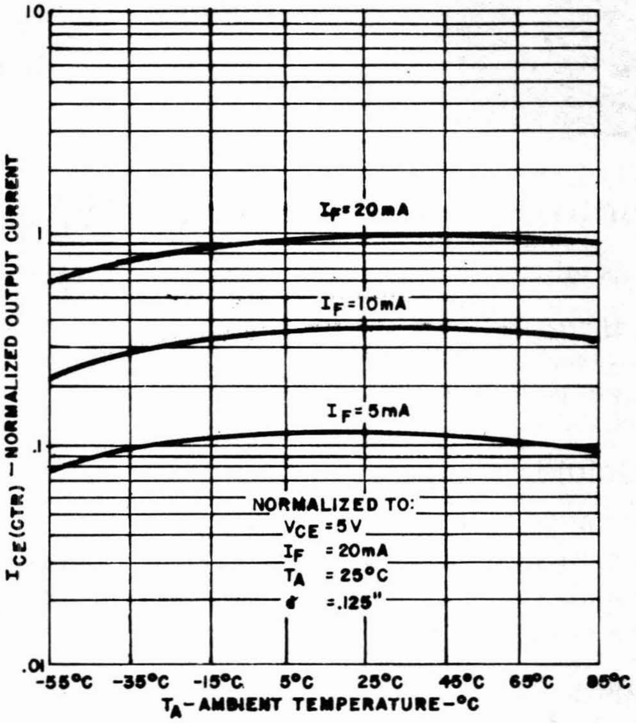
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
Output Current (I_F = 20 mA, V_{CE} = 5V)	H13B1	2500	–	–	μamps
	H13B2	1000	–	–	μamps
Saturation Voltage (I_F = 20 mA, I_C = 0.5 mA)		–	–	1.2	volts
Switching Speeds (V_{CE} = 10V, I_C = 2 mA, R_L = 100Ω)					
On Time ($t_d + t_r$)		–	150	–	μsecs
Off Time ($t_s + t_f$)		–	150	–	μsecs

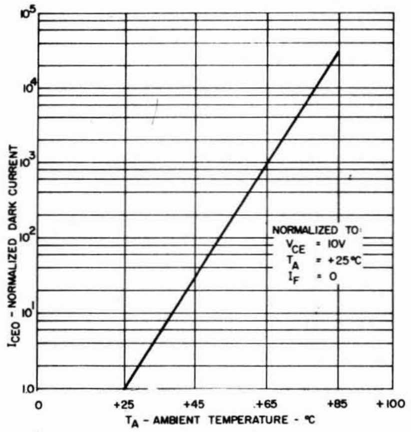
TYPICAL CHARACTERISTICS



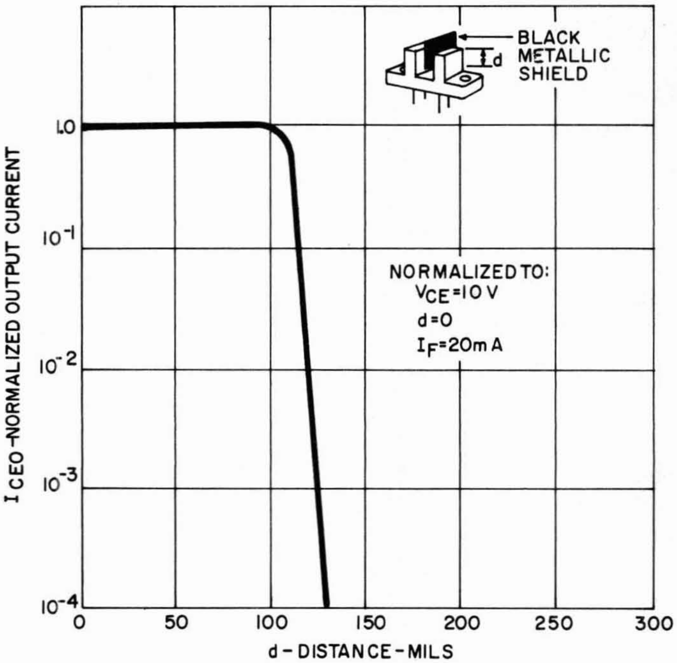
OUTPUT CURRENT VS INPUT CURRENT



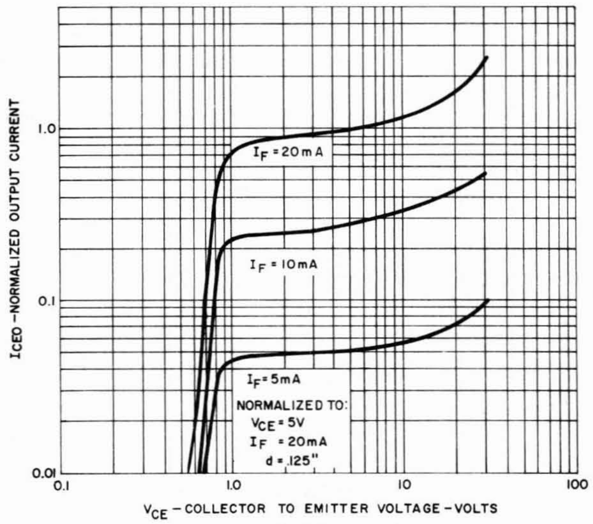
OUTPUT CURRENT VS TEMPERATURE



NORMALIZED DARK CURRENT VS TEMPERATURE



OUTPUT CURRENT VS SHIELD DISTANCE

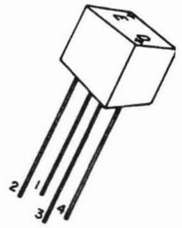


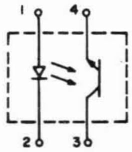
OUTPUT CHARACTERISTICS

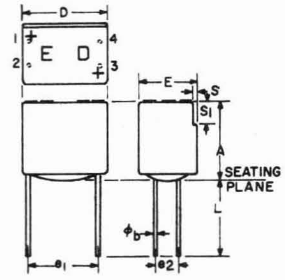
Photon Coupled Isolator H15A1,H15A2

Ga As Infrared Emitting Diodes & NPN Silicon Photo-Transistors

The General Electric H15A1 and H15A2 are gallium arsenide, infrared emitting diodes coupled with silicon photo transistors in a low cost plastic package with lead spacing, compatible to dual in-line package.







SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A		.350		8.89	
φb	.016	.019	.407	.482	1
D		.375		9.52	
e_1	.285	.315	7.24	8.00	
e_2	.090	.110	2.29	2.79	
E		.250		6.35	
L	.300		7.62		1
S	.010	.020	.26	.50	
S_1	.085	.105	2.16	2.66	

NOTES:

1. FOUR LEADS. LEAD DIAMETER CONTROLLED BETWEEN .050" (1.27MM) FROM THE SEATING PLANE AND THE END OF THE LEADS.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak)	3	ampere
(Pulse width 1 μsec 300 P Ps)		
Reverse Voltage	3	volts

*Derate 1.67 mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{ECO}	5	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.5 mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 85°C
Operating Temperature -55 to 85°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).
$5650V_{(peak)}$ $4000V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
$3500V_{(peak)}$ $2500V_{(RMS)}$

individual electrical characteristics (25°C)

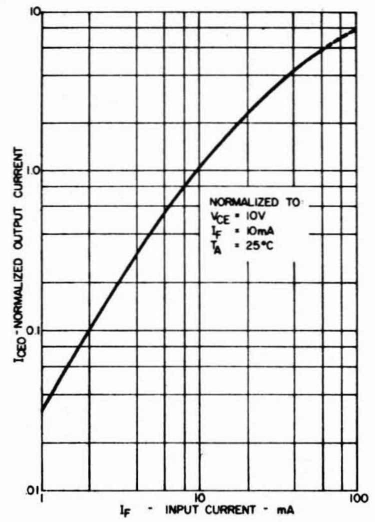
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.7	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = 0,f = 1MHz)	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = 0)	5	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	100	nanoamps
Capacitance (V_{CE} = 10V, f = 1MHz)	–	3.5	–	picofarads

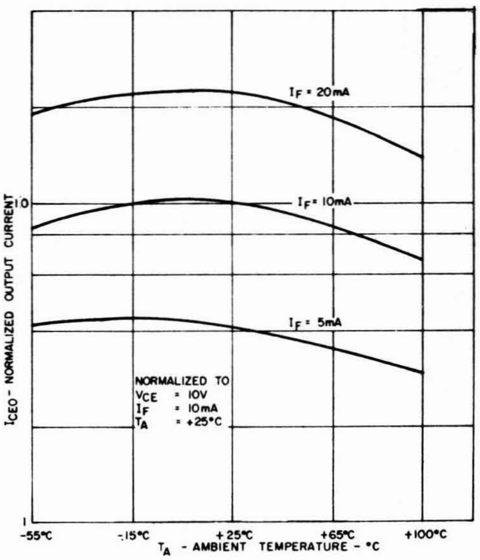
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)	H15A1	20	–	–	%
	H15A2	10	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 0.5mA)		–	0.2	0.4	volts
Isolation Resistance (Input to Output Voltage = $500V_{DC}$)		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1MHz)		–	–	2	picofarads
Switching Speeds: Turn-On Time – (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)		–	3	–	microseconds
Turn-Off Time – (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)		–	3	–	microseconds

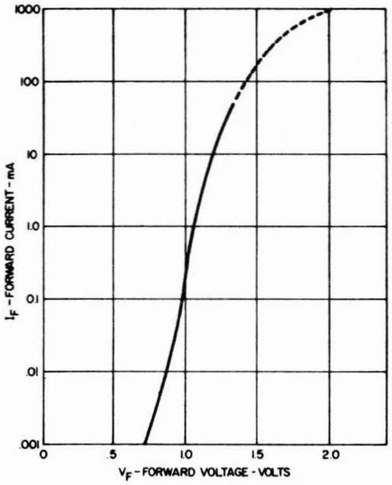
TYPICAL CHARACTERISTICS



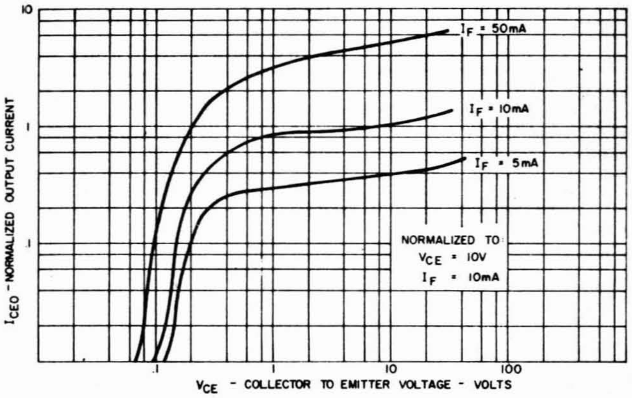
1. OUTPUT CURRENT VS. INPUT CURRENT



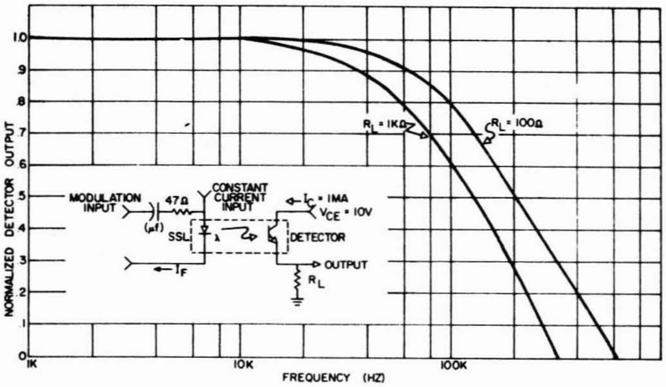
2. OUTPUT CURRENT VS. TEMPERATURE



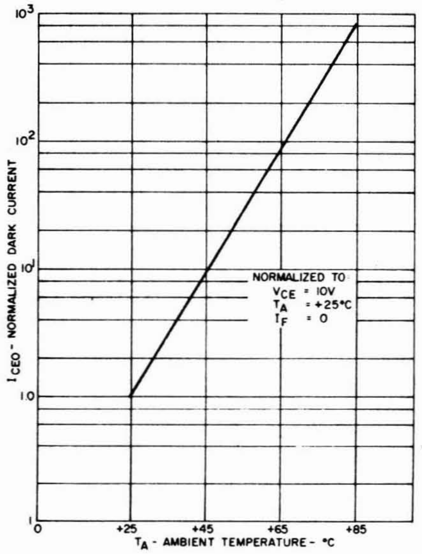
3. INPUT CHARACTERISTICS



4. OUTPUT CHARACTERISTICS

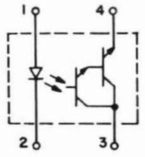


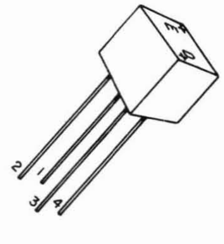
5. FREQUENCY VS. DETECTOR OUTPUT



6. NORMALIZED DARK CURRENT VS. TEMPERATURE

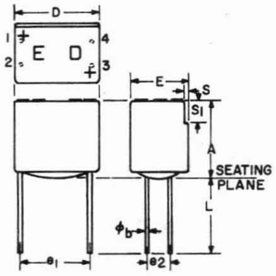
Photon Coupled Isolator H15B1,H15B2





Ga As Infrared Emitting Diode & NPN Silicon Photo-Darlington Amplifier

The General Electric H15B1 and H15B2 are gallium arsenide, infrared emitting diodes coupled with silicon photo-darlington amplifiers in a low cost plastic package with lead spacing, compatible to dual in-line package.



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A		.350		8.89	
ϕb	.016	.019	.407	.482	1
D		.375		9.52	
e_1	.285	.315	7.24	8.00	
e_2	.090	.110	2.29	2.79	
E		.250		6.35	
L	.300		7.62		1
S	.010	.020	.26	.50	
S_1	.085	.105	2.16	2.66	

NOTES:

1. FOUR LEADS. LEAD DIAMETER CONTROLLED BETWEEN .050" (1.27MM) FROM THE SEATING PLANE AND THE END OF THE LEADS.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak)	3	ampere
(Pulse width 1 µsec 300 P Ps)		
Reverse Voltage	3	volts

*Derate 1.67mW/°C above 25°C ambient.

PHOTO-DARLINGTON		
Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{ECO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.5mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 85°C
Operating Temperature -55 to 85°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).
$5650V_{(peak)}$ $4000V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
$3500V_{(peak)}$ $2500V_{(RMS)}$

individual electrical characteristics (25°C)

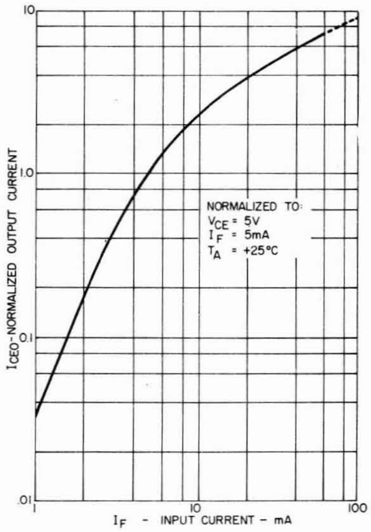
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.7	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = O,f = 1MHz)	50	–	picofarads

PHOTO-DARLINGTON	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = O)	30	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100µA, I_F = O)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = O)	–	5	100	nanoamps
Capacitance (V_{CE} = 10V, f = 1MHz)	–	6	–	picofarads

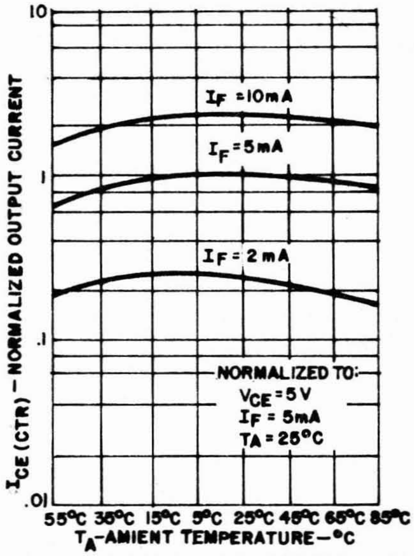
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 5mA, V_{CE} = 5V)	H15B1	400	–	–	%
	H15B2	200	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 5mA, I_C = 2mA)		–	0.8	1.4	volts
Isolation Resistance (Input to Output Voltage = $500V_{DC}$)		100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = O,f = 1MHz)		–	–	2	picofarads
Switching Speeds: Turn-On Time – (V_{CE} = 10V, I_C = 10mA, R_L = 100Ω)		–	125	–	microseconds
Turn-Off Time – (V_{CE} = 10V, I_C = 10mA, R_L = 100Ω)		–	100	–	microseconds

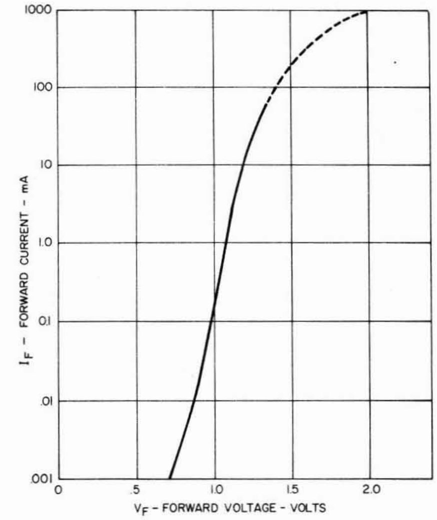
TYPICAL CHARACTERISTICS



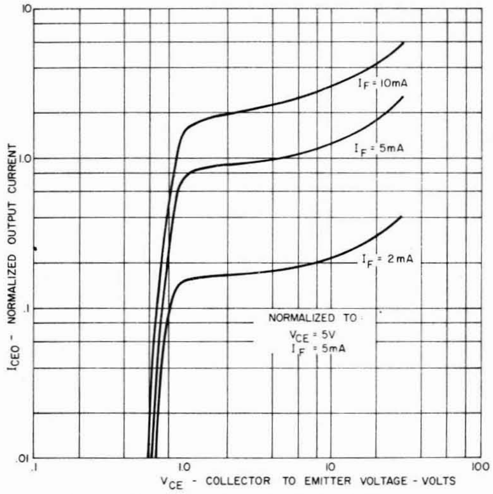
1. OUTPUT CURRENT VS. INPUT CURRENT



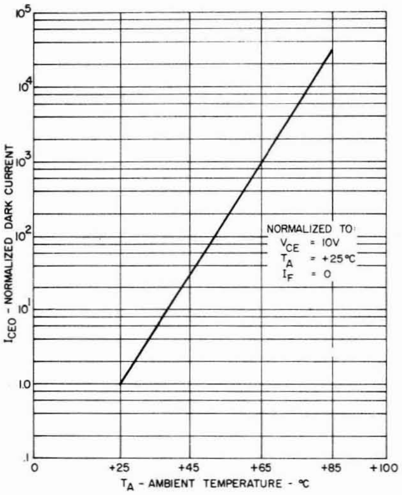
2. OUTPUT CURRENT VS. TEMPERATURE

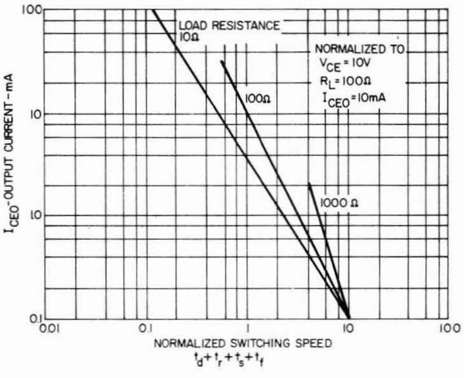


3. INPUT CHARACTERISTICS



4. OUTPUT CHARACTERISTICS





5. SWITCHING SPEED VS. OUTPUT CURRENT

6. NORMALIZED DARK CURRENT VS. TEMPERATURE

SOLID STATE

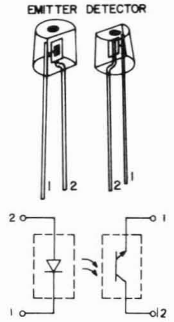
OPTOELECTRONICS

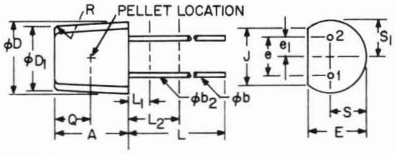
Matched Emitter – Detector Pair H17A1

The General Electric H17A1 is a matched emitter-detector pair which consists of a gallium arsenide, infrared emitting diode in a clear epoxy TO-92 type package and a silicon photo-transistor also in a clear epoxy TO-92 type package.

Each emitter and detector is marked with a color coded dot on the top of the unit (see package illustration). Emitter and detector must be paired as follows:

- Emitter – Detector
- BLACK matched to – BLUE
- ORANGE matched to – RED
- WHITE matched to – VIOLET





NOTES:
1. (TWO LEADS) ϕb2 APPLIES BETWEEN L_1 AND L_2. ϕb APPLIES BETWEEN L_2 AND .5" (12.70MM) FROM SEATING PLANE. DIAMETER IS UNCONTROLLED IN L_1 AND BEYOND. .5" (12.70MM) FROM SEATING PLANE.
2. THE CENTER LINE OF THE ACTIVE ELEMENT IS LOCATED WITHIN ±.020" (.51 MM) OF THE POSITION SHOWN.
3. AS MEASURED WITHIN .050" (1.27MM) OF THE SEATING PLANE.

SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	.170	.210	4.31	5.34	
ϕb	.016	.021	.406	.534	1
ϕb2	.016	.019	.406	.483	1
ϕD	.170	.200	4.31	5.08	
ϕD1	.160	.190	4.06	4.83	
E	.125	.155	3.17	3.94	
e	.095	.105	2.41	2.67	3
e1	.045	.055	1.14	1.40	3
J	.135	.170	3.42	4.32	
L	.500		12.70		1
L1		.050		1.27	1
L2	.250		6.35		1
Q	.095	REF.	2.29	REF.	2
R	.055		.12		
S	.080	.105	2.03	2.67	
S1	.090	REF.	2.29	REF.	

FEATURES:

- Low Cost
- Side Looking
- I/O Compatible with Integrated Circuits

absolute maximum ratings: (25°C) (unless otherwise specified)

Storage and Operating Temperature -55°C to 85°C. Lead Soldering Time (at 260°C) 10 Seconds.

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (100 µs, 1% Duty Cycle)	1	ampere
Reverse Voltage	3	volts

*Derate 1.3mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
Collector Current (Continuous)	100	milliamps
V_{CEO}	30	volts
V_{ECO}	5	volts

**Derate 2.0mW/°C above 25°C ambient.

individual electrical characteristics (25°C)

INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.2	1.7	volts
Reverse Current (V_R = 2V)	–	10	µamps
Capacitance (V = O,f = 1MHz)	50	–	pf

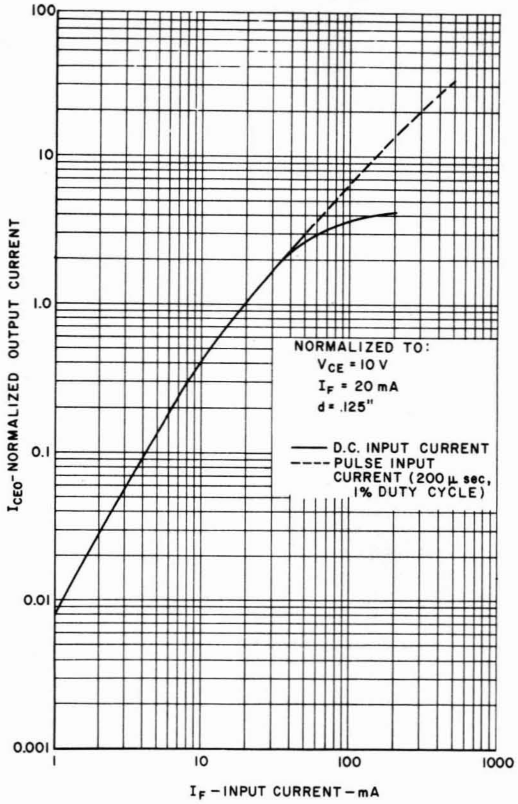
PHOTO-TRANSISTOR	MIN.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 1mA)	30	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100µA)	5	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = O,H ≈ O)	–	100	nA

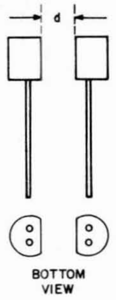
coupled electrical characteristics (25°C)

Note: Coupled electrical characteristics are measured at a separation distance of .125″ with the faces of the emitter and detector parallel within 3°.

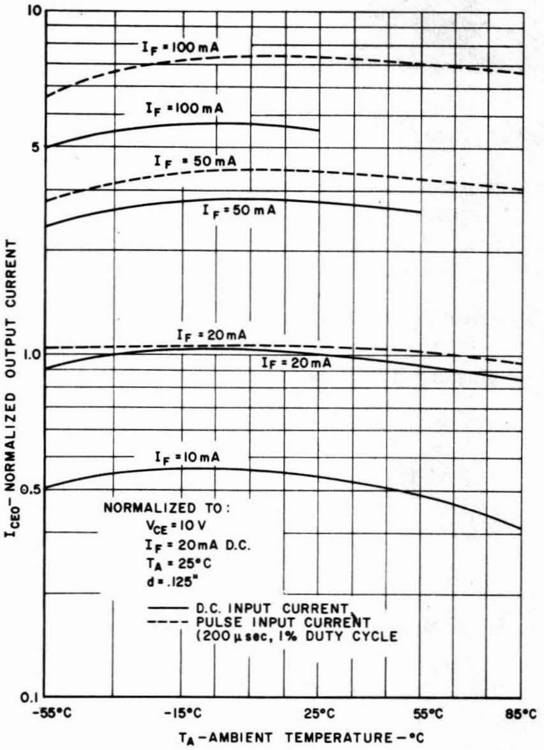
	MIN.	TYP.	MAX.	UNITS
Output Current (I_F = 20mA, V_{CE} = 10V)	50	–	–	µamps
Saturation Voltage (I_F = 20mA, I_C = 25µA)	–	0.2	0.4	volts
Switching Speeds: Turn-On Time ($t_d + t_r$) (V_{CE} = 10V, I_C = 2mA, R_L = 100Ω)	–	5	–	µsecs
Turn-Off Time ($t_s + t_f$) (V_{CE} = 10V, I_C = 2mA, R_L = 100Ω)	–	5	–	µsecs

TYPICAL CHARACTERISTICS

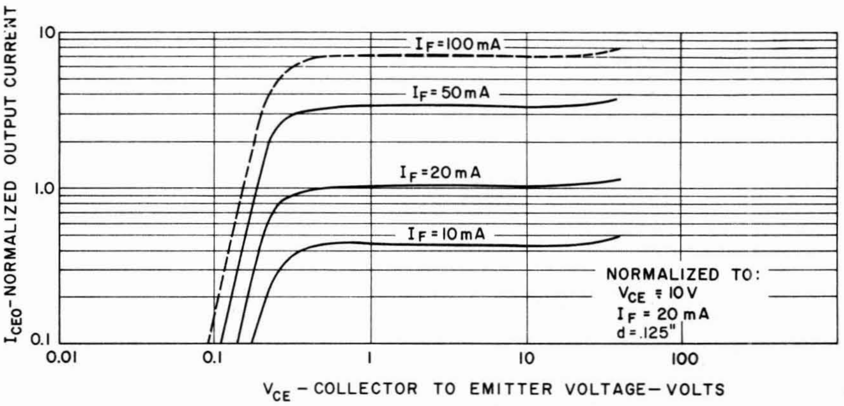




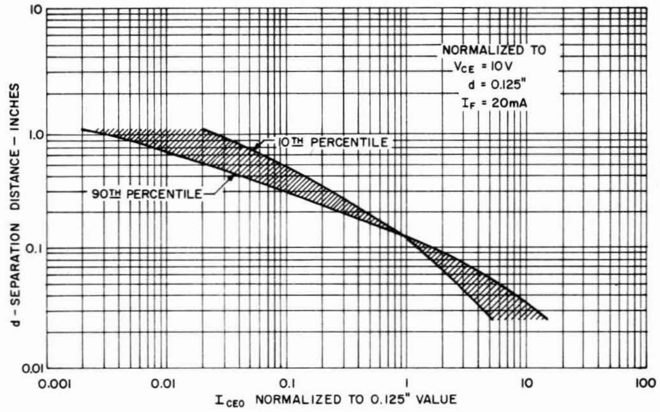
1. OUTPUT CURRENT VS. INPUT CURRENT



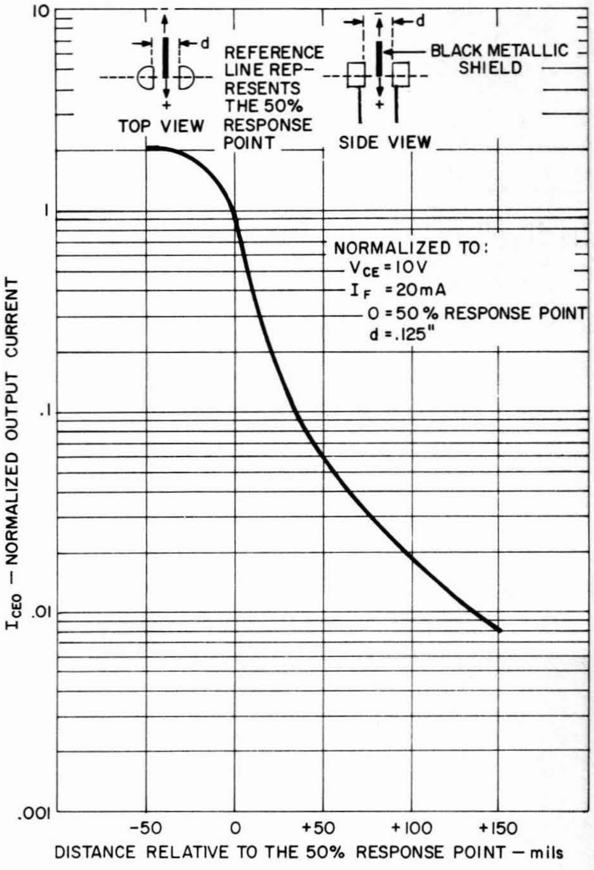
2. OUTPUT CURRENT VS. TEMPERATURE



3. OUTPUT CHARACTERISTICS

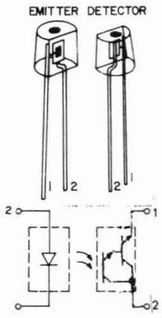


4. OUTPUT VS. DISTANCE DISTRIBUTION



5. OUTPUT CURRENT VS. SHIELD LOCATION

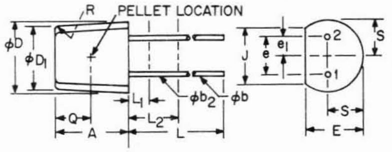
Matched Emitter – Detector Pair H17B1



The General Electric H17B1 is a matched emitter-detector pair which consists of a gallium arsenide, infrared emitting diode in a clear epoxy TO-92 type package and a silicon photo-darlington also in a clear epoxy TO-92 type package.

Each emitter and detector is marked with a color coded dot on the top of the unit (see package illustration). Emitter and detector must be paired as follows:

- Emitter – Detector
- BLACK matched – BROWN
- ORANGE matched to – YELLOW
- WHITE matched to – GREEN



NOTES:
1. (TWO LEADS) ϕb_2 APPLIES BETWEEN L_1 AND L_2. ϕb APPLIES BETWEEN L_2 AND .5" (12.70MM) FROM SEATING PLANE. DIAMETER IS UNCONTROLLED IN L_1 AND BEYOND. .5" (12.70MM) FROM SEATING PLANE.
2. THE CENTER LINE OF THE ACTIVE ELEMENT IS LOCATED WITHIN ±.020" (.51 MM) OF THE POSITION SHOWN.
3. AS MEASURED WITHIN .050" (1.27MM) OF THE SEATING PLANE.

SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	.170	.210	4.31	5.34	
ϕb	.016	.021	.406	.534	1
ϕb_2	.016	.019	.406	.483	1
ϕD	.170	.200	4.31	5.08	
ϕD_1	.160	.190	4.06	4.83	
E	.125	.155	3.17	3.94	
e	.095	.105	2.41	2.67	3
e_1	.045	.055	1.14	1.40	3
J	.135	.170	3.42	4.32	
L	.500		12.70		1
L_1		.050		1.27	1
L_2	.250		6.35		1
Q	.095 REF.		2.29 REF.		2
R	.055		.12		
S	.080	.105	2.03	2.67	
S_1	.090 REF.		2.29 REF.		

FEATURES:

- Low Cost
- Side Looking
- I/O Compatible with Integrated Circuits

absolute maximum ratings: (25°C) (unless otherwise specified)

Storage and Operating Temperature -55°C to 85°C. Lead Soldering Time (at 260°C) 10 Seconds.

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (100 μs, 1% Duty Cycle)	1	ampere
Reverse Voltage	3	volts

*Derate 1.33mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
Collector Current (Continuous)	100	milliamps
V_{CEO}	25	volts
V_{ECO}	7	volts

**Derate 2.0mW/°C above 25°C ambient.

individual electrical characteristics (25°C)

INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.2	1.7	volts
Reverse Current (V_R = 2V)	–	10	μ amps
Capacitance (V = 0,f = 1MHz)	50	–	pf

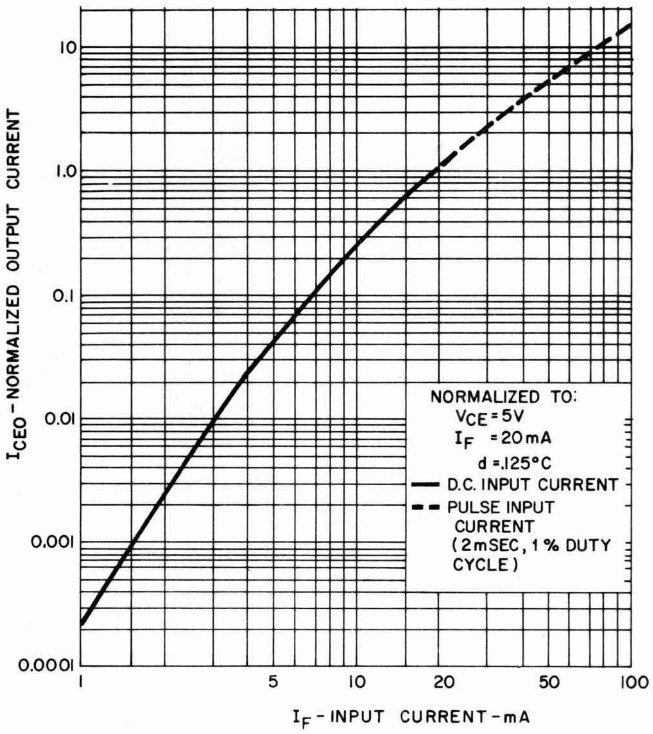
PHOTO-DARLINGTON	MIN.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 1mA)	25	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA)	7	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0,H ≈ 0)		100	nA

coupled electrical characteristics (25°C)

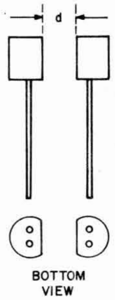
Note: Coupled electrical characteristics are measured at a separation distance of .125" with the faces of the emitter and detector parallel within 3°.

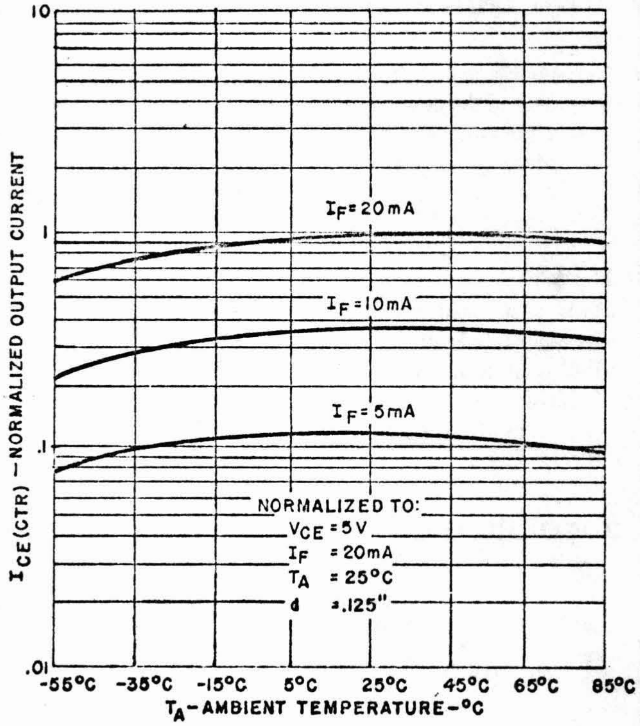
	MIN.	TYP.	MAX.	UNITS
Output Current (I_F = 20mA, V_{CE} = 5V)	1000	–	–	μ amps
Saturation Voltage (I_F = 20mA, I_C = 0.5mA)	–	–	1.2	volts
Switching Speeds: Turn-On Time ($t_d + t_r$) (V_{CE} = 10V, I_C = 2mA, R_L = 100Ω)	–	150	–	μ secs
Turn-Off Time ($t_s + t_f$) (V_{CE} = 10V, I_C = 2mA, R_L = 100Ω)	–	150	–	μ secs

TYPICAL CHARACTERISTICS

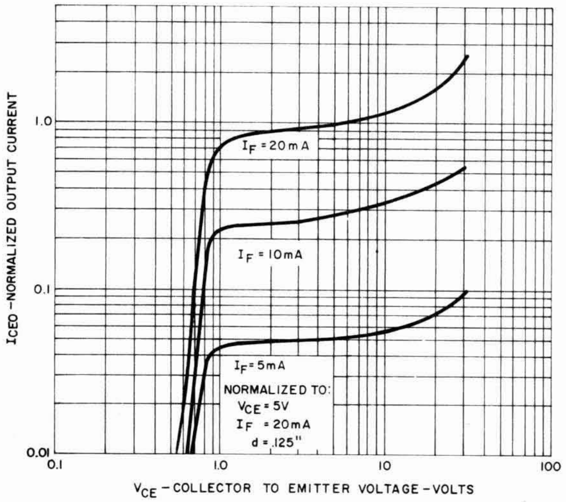


1. OUTPUT CURRENT VS. INPUT CURRENT

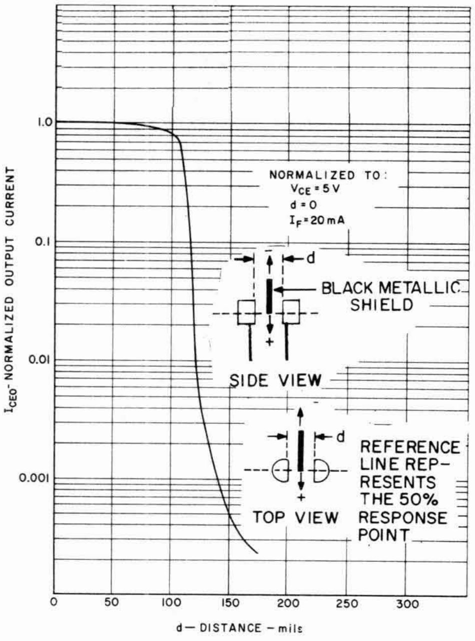




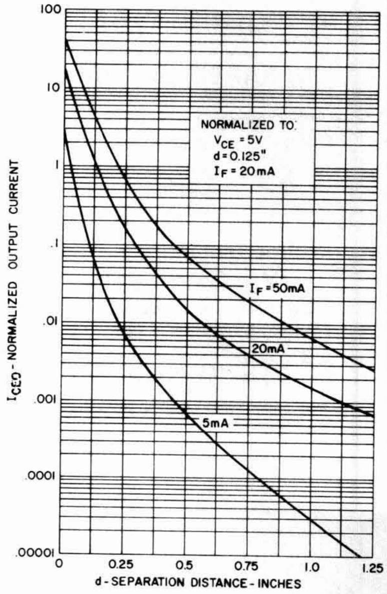
2. OUTPUT CURRENT VS. TEMPERATURE



3. OUTPUT CHARACTERISTICS



4. OUTPUT CURRENT VS. SHIELD LOCATION



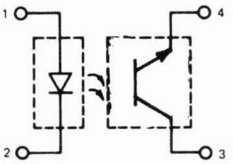
5. OUTPUT VS. DISTANCE

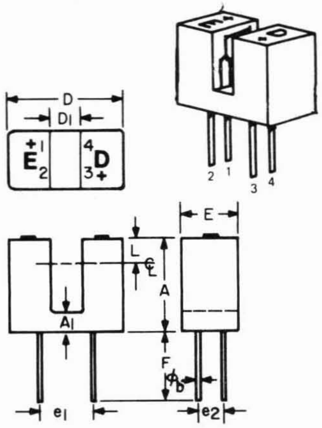
Photon Coupled Interrupter Module H20A1, H20A2

The General Electric H20A1 and H20A2 are gallium arsenide infrared emitting diodes coupled with a silicon photo-transistor in a plastic housing. The gap in the housing provides a means of interrupting the signal with tape, cards, shaft encoders, or other opaque material, switching the output transistor from an "ON" into an "OFF" state.

FEATURES:

- Low cost, plastic module
- Non-contact switching
- Fast switching speeds
- Solid-state reliability
- I/O compatible with integrated circuits





SYM.	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.390	.400	9.91	10.16	
A_1	.075	.085	1.91	2.15	
ϕb	.016	.019	.407	.482	1
D	.475	.495	12.07	12.57	
D_1	.120	.130	3.05	3.30	
e_1	.205	.235	5.21	5.96	
e_2	.090	.110	2.29	2.79	
E	–	.250	–	6.35	
F	.300	–	7.62	–	1
L	.110	NOM.	2.79	NOM.	2

NOTES:
1. FOUR LEADS. LEAD DIAMETER CONTROLLED BETWEEN .050"(1.27 MM) FROM THE SEATING PLANE AND THE END OF THE LEADS.
2. THE SENSING AREA FALLS WITHIN A .060" (1.52 MM) SQUARE ON THIS CENTERLINE.

absolute maximum ratings: (25 °C) (unless otherwise specified)

Storage and Operating Temperature -55°C to 85°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak 100 μs, 1% duty cycle)	1	amp
Reverse Voltage	3	volts

*Derate 1.67 mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
Collector Current (Continuous)	100	milliamps
V_{CEO}	30	volts
V_{ECO}	5	volts

**Derate 2.5 mW/°C above 25°C ambient.

individual electrical characteristics (25 °C)

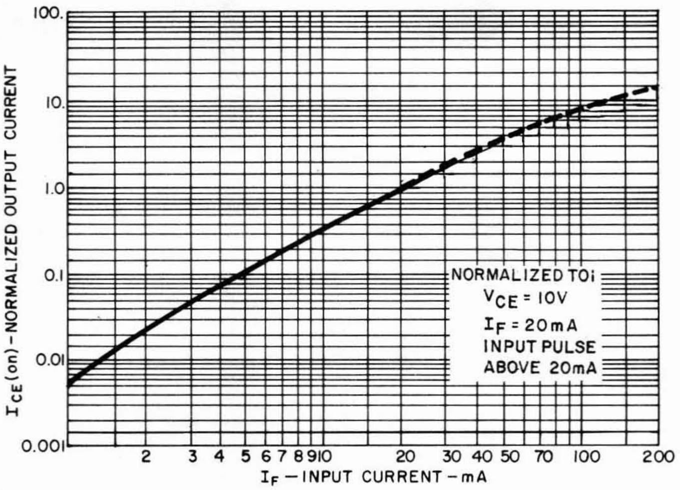
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 20 mA)	1.3	1.7	volts
Reverse Current (V_R = 3 V)	–	10	μamps
Capacitance (V = 0, f = 1 MHz)	25	–	pF

PHOTO-TRANSISTOR	MIN.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ (I_C = 10 mA)	30	–	volts
Breakdown Voltage $V_{(BR)ECO}$ (I_E = 100 μA)	5	–	volts
Collector Dark Current I_{CEO} (V_{CE} = 10 V, I_F = 0, H = 0)	–	100	nA

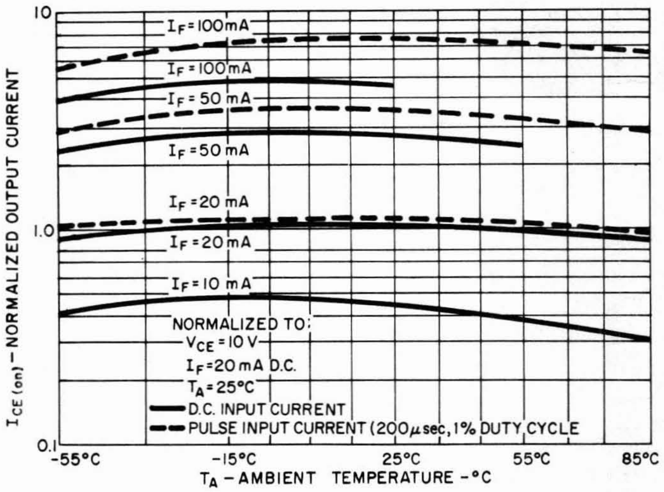
coupled electrical characteristics (25 °C)

		MIN.	TYP.	MAX.	UNITS
Output Current (I_F = 20 mA, V_{CE} = 10 V) –	H20A1	200	400	–	μamps
–	H20A2	50	–	–	μamps
Saturation Voltage (I_F = 20 mA, I_C = 25 μA)		–	0.2	0.4	volts
Switching Speeds:					
On Time ($t_d + t_r$) – (V_{CE} = 10 V, I_C = 2 mA, R_L = 100 Ω)		–	5	–	μsecs
Off Time ($t_s + t_f$) – (V_{CE} = 10 V, I_C = 2 mA, R_L = 100 Ω)		–	5	–	μsecs

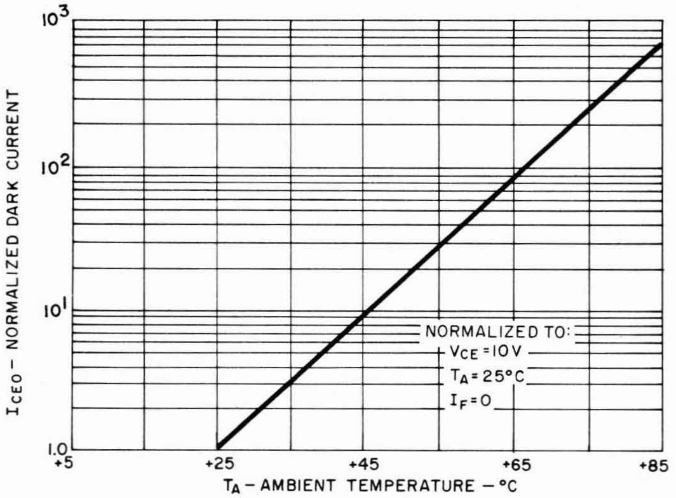
TYPICAL CHARACTERISTICS



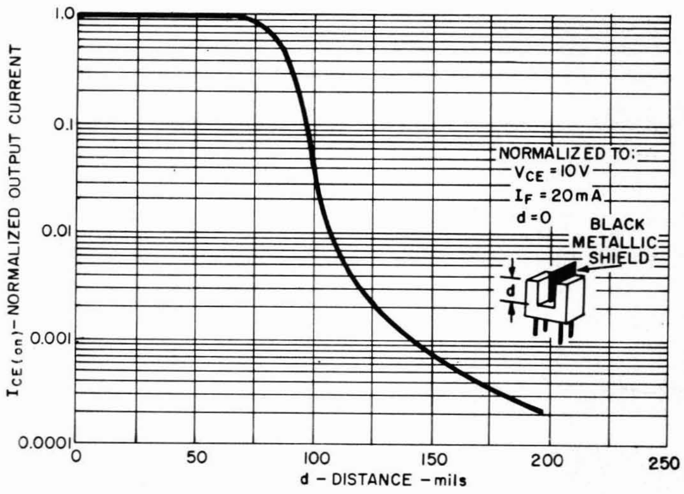
OUTPUT CURRENT VS. INPUT CURRENT



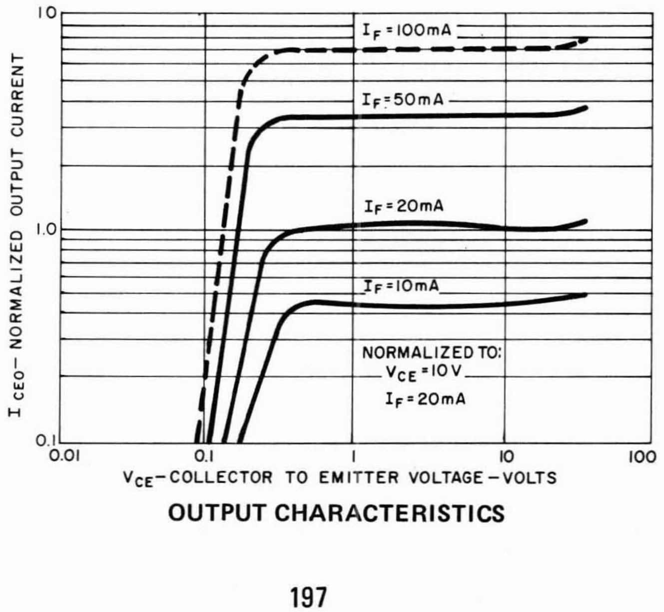
OUTPUT CURRENT VS. TEMPERATURE



NORMALIZED DARK CURRENT VS. TEMPERATURE



OUTPUT CURRENT VS. SHIELD DISTANCE



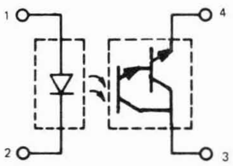
OUTPUT CHARACTERISTICS

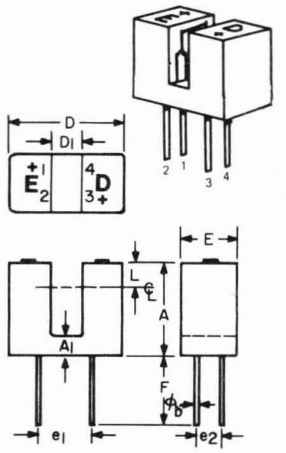
Photon Coupled Interrupter Module H20B1, H20B2

The General Electric H20B1 and H20B2 are gallium arsenide infrared emitting diodes coupled with a silicon photo-darlington in a plastic housing. The gap in the housing provides a means of interrupting the signal with tape, cards, shaft encoders, or other opaque material, switching the output transistor from an "ON" into an "OFF" state.

FEATURES:

- Low cost, plastic module
- Non-contact switching
- Solid-state reliability
- I/O compatible with integrated circuits





SYM.	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.390	.400	9.91	10.16	
A1	.075	.085	1.91	2.15	
φb	.016	.019	.407	.482	1
D	.475	.495	12.07	12.57	
D1	.120	.130	3.05	3.30	
e1	.205	.235	5.21	5.96	
e2	.090	.110	2.29	2.79	
E	–	.250	–	6.35	
F	.300	–	7.62	–	1
L	.110 NOM.		2.79 NOM.		2

NOTES:
1. FOUR LEADS. LEAD DIAMETER CONTROLLED BETWEEN .050"(1.27 MM) FROM THE SEATING PLANE AND THE END OF THE LEADS.
2. THE SENSING AREA FALLS WITHIN A .060" (1.52 MM) SQUARE ON THIS CENTERLINE.

absolute maximum ratings: (25 °C) (unless otherwise specified)

Storage and Operating Temperature -55°C to 85°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak, 100 μs, 1% duty cycle)	1	amp
Reverse Voltage	3	volts

*Derate 1.67 mW/°C above 25°C ambient.

PHOTO-DARLINGTON		
Power Dissipation	**150	milliwatts
Collector Current (Continuous)	100	milliamps
V_{CEO}	30	volts
V_{ECO}	7	volts

**Derate 2.5 mW/°C above 25°C ambient.

individual electrical characteristics (25 °C)

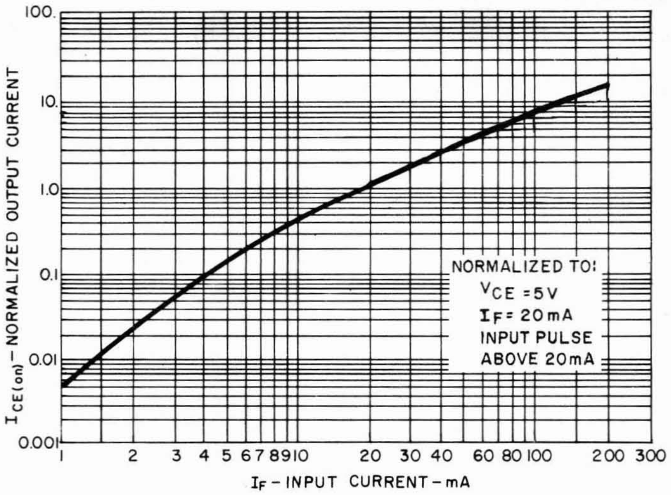
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 20 mA)	1.3	1.7	volts
Reverse Current (V_R = 3 V)	–	10	μ amps
Capacitance (V = 0, f = 1 MHz)	25	–	pF

PHOTO-DARLINGTON	MIN.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ (I_C = 10 mA)	30	–	volts
Breakdown Voltage $V_{(BR)ECO}$ (I_E = 100 μA)	7	–	volts
Collector Dark Current I_{CEO} (V_{CE} = 10V, I_F = 0, H = 0)	–	100	nA

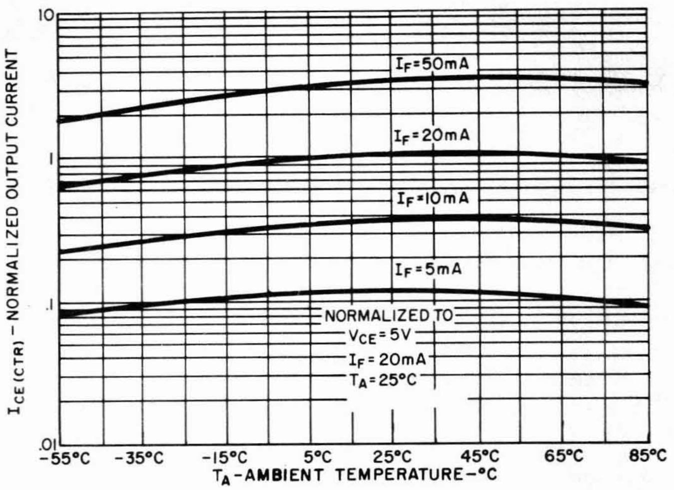
coupled electrical characteristics (25 °C)

		MIN.	TYP.	MAX.	UNITS
Output Current (I_F = 20 mA, V_{CE} = 5 V) –	H20B1	2.5	–	–	m amps
–	H20B2	1.0	–	–	m amps
Saturation Voltage (I_F = 20 mA, I_C = 0.5 mA)		–	–	1.2	volts
Switching Speeds:					
On Time ($t_d + t_r$) – (V_{CE} = 10 V, I_C = 2 mA, R_L = 100 Ω)		–	150	–	μsecs
Off Time ($t_s + t_f$) – (V_{CE} = 10 V, I_C = 2 mA, R_L = 100 Ω)		–	150	–	μsecs

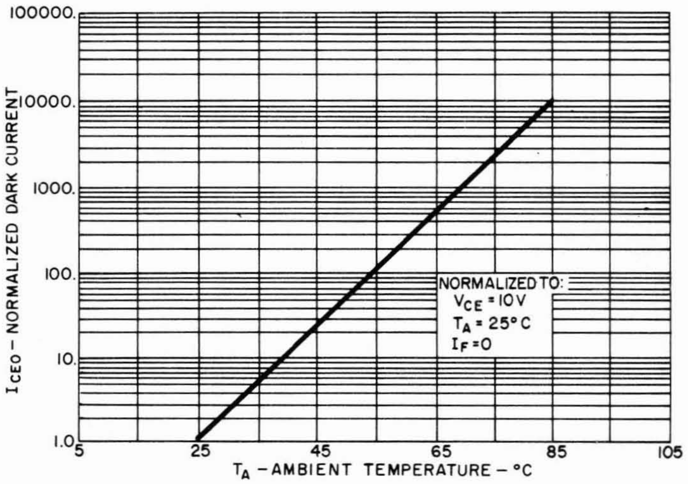
TYPICAL CHARACTERISTICS



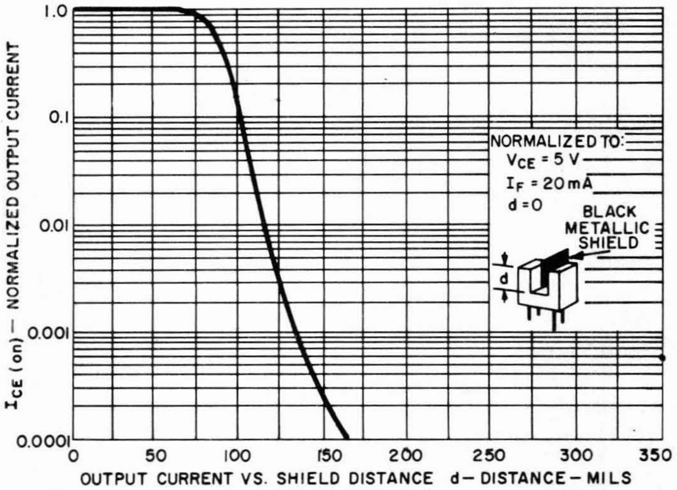
OUTPUT CURRENT VS. INPUT CURRENT



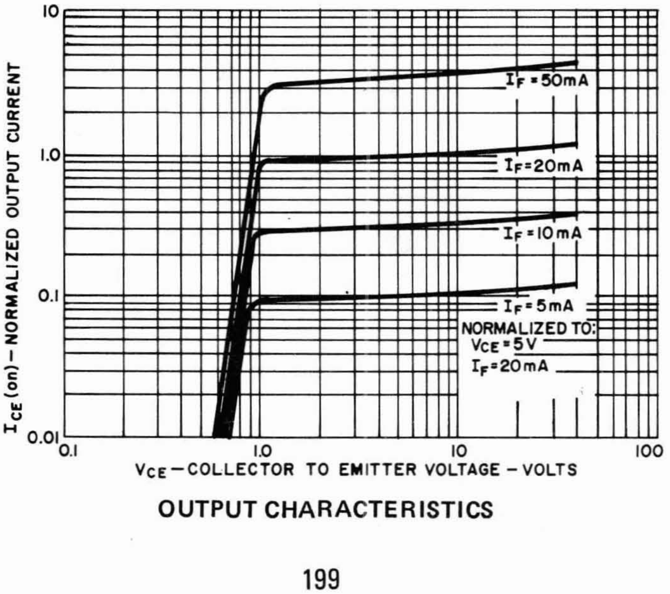
OUTPUT CURRENT VS. TEMPERATURE



NORMALIZED DARK CURRENT VS. TEMPERATURE



OUTPUT CURRENT VS. SHIELD DISTANCE

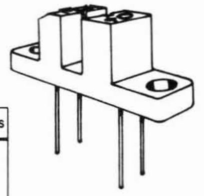


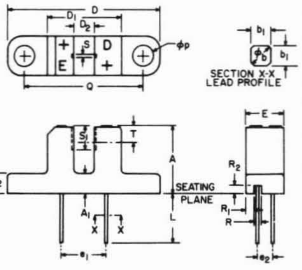
OUTPUT CHARACTERISTICS

1mm Aperture

Photon Coupled Interrupter Module H21A1, H21A2, H21A3

The General Electric H21A Interrupter Module is a gallium arsenide infrared emitting diode coupled to a silicon phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost, and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" into an "OFF" state.





SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
A_2	3.0	3.2	.119	.125	
ϕb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D	24.3	24.7	.957	.972	
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
e_2	2.3	2.8	.091	.110	
E	6.15	6.35	.243	.249	
L	8.00		.315		
ϕp	3.2	3.4	.126	.133	
Q	18.9	19.2	.745	.755	
R	1.3 NOM.		.051 NOM.		
R_1	1.3 NOM.		.051 NOM.		
R_2	1.3 NOM.		.051 NOM.		
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

NOTES:

1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27 MM (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ±0.75 MM (±.030 INCH).

absolute maximum ratings: (25°C)

TOTAL DEVICE		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ⩽ 1 μs PRR ⩽ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}	6	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics: (25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60mA$	–	–	1.7	V
Reverse Current I_R $V_R = 5V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1MHz$	–	30	–	pF

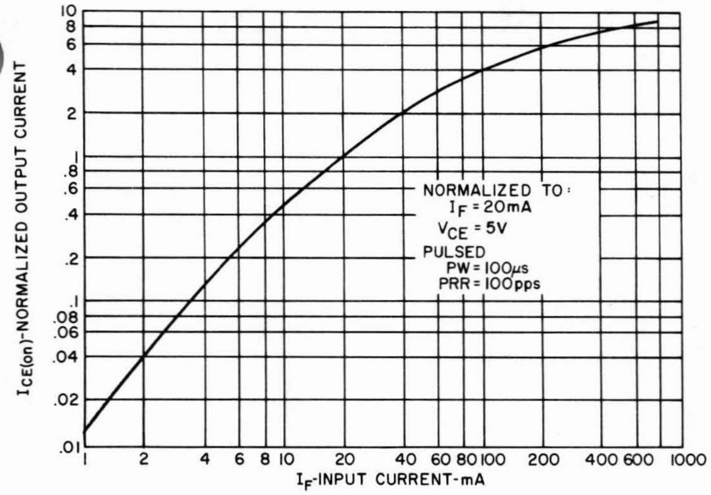
DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1 mA$	30	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\mu A$	6	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 25V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1MHz$	–	3.3	5	pF

coupled electrical characteristics: (25°C) (See Note 1)

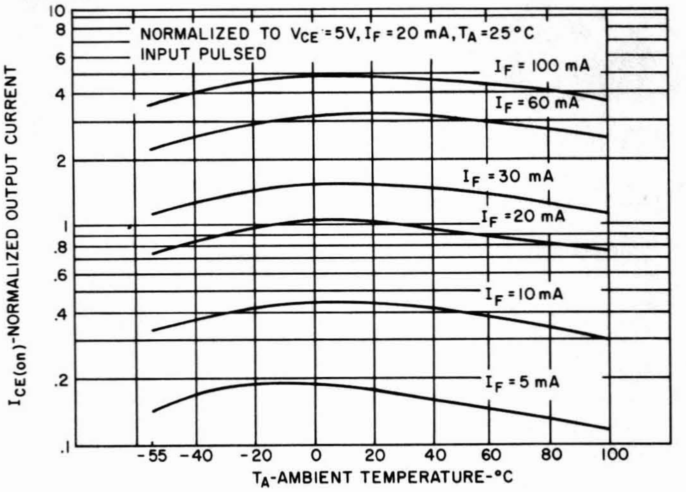
		H21A1			H21A2			H21A3			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$I_{CE(on)}$	$I_F = 5mA, V_{CE} = 5V$	0.15	–	–	0.30	–	–	0.60	–	–	mA
$I_{CE(on)}$	$I_F = 20mA, V_{CE} = 5V$	1.0	–	–	2.0	–	–	4.0	–	–	mA
$I_{CE(on)}$	$I_F = 30mA, V_{CE} = 5V$	1.9	–	–	3.0	–	–	5.5	–	–	mA
$V_{CE(sat)}$	$I_F = 20mA, I_C = 1.8mA$	–	–	–	–	–	0.40	–	–	0.40	V
$V_{CE(sat)}$	$I_F = 30mA, I_C = 1.8mA$	–	–	0.40	–	–	–	–	–	–	V
t_{on}	$V_{CC} = 5V, I_F = 30mA, R_L = 2.5K\Omega$	–	8	–	–	8	–	–	8	–	μs
t_{off}	$V_{CC} = 5V, I_F = 30mA, R_L = 2.5K\Omega$	–	50	–	–	50	–	–	50	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

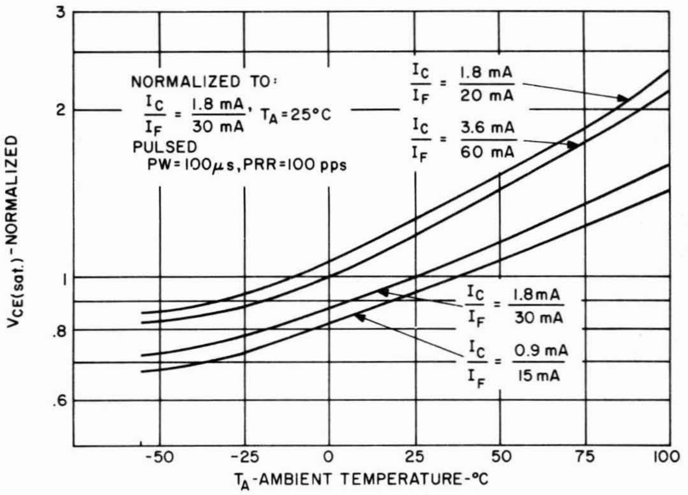
TYPICAL CHARACTERISTICS



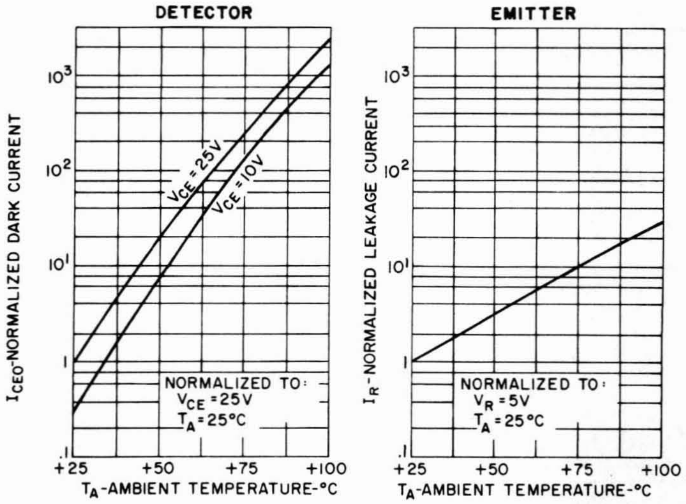
1. OUTPUT CURRENT VS. INPUT CURRENT



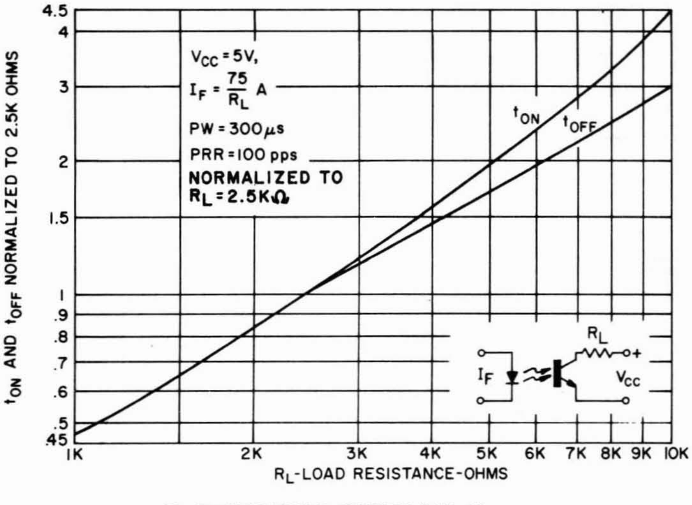
2. OUTPUT CURRENT VS. TEMPERATURE



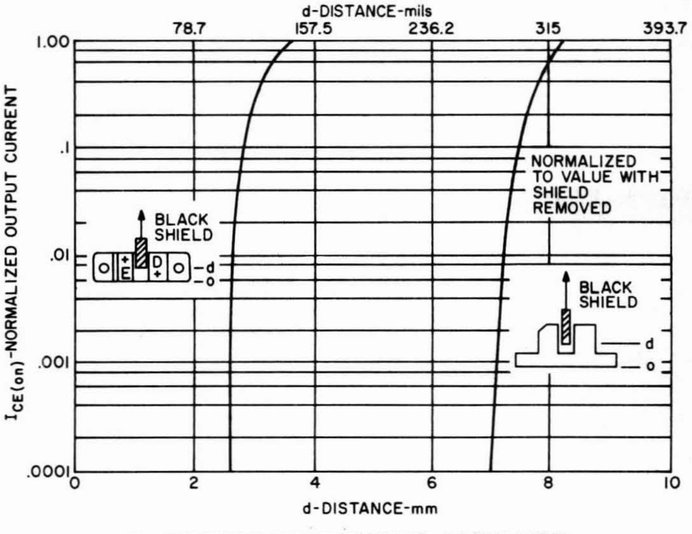
3. $V_{CE(sat)}$ VS. TEMPERATURE



4. LEAKAGE CURRENTS VS. TEMPERATURE



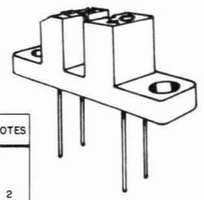
5. SWITCHING SPEED VS. R_L



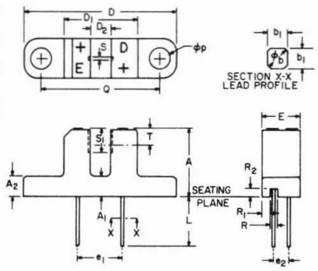
6. OUTPUT CURRENT VS. DISTANCE

1mm Aperture

Photon Coupled Interrupter Module H21A4, H21A5, H21A6



The General Electric H21A Interrupter Module is a gallium arsenide infrared emitting diode coupled to a silicon phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost, and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" into an "OFF" state.



SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
A_2	3.0	3.2	.119	.125	
ϕb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D	24.3	24.7	.957	.972	
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
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L	8.00		.315		
ϕp	3.2	3.4	.126	.133	
Q	18.9	19.2	.745	.755	
R	1.3 NOM.		.051 NOM.		
R_1	1.3 NOM.		.051 NOM.		
R_2	1.3 NOM.		.051 NOM.		
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

NOTES:
1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27 MM (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ±0.75 MM (±.030 INCH).

absolute maximum ratings: (25°C)

TOTAL DEVICE		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ⩽ 1 μs PRR ⩽ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	55	V
Emitter-Collector Voltage	V_{ECO}	6	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics: (25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\,\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60\,mA$	–	–	1.7	V
Reverse Current I_R $V_R = 5V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1MHz$	–	30	–	pF

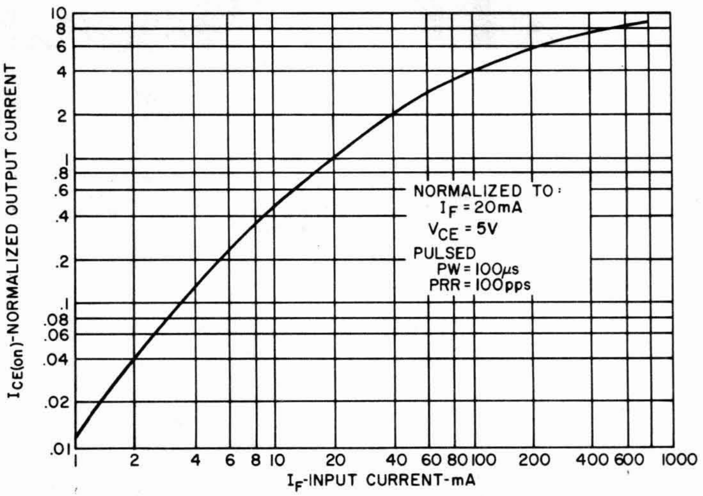
DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1\,mA$	55	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\,\mu A$	6	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 45V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1MHz$	–	3.3	5	pF

coupled electrical characteristics: (25°C) (See Note 1)

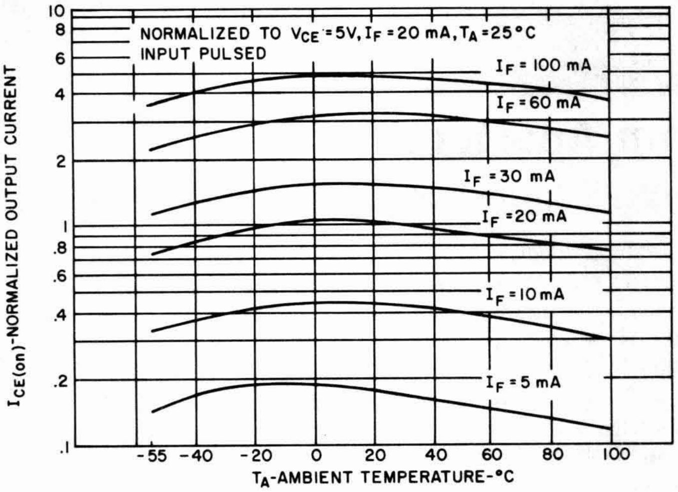
		H21A4			H21A5			H21A6			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$I_{CE(on)}$	$I_F = 5mA, V_{CE} = 5V$	0.15	–	–	0.30	–	–	0.60	–	–	mA
$I_{CE(on)}$	$I_F = 20mA, V_{CE} = 5V$	1.0	–	–	2.0	–	–	4.0	–	–	mA
$I_{CE(on)}$	$I_F = 30mA, V_{CE} = 5V$	1.9	–	–	3.0	–	–	5.5	–	–	mA
$V_{CE(sat)}$	$I_F = 20mA, I_C = 1.8mA$	–	–	–	–	–	0.40	–	–	0.40	V
$V_{CE(sat)}$	$I_F = 30mA, I_C = 1.8mA$	–	–	0.40	–	–	–	–	–	–	V
t_{on}	$V_{CC} = 5V, I_F = 30mA, R_L = 2.5K\Omega$	–	8	–	–	8	–	–	8	–	μs
t_{off}	$V_{CC} = 5V, I_F = 30mA, R_L = 2.5K\Omega$	–	50	–	–	50	–	–	50	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

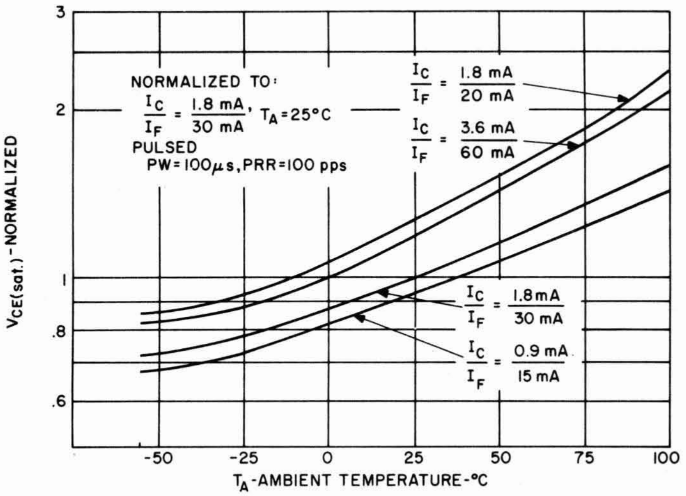
TYPICAL CHARACTERISTICS



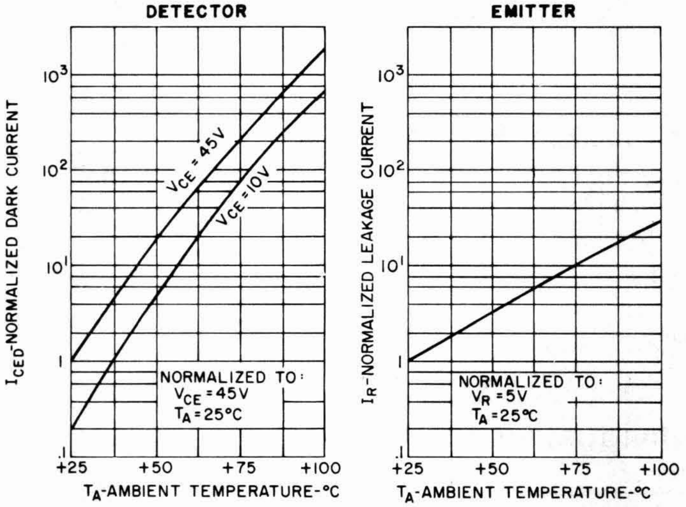
1. OUTPUT CURRENT VS. INPUT CURRENT



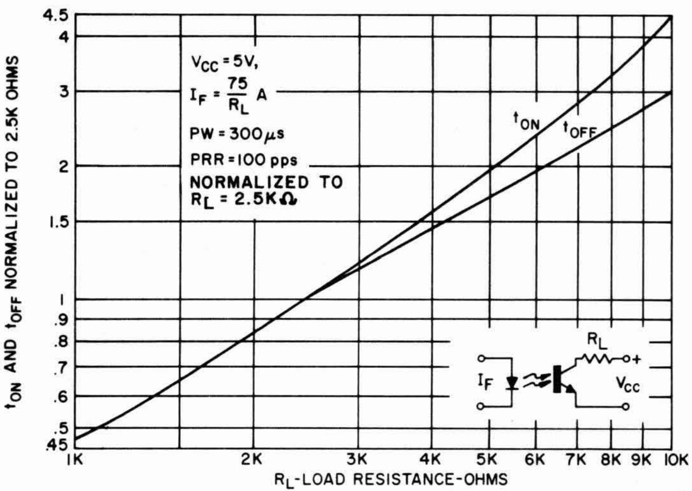
2. OUTPUT CURRENT VS. TEMPERATURE



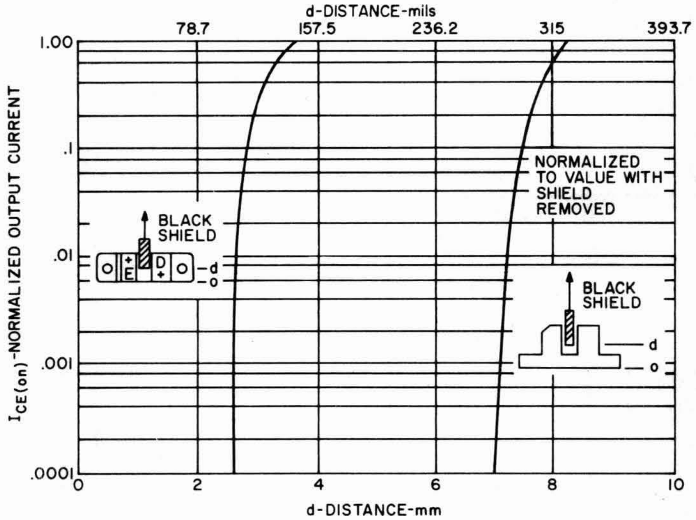
3. $V_{CE\,(sat)}$ VS. TEMPERATURE



4. LEAKAGE CURRENTS VS. TEMPERATURE



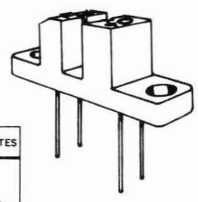
5. SWITCHING SPEED VS. R_L



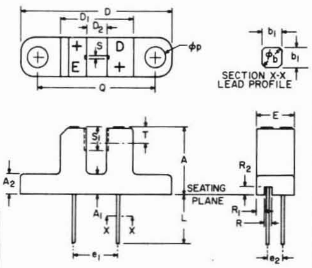
6. OUTPUT CURRENT VS. SHIELD DISTANCE

1mm Aperture

Photon Coupled Interrupter Module H21B1, H21B2, H21B3



The General Electric H21B Interrupter Module is a gallium arsenide infrared emitting diode coupled to a silicon darlington connected phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost, and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" into an "OFF" state.



SYMBOL	MILLIMETERS MIN.	MILLIMETERS MAX.	INCHES MIN.	INCHES MAX.	NOTES
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
A_2	3.0	3.2	.119	.125	
φb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D	24.3	24.7	.957	.972	
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
e_2	2.3	2.8	.091	.110	
E	6.15	6.35	.243	.249	
L	8.00		.315		
φp	3.2	3.4	.126	.133	
Q	18.9	19.2	.745	.755	
R	1.3 NOM.		.051 NOM.		
R_1	1.3 NOM.		.051 NOM.		
R_2	1.3 NOM.		.051 NOM.		
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

NOTES:

1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27 MM (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ±0.75 MM (±.030 INCH).

absolute maximum ratings: (25°C)

TOTAL DEVICE		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ⩽ 1 μs PRR ⩽ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

DARLINGTON CONNECTED PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}	7	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics:(25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60mA$	–	–	1.7	V
Reverse Current I_R $V_R = 5V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1MHz$	–	30	–	pF

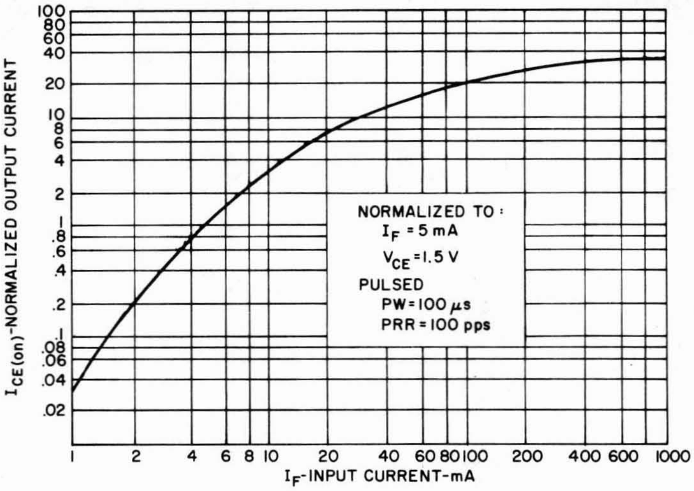
DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1 mA$	30	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\mu A$	7	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 25V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1MHz$	–	5	8	pF

coupled electrical characteristics: (25°C) (See Note 1)

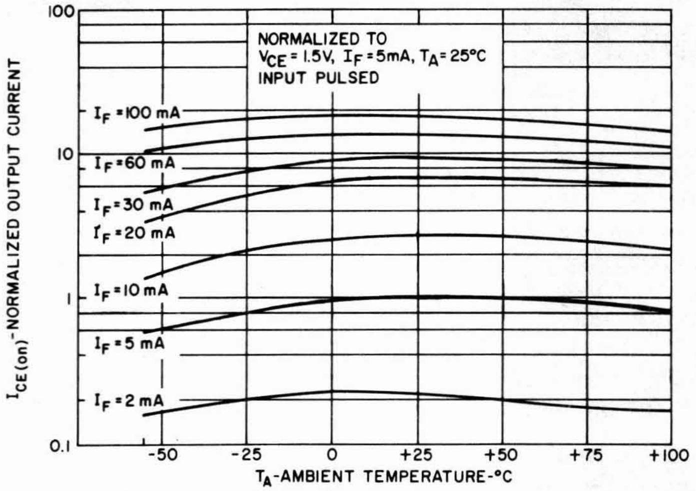
		H21B1			H21B2			H21B3			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$I_{CE(on)}$	$I_F = 2mA, V_{CE} = 1.5V$	0.5	–	–	1.0	–	–	2.0	–	–	mA
$I_{CE(on)}$	$I_F = 5mA, V_{CE} = 1.5V$	2.5	–	–	5.0	–	–	10	–	–	mA
$I_{CE(on)}$	$I_F = 10mA, V_{CE} = 1.5V$	7.5	–	–	14	–	–	25	–	–	mA
$V_{CE(sat)}$	$I_F = 10mA, I_C = 1.8mA$	–	–	1.0	–	–	1.0	–	–	1.0	V
$V_{CE(sat)}$	$I_F = 60mA, I_C = 50mA$	–	–	–	–	–	1.5	–	–	1.5	V
t_{on}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	45	–	–	45	–	–	45	–	μs
	$V_{CC} = 5V, I_F = 60mA, R_L = 75\Omega$	–	–	–	–	7	–	–	7	–	μs
t_{off}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	250	–	–	250	–	–	250	–	μs
	$V_{CC} = 5V, I_F = 60mA, R_L = 75\Omega$	–	–	–	–	45	–	–	45	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

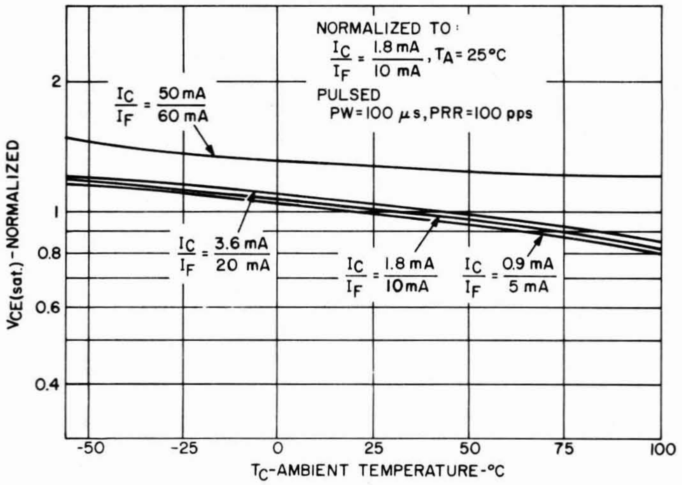
TYPICAL CHARACTERISTICS



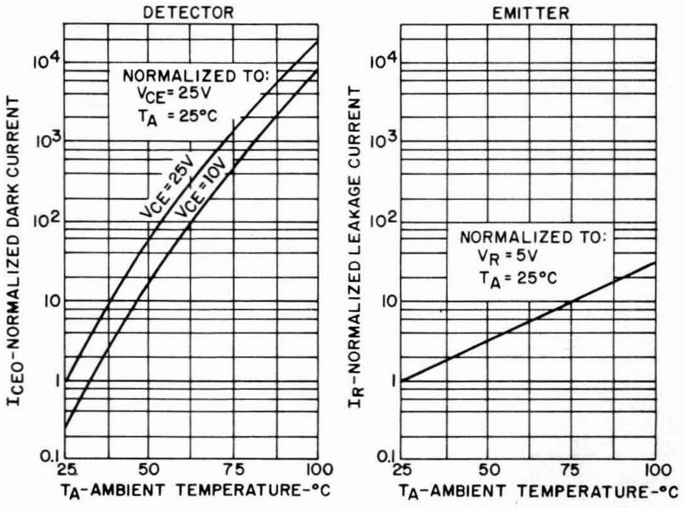
1. OUTPUT CURRENT VS. INPUT CURRENT



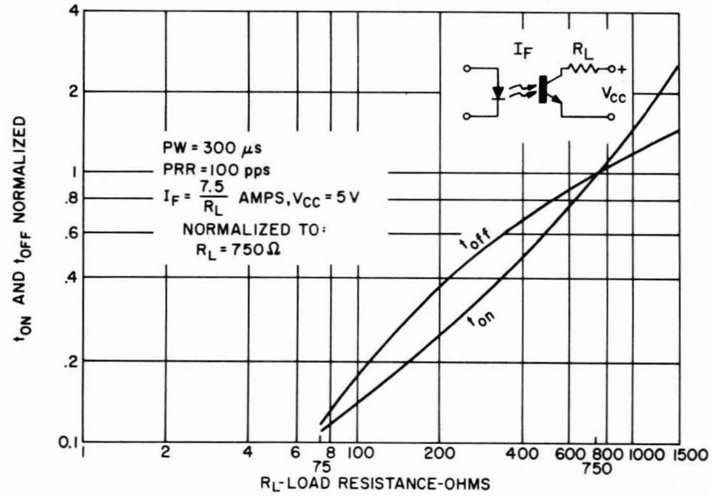
2. OUTPUT CURRENT VS. TEMPERATURE



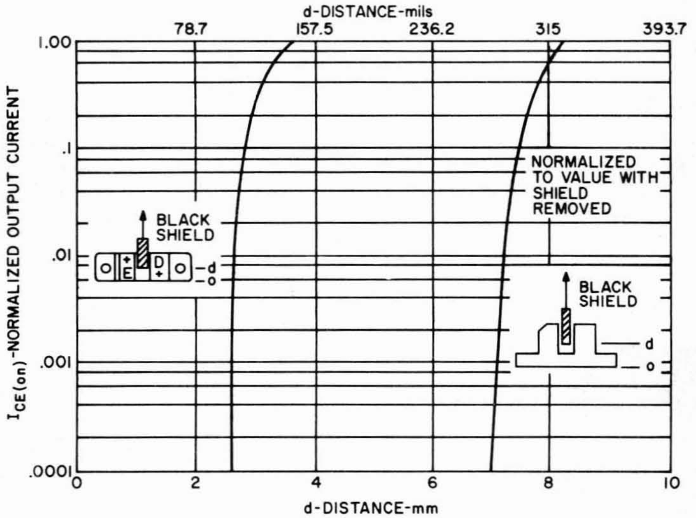
3. $V_{CE\,(sat)}$ VS. TEMPERATURE



4. LEAKAGE CURRENTS VS. TEMPERATURE



5. SWITCHING SPEED VS. R_L

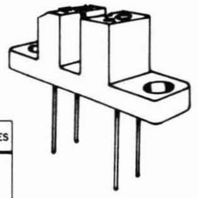


6. OUTPUT CURRENT VS. SHIELD DISTANCE

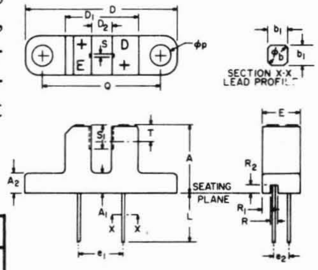
SOLID STATE
OPTOELECTRONICS

1mm Aperture

Photon Coupled Interrupter Module H21B4, H21B5, H21B6



The General Electric H21B Interrupter Module is a gallium arsenide infrared emitting diode coupled to a silicon darlington connected phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost, and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" into an "OFF" state.



SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
A_2	3.0	3.2	.119	.125	
φb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D	24.3	24.7	.957	.972	
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
e_2	2.3	2.8	.091	.110	
E	6.15	6.35	.243	.249	
L	8.00		.315		
φp	3.2	3.4	.126	.133	
Q	18.9	19.2	.745	.755	
R	1.3 NOM.		.051 NOM.		
R_1	1.3 NOM.		.051 NOM.		
R_2	1.3 NOM.		.051 NOM.		
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

NOTES:
1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27 MM (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ±0.75 MM (±.030 INCH).

absolute maximum ratings: (25°C)

TOTAL DEVICE		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ≤ 1 μs PRR ≤ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

DARLINGTON CONNECTED PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	55	V
Emitter-Collector Voltage	V_{ECO}	7	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics:(25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\,\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60\,mA$	–	–	1.7	V
Reverse Current I_R $V_R = 5V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1 MHz$	–	30	–	pF

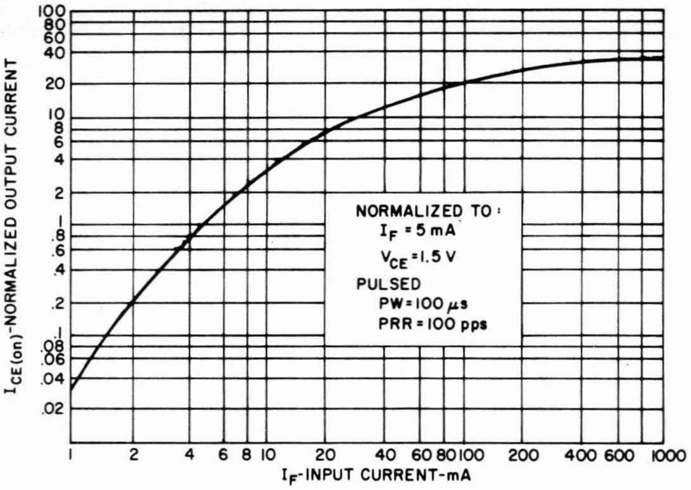
DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1\,mA$	55	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\,\mu A$	7	–	–	V
Collector Dark Current I_{CEO}, $V_{CE} = 45V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1 MHz$	–	5	8	pF

coupled electrical characteristics:(25°C) (See Note 1)

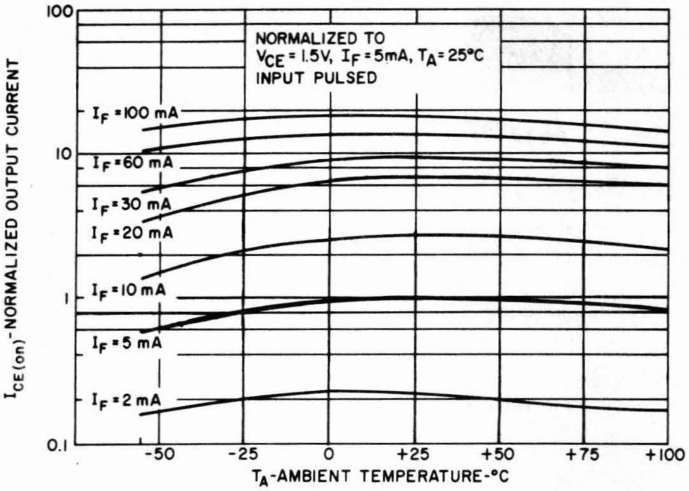
		H21B4			H21B5			H21B6			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$I_{CE(on)}$	$I_F = 2mA, V_{CE} = 1.5V$	0.5	–	–	1.0	–	–	2.0	–	–	mA
$I_{CE(on)}$	$I_F = 5mA, V_{CE} = 1.5V$	2.5	–	–	5.0	–	–	10	–	–	mA
$I_{CE(on)}$	$I_F = 10mA, V_{CE} = 1.5V$	7.5	–	–	14	–	–	25	–	–	mA
$V_{CE(sat)}$	$I_F = 10mA, I_C = 1.8mA$	–	–	1.0	–	–	1.0	–	–	1.0	V
$V_{CE(sat)}$	$I_F = 60mA, I_C = 50mA$	–	–	–	–	–	1.5	–	–	1.5	V
t_{on}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	45	–	–	45	–	–	45	–	μs
	$V_{CC} = 5V, I_F = 60mA, R_L = 75\Omega$	–	–	–	–	7	–	–	7	–	μs
t_{off}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	250	–	–	250	–	–	250	–	μs
	$V_{CC} = 5V, I_F = 60mA, R_L = 75\Omega$	–	–	–	–	45	–	–	45	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

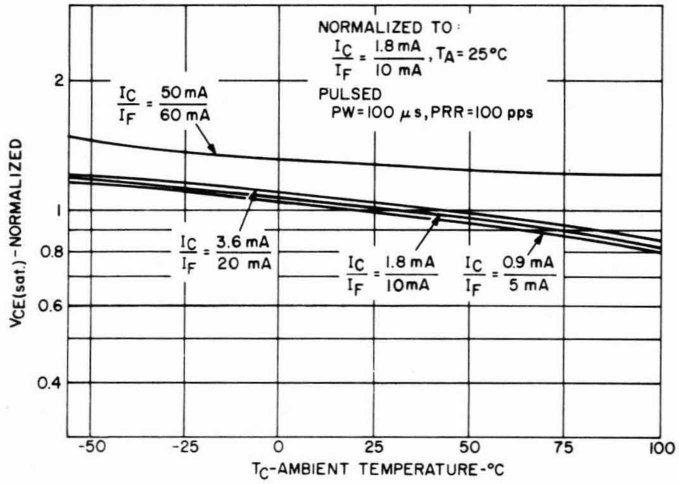
TYPICAL CHARACTERISTICS



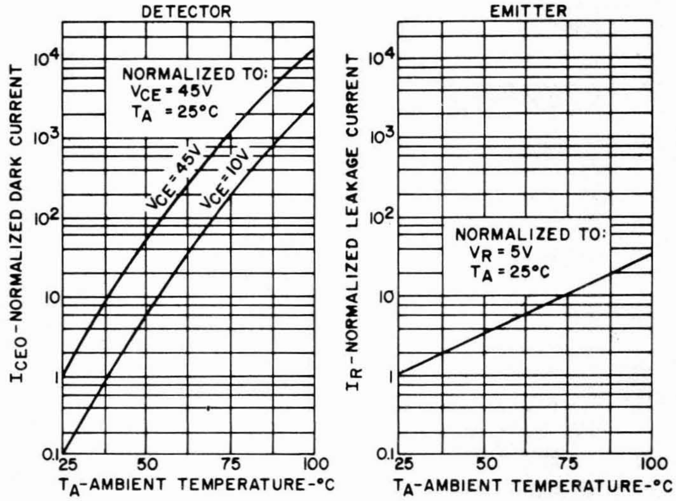
1. OUTPUT CURRENT VS. INPUT CURRENT



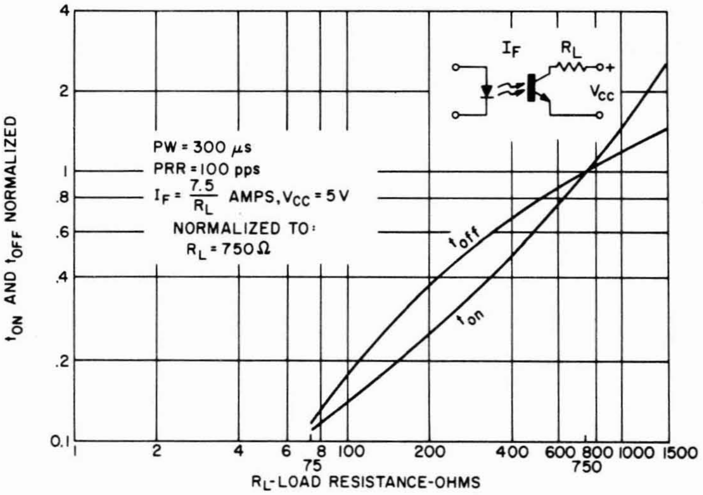
2. OUTPUT CURRENT VS. TEMPERATURE



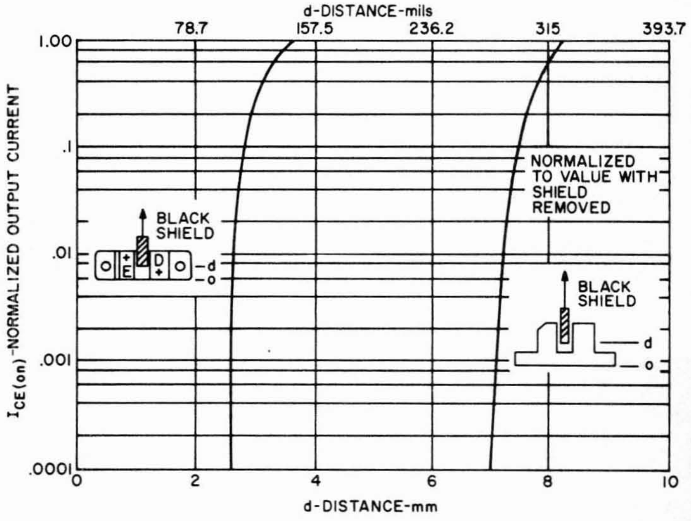
3. $V_{CE\,(sat)}$ VS. TEMPERATURE



4. LEAKAGE CURRENTS VS. TEMPERATURE



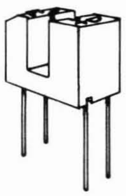
5. SWITCHING SPEED VS. R_L



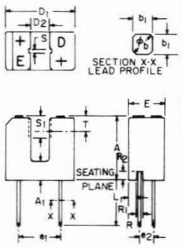
6. OUTPUT CURRENT VS. SHIELD DISTANCE

SOLID STATE
OPTOELECTRONICS

1mm Aperture
Photon Coupled Interrupter Module H22A1,H22A2,H22A3



The General Electric H22A Interrupter Module is a gallium arsenide infrared emitting diode coupled to a silicon phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost, and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" into an "OFF" state.



SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
ϕb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
e_2	2.3	2.8	.091	.110	
E	6.15	6.35	.243	.249	
L	8.00		.315		
R	1.3 NOM.		.051 NOM.		
R_1	1.3 NOM.		.051 NOM.		
R_2	1.3 NOM.		.051 NOM.		
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

NOTES:

1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27 MM (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ±0.75 MM (±.030 INCH).

absolute maximum ratings: (25°C)

TOTAL DEVICE		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ⩽ 1 μs PRR ⩽ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}	6	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics:(25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60 mA$	–	–	1.7	V
Reverse Current I_R $V_R = 5V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1MHz$	–	30	–	pF

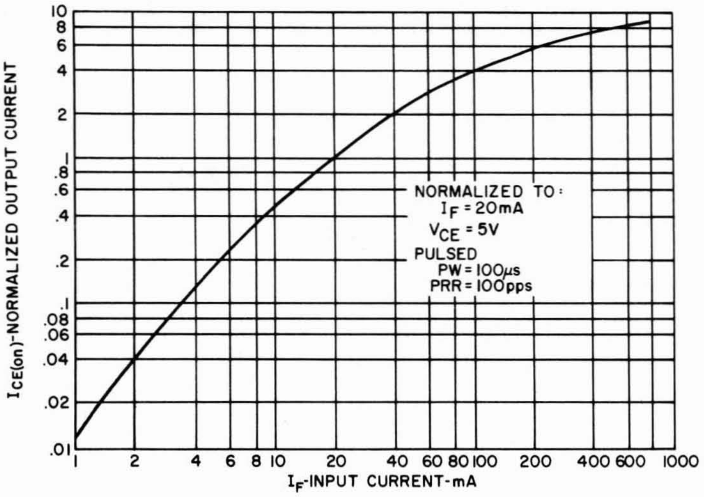
DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1 mA$	30	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\mu A$	6	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 25V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1MHz$	–	3.3	5	pF

coupled electrical characteristics:(25°C) (See Note 1)

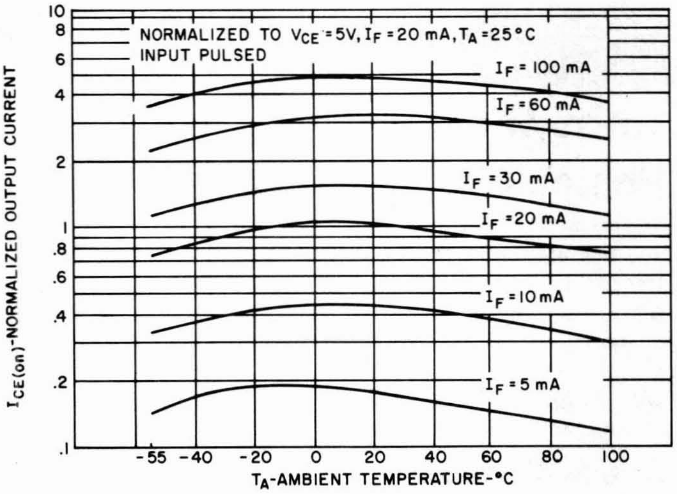
	H22A1			H22A2			H22A3			UNITS
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$I_{CE(on)}$ $I_F = 5mA, V_{CE} = 5V$	0.15	–	–	0.30	–	–	0.60	–	–	mA
$I_{CE(on)}$ $I_F = 20mA, V_{CE} = 5V$	1.0	–	–	2.0	–	–	4.0	–	–	mA
$I_{CE(on)}$ $I_F = 30mA, V_{CE} = 5V$	1.9	–	–	3.0	–	–	5.5	–	–	mA
$V_{CE(sat)}$ $I_F = 20mA, I_C = 1.8mA$	–	–	–	–	–	0.40	–	–	0.40	V
$V_{CE(sat)}$ $I_F = 30mA, I_C = 1.8mA$	–	–	0.40	–	–	–	–	–	–	V
t_{on} $V_{CC} = 5V, I_F = 30mA, R_L = 2.5K\Omega$	–	8	–	–	8	–	–	8	–	μs
t_{off} $V_{CC} = 5V, I_F = 30mA, R_L = 2.5K\Omega$	–	50	–	–	50	–	–	50	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

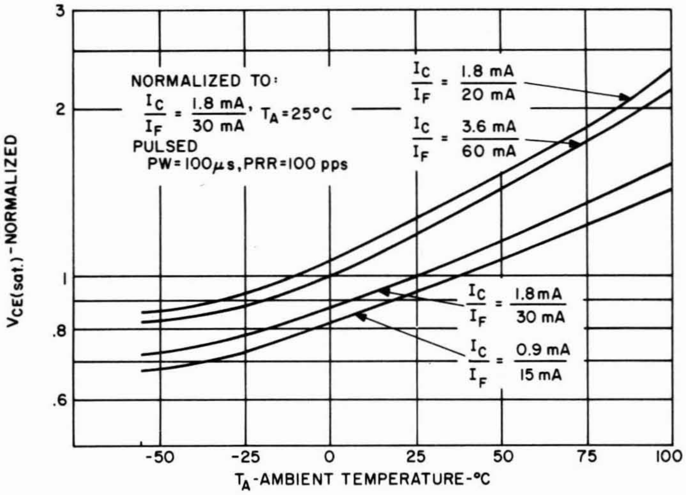
TYPICAL CHARACTERISTICS



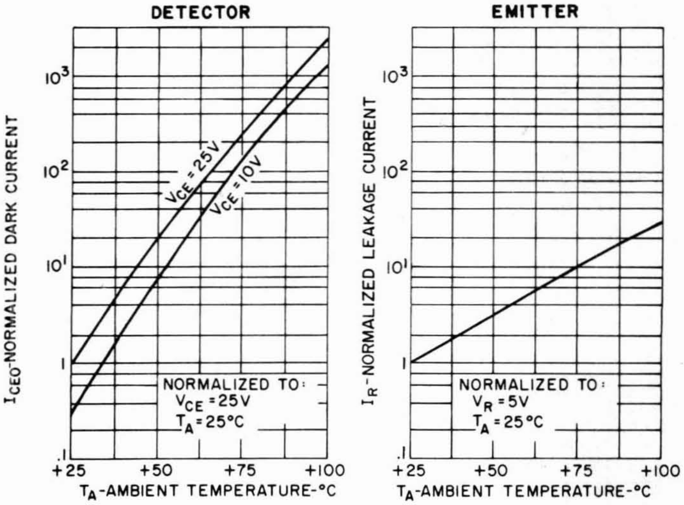
1. OUTPUT CURRENT VS. INPUT CURRENT



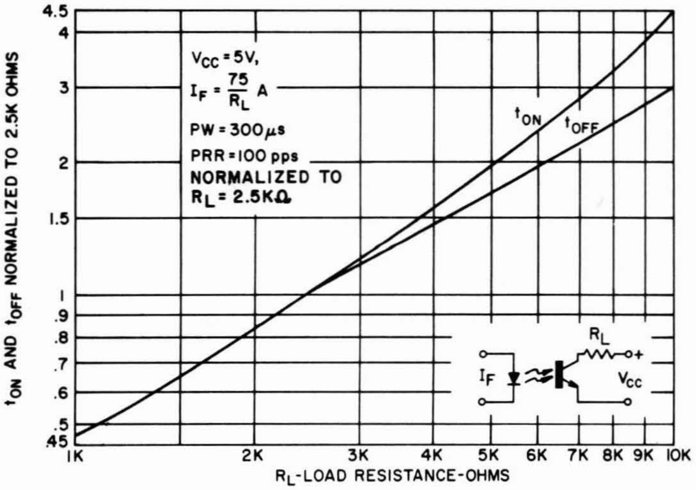
2. OUTPUT CURRENT VS. TEMPERATURE



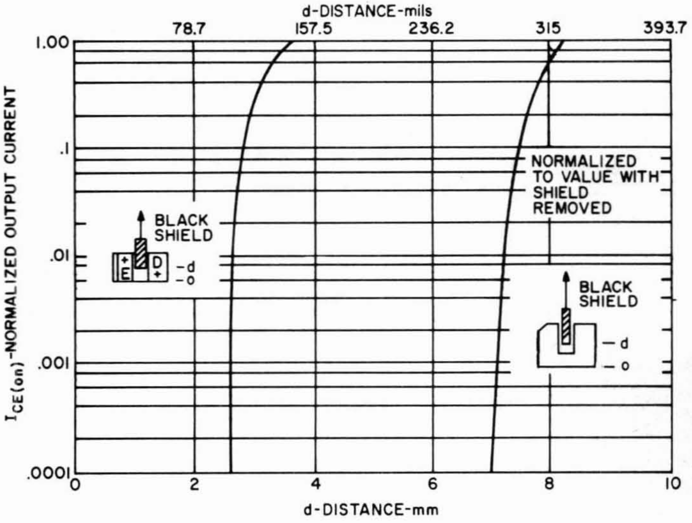
3. $V_{CE\ (sat)}$ VS. TEMPERATURE



4. LEAKAGE CURRENTS VS. TEMPERATURE



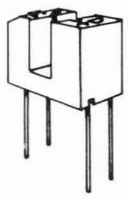
5. SWITCHING SPEED VS. R_L



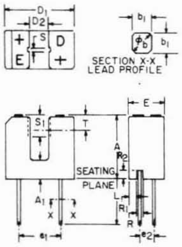
6. OUTPUT CURRENT VS. SHIELD DISTANCE

1mm Aperture

Photon Coupled Interrupter Module H22A4, H22A5, H22A6



The General Electric H22A Interrupter Module is a gallium arsenide infrared emitting diode coupled to a silicon phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost, and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" into an "OFF" state.



SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
ϕb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
e_2	2.3	2.8	.091	.110	
E	6.15	6.35	.243	.249	
L	8.00		.315		
R	1.3 NOM.		.051 NOM.		
R_1	1.3 NOM.		.051 NOM.		
R_2	1.3 NOM.		.051 NOM.		
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

NOTES:

1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27 MM (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ±0.75 MM (±.030 INCH).

absolute maximum ratings: (25°C)

TOTAL DEVICE		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ≤ 1 µs PRR ≤ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	55	V
Emitter-Collector Voltage	V_{ECO}	6	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics:(25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\,\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60\,mA$	–	–	1.7	V
Reverse Current I_R $V_R = 5\,V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1\,MHz$	–	30	–	pF

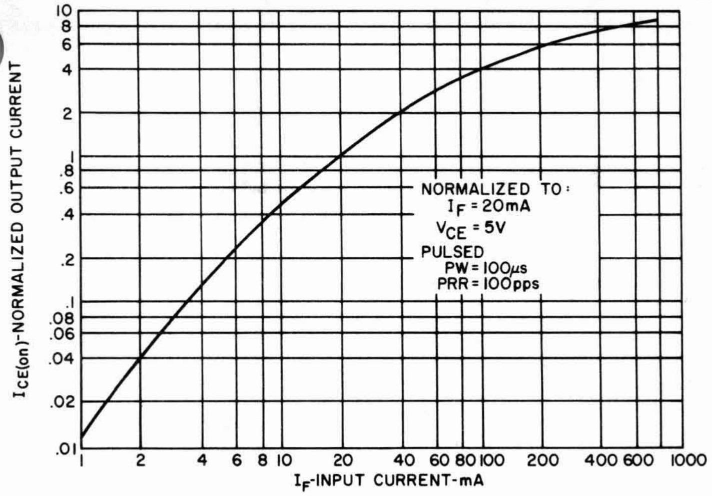
DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1\,mA$	55	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\,\mu A$	6	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 45V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1\,MHz$	–	3.3	5	pF

coupled electrical characteristics:(25°C) (See Note 1)

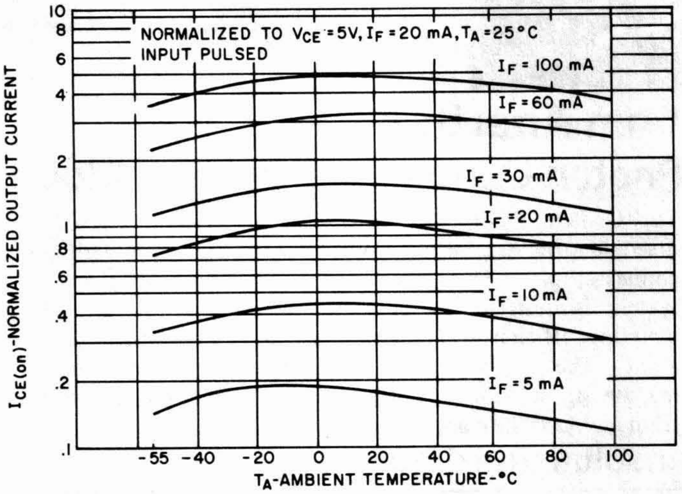
	H22A4			H22A5			H22A6			UNITS
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$I_{CE(on)}$ $I_F = 5mA, V_{CE} = 5V$	0.15	–	–	0.30	–	–	0.60	–	–	mA
$I_{CE(on)}$ $I_F = 20mA, V_{CE} = 5V$	1.0	–	–	2.0	–	–	4.0	–	–	mA
$I_{CE(on)}$ $I_F = 30mA, V_{CE} = 5V$	1.9	–	–	3.0	–	–	5.5	–	–	mA
$V_{CE(sat)}$ $I_F = 20mA, I_C = 1.8mA$	–	–	–	–	–	0.40	–	–	0.40	V
$V_{CE(sat)}$ $I_F = 30mA, I_C = 1.8mA$	–	–	0.40	–	–	–	–	–	–	V
t_{on} $V_{CC} = 5V, I_F = 30mA, R_L = 2.5K\Omega$	–	8	–	–	8	–	–	8	–	µs
t_{off} $V_{CC} = 5V, I_F = 30mA, R_L = 2.5K\Omega$	–	50	–	–	50	–	–	50	–	µs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

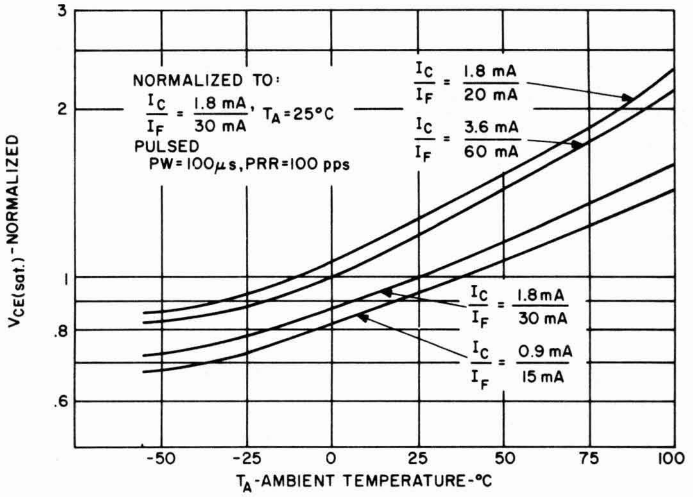
TYPICAL CHARACTERISTICS



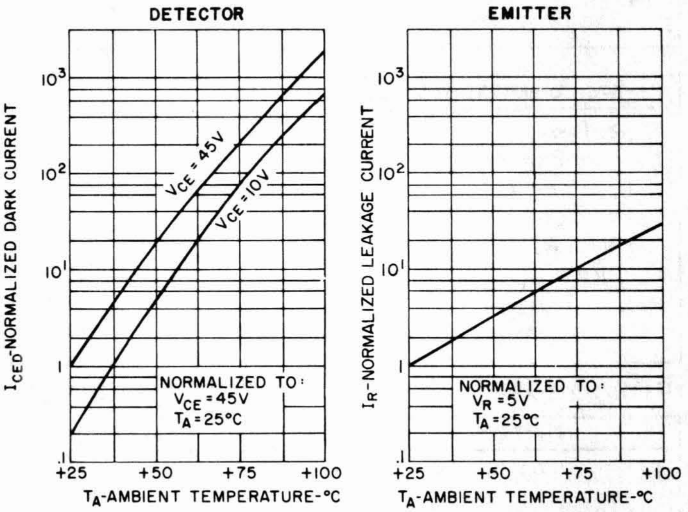
1. OUTPUT CURRENT VS. INPUT CURRENT



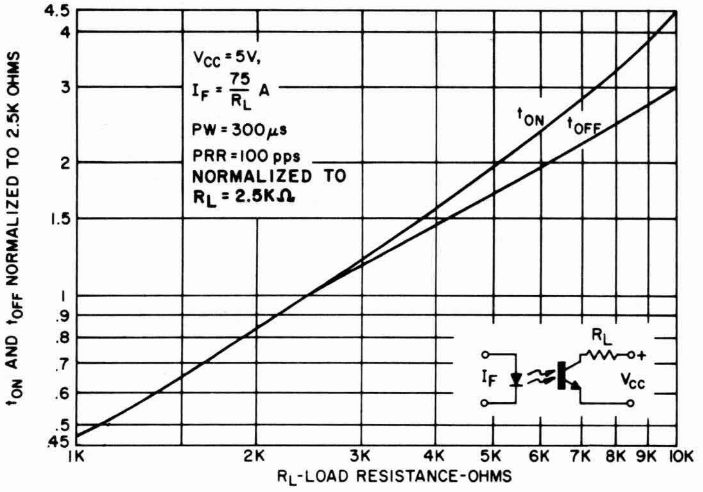
2. OUTPUT CURRENT VS. TEMPERATURE



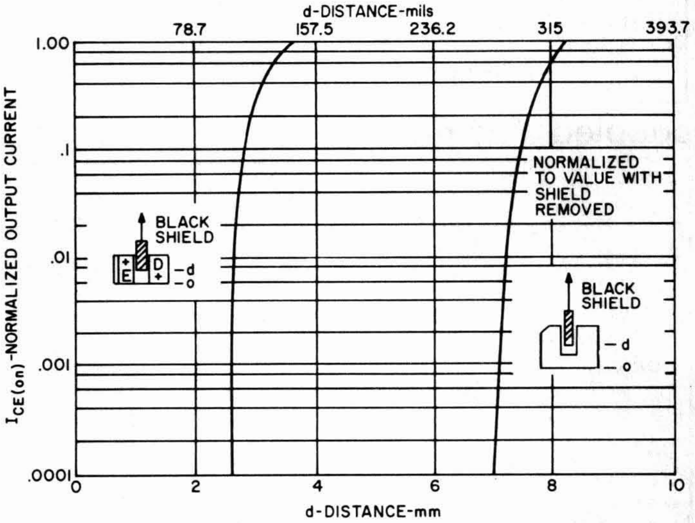
3. $V_{CE(sat)}$ VS. TEMPERATURE



4. LEAKAGE CURRENTS VS. TEMPERATURE



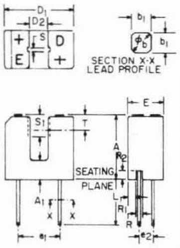
5. SWITCHING SPEED VS. R_L



6. OUTPUT CURRENT VS. SHIELD DISTANCE

1mm Aperture
Photon Coupled Interrupter Module H22B1, H22B2, H22B3

The General Electric H22B Interrupter Module is a gallium arsenide infrared emitting diode coupled to a silicon darlington connected phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost, and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" into an "OFF" state.



SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
ϕb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
e_2	2.3	2.8	.091	.110	
E	6.15	6.35	.243	.249	
L	8.00		.315		
R	1.3 NOM.		.051 NOM.		
R_1	1.3 NOM.		.051 NOM.		
R_2	1.3 NOM.		.051 NOM.		
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

NOTES:
1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27 MM (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ±0.75 MM (±.030 INCH).

absolute maximum ratings: (25°C)

TOTAL DEVICE		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ⩽ 1 μs PRR ⩽ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

DARLINGTON CONNECTED PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}	7	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics:(25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\,\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60\,mA$	–	–	1.7	V
Reverse Current I_R $V_R = 5V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1MHz$	–	30	–	pF

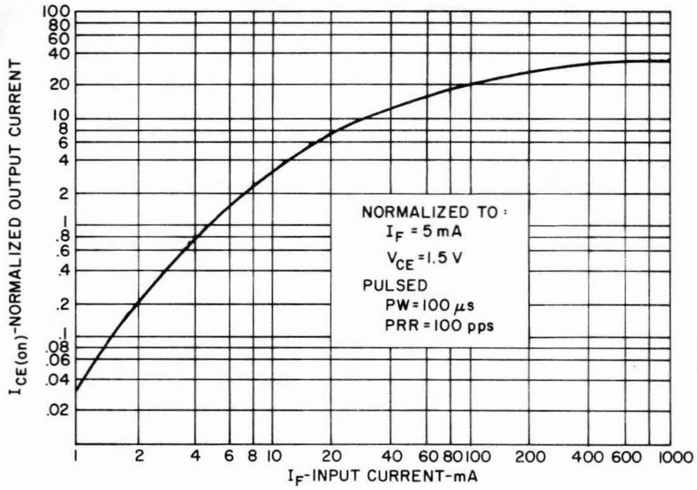
DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1\,mA$	30	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\,\mu A$	7	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 25V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1MHz$	–	5	8	pF

coupled electrical characteristics:(25°C) (See Note 1)

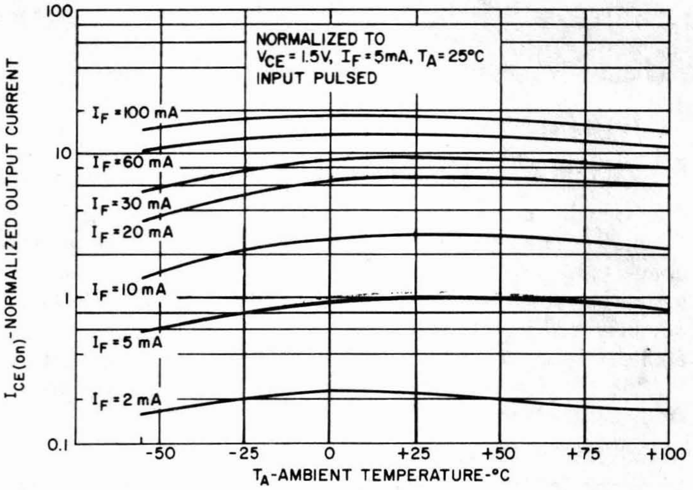
		H22B1			H22B2			H22B3			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$I_{CE(on)}$	$I_F = 2mA, V_{CE} = 1.5V$	0.5	–	–	1.0	–	–	2.0	–	–	mA
$I_{CE(on)}$	$I_F = 5mA, V_{CE} = 1.5V$	2.5	–	–	5.0	–	–	10	–	–	mA
$I_{CE(on)}$	$I_F = 10mA, V_{CE} = 1.5V$	7.5	–	–	14	–	–	25	–	–	mA
$V_{CE(sat)}$	$I_F = 10mA, I_C = 1.8mA$	–	–	1.0	–	–	1.0	–	–	1.0	V
$V_{CE(sat)}$	$I_F = 60mA, I_C = 50mA$	–	–	–	–	–	1.5	–	–	1.5	V
t_{on}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	45	–	–	45	–	–	45	–	μs
	$V_{CC} = 5V, I_F = 60mA, R_L = 75\Omega$	–	–	–	–	7	–	–	7	–	μs
t_{off}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	250	–	–	250	–	–	250	–	μs
	$V_{CC} = 5V, I_F = 60mA, R_L = 75\Omega$	–	–	–	–	45	–	–	45	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

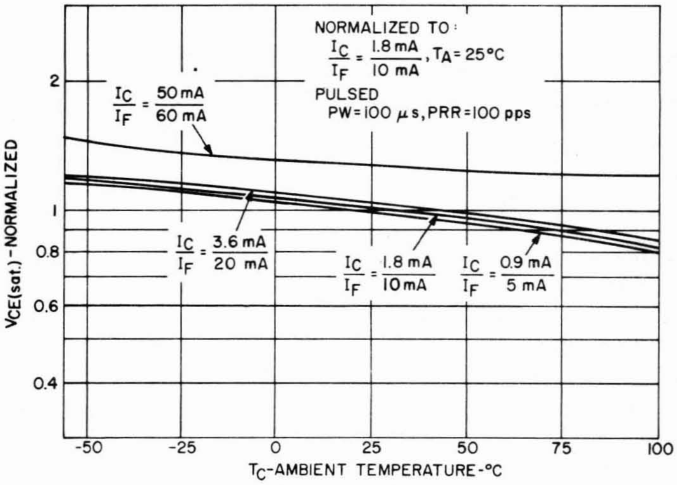
TYPICAL CHARACTERISTICS



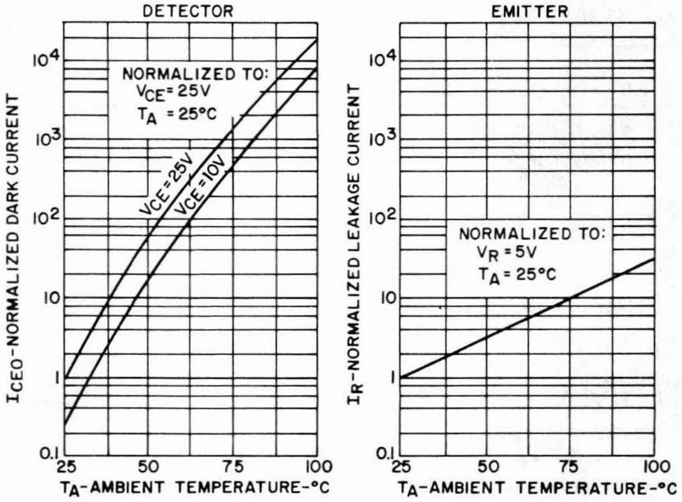
1. OUTPUT CURRENT VS. INPUT CURRENT



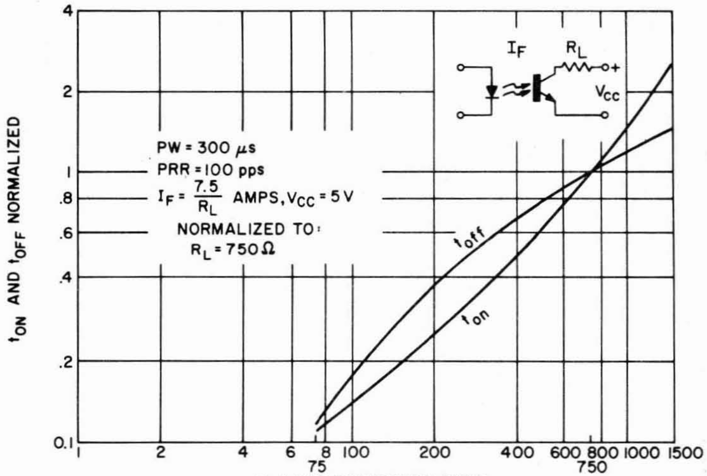
2. OUTPUT CURRENT VS. TEMPERATURE



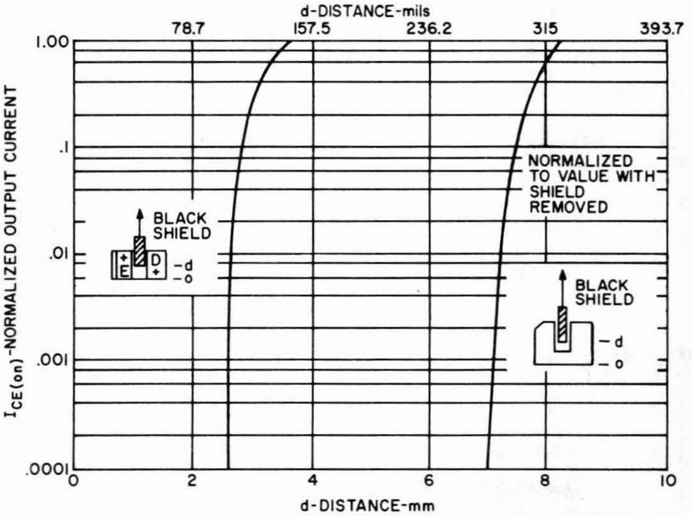
3. $V_{CE\,(sat)}$ VS. TEMPERATURE



4. LEAKAGE CURRENTS VS. TEMPERATURE



5. SWITCHING SPEED VS. R_L

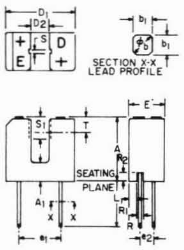


6. OUTPUT CURRENT VS. SHIELD DISTANCE

1mm Aperture

Photon Coupled Interrupter Module H22B4, H22B5, H22B6

The General Electric H22B Interrupter Module is a gallium arsenide infrared emitting diode coupled to a silicon darlington connected phototransistor in a plastic housing. The packaging system is designed to optimize the mechanical resolution, coupling efficiency, ambient light rejection, cost, and reliability. The gap in the housing provides a means of interrupting the signal with an opaque material, switching the output from an "ON" into an "OFF" state.



SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	10.7	11.0	.422	.433	
A_1	3.0	3.2	.119	.125	
ϕb	.600	.750	.024	.030	2
b_1	.50 NOM.		.020 NOM.		2
D_1	11.6	12.0	.457	.472	
D_2	3.0	3.3	.119	.129	
e_1	6.9	7.5	.272	.295	
e_2	2.3	2.8	.091	.110	
E	6.15	6.35	.243	.249	
L	8.00		.315		
R	1.3 NOM.		.051 NOM.		
R_1	1.3 NOM.		.051 NOM.		
R_2	1.3 NOM.		.051 NOM.		
S	.85	1.0	.034	.039	
S_1	3.45	3.75	.136	.147	
T	2.6 NOM.		.103 NOM.		3

NOTES:
1. INCH DIMENSIONS ARE DERIVED FROM MILLIMETERS.
2. FOUR LEADS. LEAD CROSS SECTION IS CONTROLLED BETWEEN 1.27 MM (.050") FROM SEATING PLANE AND THE END OF THE LEADS.
3. THE SENSING AREA IS DEFINED BY THE "S" DIMENSION AND BY DIMENSION "T" ±0.75 MM (±.030 INCH).

absolute maximum ratings: (25°C)

TOTAL DEVICE		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ⩽ 1 μs PRR ⩽ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

DARLINGTON CONNECTED PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	55	V
Emitter-Collector Voltage	V_{ECO}	7	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics:(25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\,\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60\,mA$	–	–	1.7	V
Reverse Current I_R $V_R = 5\,V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1\,MHz$	–	30	–	pF

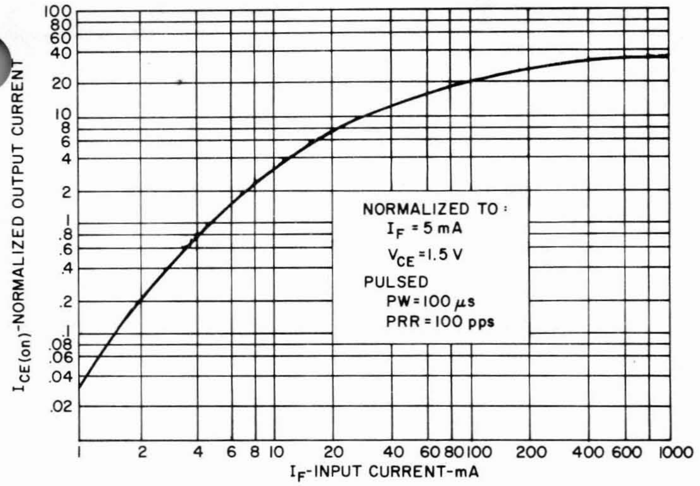
DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1\,mA$	55	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\,\mu A$	7	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 45V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1\,MHz$	–	5	8	pF

coupled electrical characteristics:(25°C) (See Note 1)

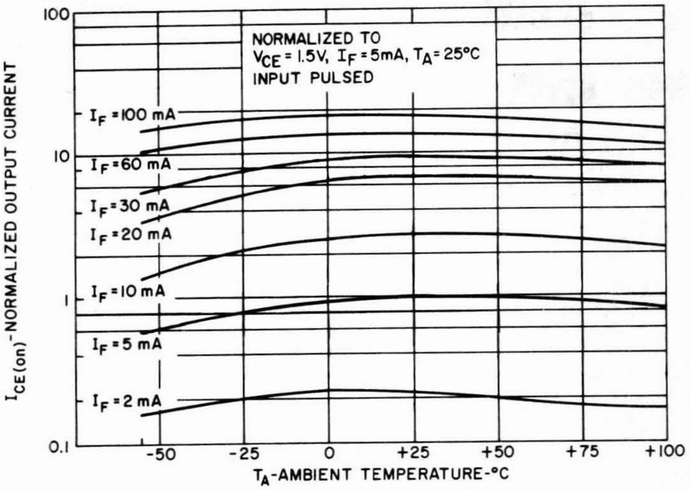
		H22B4			H22B5			H22B6			UNITS
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
$I_{CE(on)}$	$I_F = 2mA, V_{CE} = 1.5V$	0.5	–	–	1.0	–	–	2.0	–	–	mA
$I_{CE(on)}$	$I_F = 5mA, V_{CE} = 1.5V$	2.5	–	–	5.0	–	–	10	–	–	mA
$I_{CE(on)}$	$I_F = 10mA, V_{CE} = 1.5V$	7.5	–	–	14	–	–	25	–	–	mA
$V_{CE(sat)}$	$I_F = 10mA, I_C = 1.8mA$	–	–	1.0	–	–	1.0	–	–	1.0	V
$V_{CE(sat)}$	$I_F = 60mA, I_C = 50mA$	–	–	–	–	–	1.5	–	–	1.5	V
t_{on}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	45	–	–	45	–	–	45	–	μs
	$V_{CC} = 5V, I_F = 60mA, R_L = 75\Omega$	–	–	–	–	7	–	–	7	–	μs
t_{off}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	250	–	–	250	–	–	250	–	μs
	$V_{CC} = 5V, I_F = 60mA, R_L = 75\Omega$	–	–	–	–	45	–	–	45	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

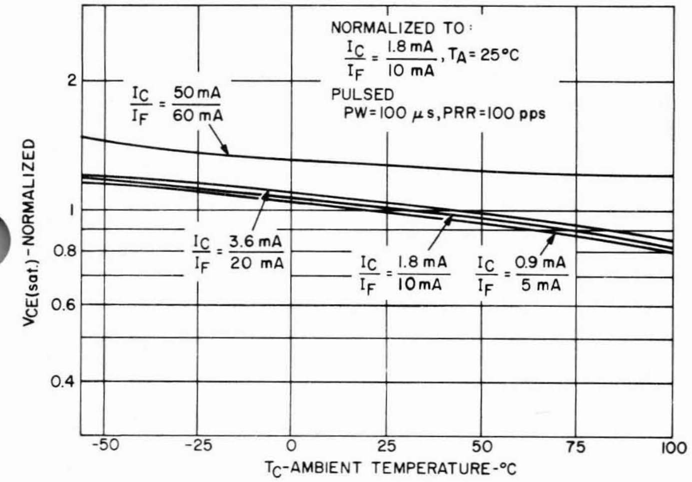
TYPICAL CHARACTERISTICS



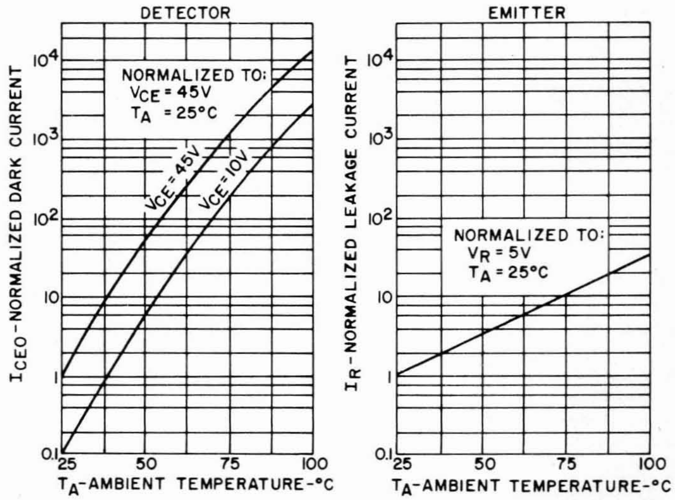
1. OUTPUT CURRENT VS. INPUT CURRENT



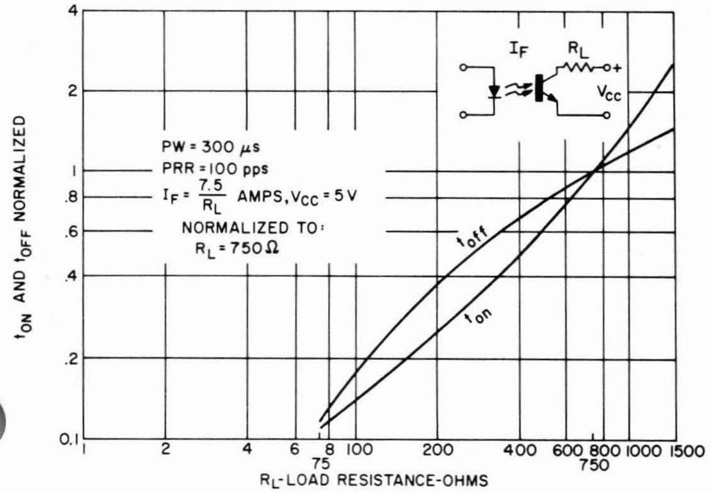
2. OUTPUT CURRENT VS. TEMPERATURE



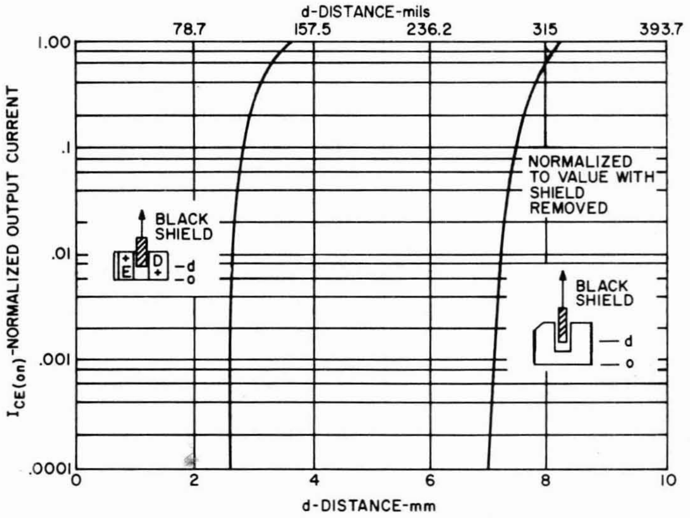
3. $V_{CE\,(sat)}$ VS. TEMPERATURE



4. LEAKAGE CURRENTS VS. TEMPERATURE



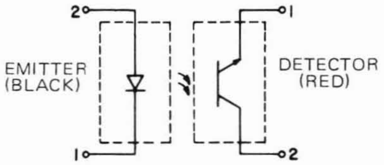
5. SWITCHING SPEED VS. R_L

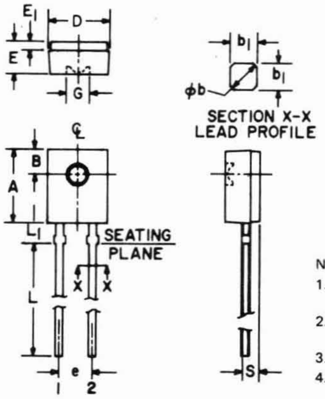


6. OUTPUT CURRENT VS. SHIELD DISTANCE

Matched Emitter-Detector Pair H23A1

The General Electric H23A1 is a matched emitter-detector pair which consists of a gallium arsenide, infrared emitting diode and a silicon phototransistor. The clear epoxy packaging system is designed to optimize the mechanical resolution, coupling efficiency, cost, and reliability. The devices are marked with a color dot for easy identification of the emitter and detector.





SYM	MILLIMETERS		INCHES		NOTES
	MIN	MAX	MIN	MAX	
A	5.59	5.80	.220	.228	
B	1.78	NOM.	.070	NOM.	2
ϕb	.60	.75	.024	.030	1
b_1	.51	NOM.	.020	NOM.	1
D	4.45	4.70	.175	.185	
E	2.41	2.67	.095	.105	
E_1	.58	.69	.023	.027	
e	2.41	2.67	.095	.105	3
G	1.98	NOM.	.078	NOM.	
L	12.7	–	.500	–	
L_1	1.40	1.65	.055	.065	
S	.83	.94	.033	.037	3

NOTES:

1. Two leads. Lead cross section dimensions uncontrolled within 1.27 MM (.050") of seating plane.
2. Centerline of active element located within .25 MM (.010") of true position.
3. As measured at the seating plane.
4. Inch dimensions derived from millimeters.

absolute maximum ratings: (25°C)

EMITTER-DETECTOR PAIR

Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE

Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ⩽ 1μs PRR ⩽ 300 pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

PHOTOTRANSISTOR

Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}	6	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics (25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60$ mA	–	–	1.7	V
Reverse Current I_R $V_R = 5V$	–	–	100	nA
Capacitance C_j V = 0, f = 1 MHz	–	30	–	pF

DETECTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1$ mA	30	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\mu A$	6	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 25V$	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V$, f = 1 MHz	–	3.3	5	pF

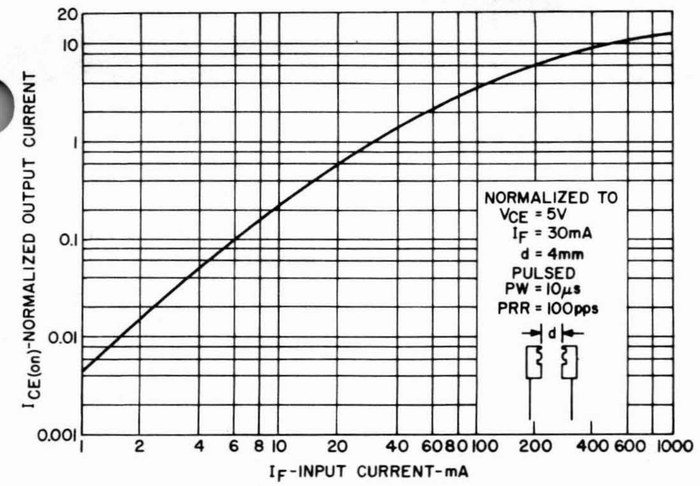
coupled electrical characteristics (25°C) (See Note 1)

Note: Coupled electrical characteristics are measured at a separation distance of 4mm (.155 inches) with the lenses of the emitter and detector on a common axis within 0.1mm and parallel within 5°.

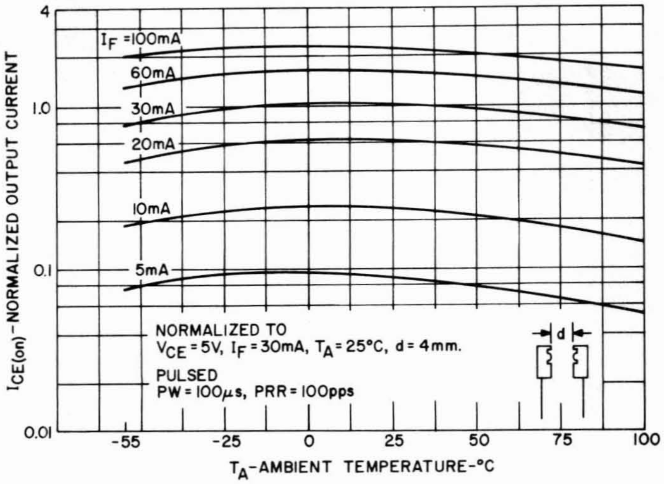
		MIN.	TYP.	MAX.	UNITS
$I_{CE(on)}$	I_F = 30mA, V_{CE} = 5V	1.5	–	–	mA
$V_{CE(sat)}$	I_F = 30mA, I_C = 1.8mA	–	–	0.40	V
t_{on}	V_{CC} = 5V, I_F = 30mA, R_L = 2.5KΩ	–	8	–	μs
t_{off}	V_{CC} = 5V, I_F = 30mA, R_L = 2.5KΩ	–	50	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

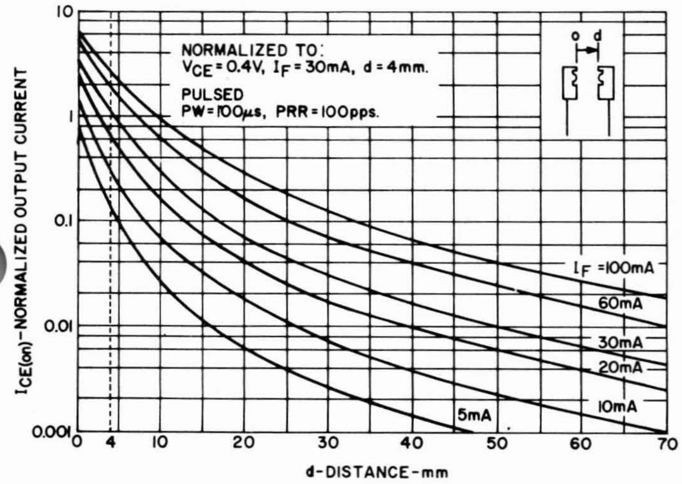
TYPICAL CHARACTERISTICS



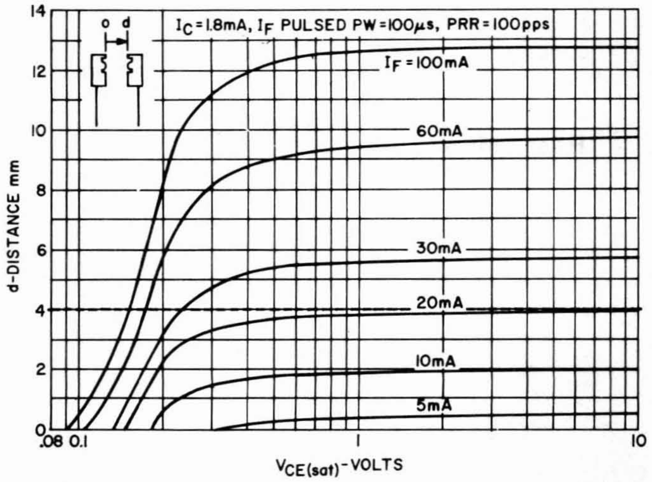
1. OUTPUT CURRENT VS. INPUT CURRENT



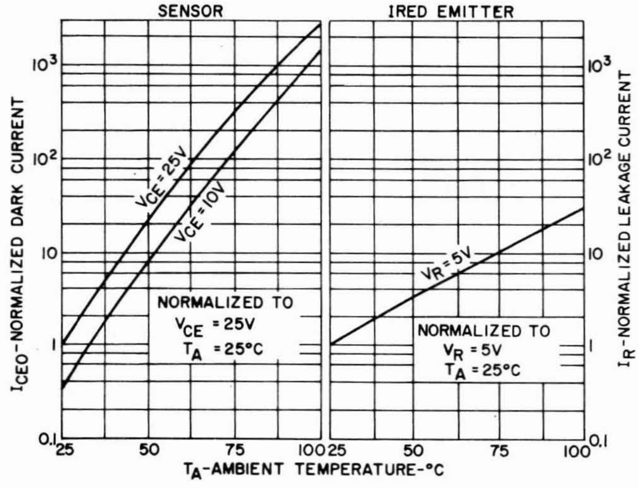
2. OUTPUT CURRENT VS. TEMPERATURE



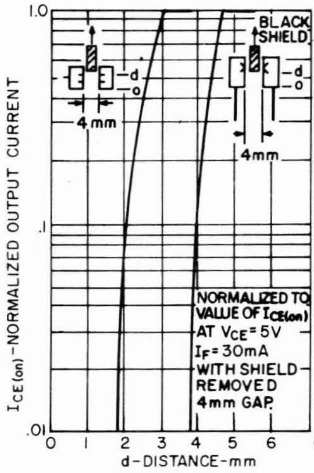
3. OUTPUT CURRENT VS. DISTANCE



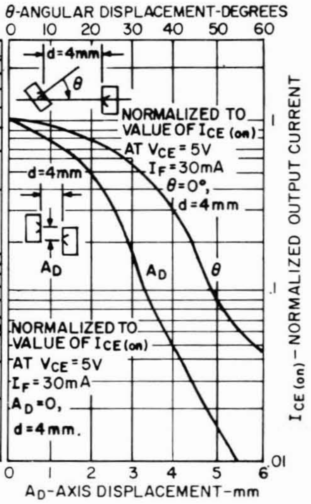
4. $V_{CE(sat)}$ VS. DISTANCE



5. LEAKAGE CURRENTS VS. TEMPERATURE



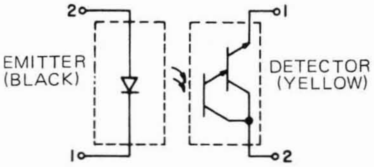
6A. OUTPUT CURRENT VS. SHIELD DISTANCE

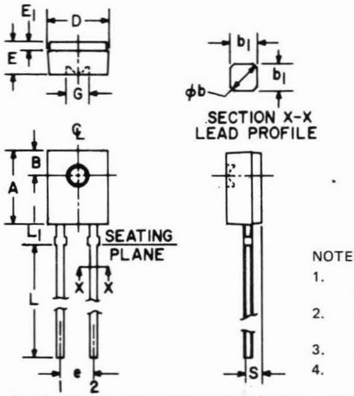


6B. OUTPUT CURRENT VS. DISPLACEMENT (ANGULAR & AXIS)

Matched Emitter-Detector Pair H23B1

The General Electric H23B1 is a matched emitter-detector pair which consists of a gallium arsenide, infrared emitting diode and a silicon, darlington connected, phototransistor. The clear epoxy packaging system is designed to optimize the mechanical resolution, coupling efficiency, cost, and reliability. The devices are marked with a color dot for easy identification of the emitter and detector.





SYM	MILLI-METERS		INCHES		NOTES
	MIN	MAX	MIN	MAX	
A	5.59	5.80	.220	.228	
B	1.78	NOM.	.070	NOM.	2
ϕb	.60	.75	.024	.030	1
b_1	.51	NOM.	.020	NOM.	1
D	4.45	4.70	.175	.185	
E	2.41	2.67	.095	.105	
E_1	.58	.69	.023	.027	
e	2.41	2.67	.095	.105	3
G	1.98	NOM.	.078	NOM.	
L	12.7	–	.500	–	
L_1	1.40	1.65	.055	.065	
S	.83	.94	.033	.037	3

NOTES:

1. Two leads. Lead cross section dimensions uncontrolled within 1.27 MM (.050") of seating plane.
2. Centerline of active element located within .25 MM (.010") of true position.
3. As measured at the seating plane.
4. Inch dimensions derived from millimeters.

absolute maximum ratings: (25°C)

EMITTER – DETECTOR PAIR		
Storage Temperature	T_{STG}	-55°C to +100°C
Operating Temperature	T_J	-55°C to +100°C
Lead Soldering Temperature (5 seconds maximum)	T_L	260°C

INFRARED EMITTING DIODE			
Power Dissipation	P_E	*100	mW
Forward Current (Continuous)	I_F	60	mA
Forward Current (Peak) (Pulse Width ⩽ 1μs PRR ⩽ 300pps)	I_F	3	A
Reverse Voltage	V_R	6	V

*Derate 1.33 mW/°C above 25°C ambient.

DARLINGTON CONNECTED PHOTOTRANSISTOR			
Power Dissipation	P_D	**150	mW
Collector Current (Continuous)	I_C	100	mA
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}	7	V

**Derate 2.0 mW/°C above 25°C ambient.

individual electrical characteristics (25°C) (See Note 1)

EMITTER	MIN.	TYP.	MAX.	UNITS
Reverse Breakdown Voltage $V_{(BR)R}$ $I_R = 10\mu A$	6	–	–	V
Forward Voltage V_F $I_F = 60$ mA	–	–	1.7	V
Reverse Current I_R $V_R = 5V$	–	–	100	nA
Capacitance C_i $V = 0, f = 1$ MHz	–	30	–	pF

DETECTOR	MIN	TYP.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ $I_C = 1$ mA	30	–	–	V
Breakdown Voltage $V_{(BR)ECO}$ $I_E = 100\ \mu A$	7	–	–	V
Collector Dark Current I_{CEO} $V_{CE} = 25$ V	–	–	100	nA
Capacitance C_{ce} $V_{CE} = 5V, f = 1$ MHz	–	5	8	pF

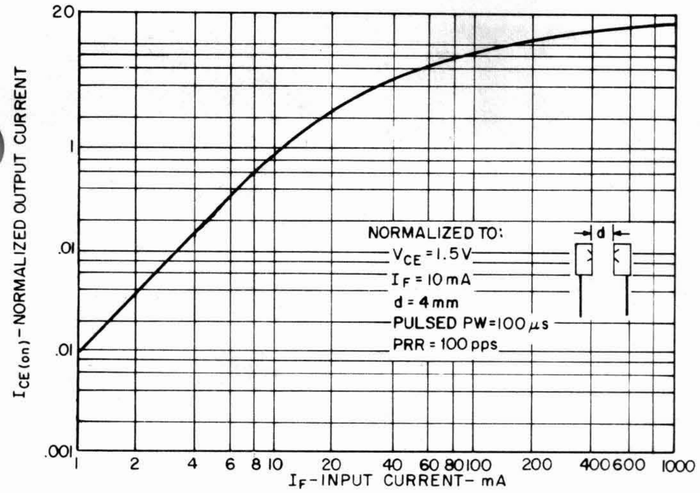
coupled electrical characteristics (25°C) (See Note 1)

Note: Coupled electrical characteristics are measured at a separation distance of 4mm (.155 inches) with the lenses of the emitter and detector on a common axis within 0.1mm and parallel within 5°.

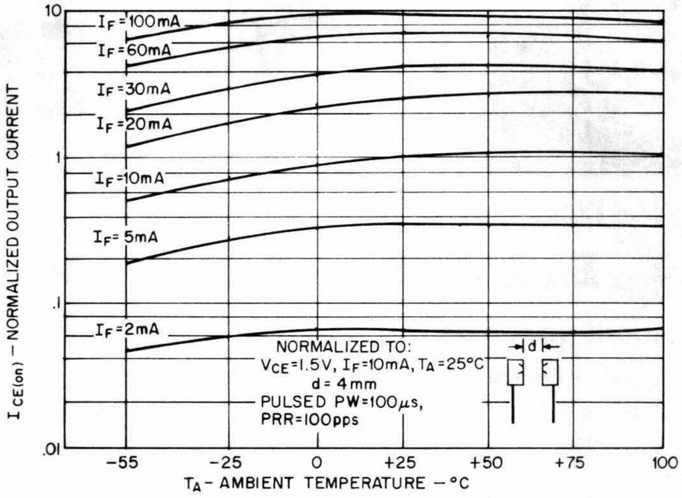
		MIN.	TYP.	MAX.	UNITS
$I_{CE(on)}$	$I_F = 10mA, V_{CE} = 1.5V$	7.5	–	–	mA
$V_{CE(sat)}$	$I_F = 10mA, I_C = 1.8$ mA	–	–	1.0	V
t_{on}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	45	–	μs
t_{off}	$V_{CC} = 5V, I_F = 10mA, R_L = 750\Omega$	–	250	–	μs

Note 1: Stray irradiation can alter values of characteristics. Adequate shielding should be provided.

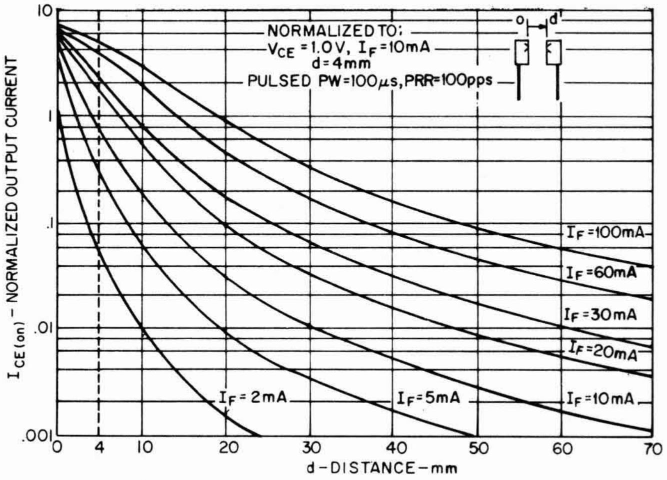
TYPICAL CHARACTERISTICS



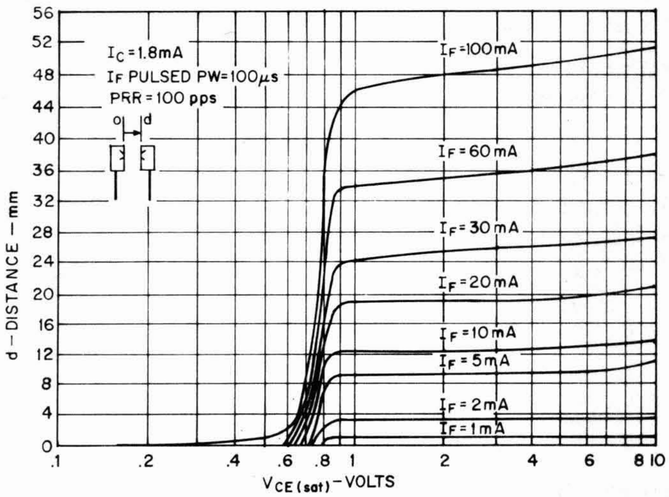
1. OUTPUT CURRENT VS. INPUT CURRENT



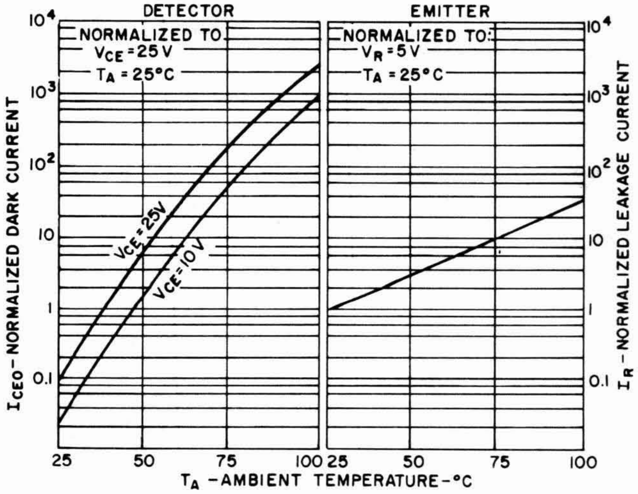
2. OUTPUT CURRENT VS. TEMPERATURE



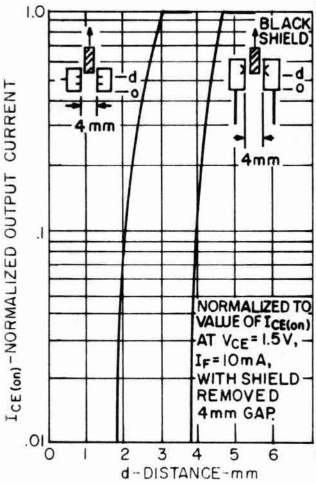
3. OUTPUT CURRENT VS. DISTANCE



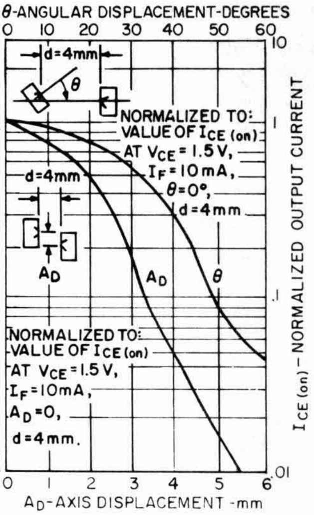
4. $V_{CE(sat)}$ VS. DISTANCE



5. LEAKAGE CURRENTS VS. TEMPERATURE



6A. OUTPUT CURRENT VS. SHIELD DISTANCE



6B. OUTPUT CURRENT VS. DISPLACEMENT (ANGULAR & AXIS)

SOLID STATE
OPTOELECTRONICS

Infrared Emitter

CQX14-CQX15-CQX16-CQX17

Gallium Arsenide Infrared-Emitting Diode

The General Electric CQX14-CQX15-CQX16-CQX17 Series are gallium arsenide, light emitting diodes which emit non-coherent, infrared energy with a peak wave length of 940 nanometers. They are ideally suited for use with silicon detectors.

absolute maximum ratings: (25°C unless otherwise specified)

Voltage:			
Reverse Voltage	V_R	3	volts
Currents:			
Forward Current Continuous	I_F	100	mA
Forward Current (pw 1 μs, 200 Hz)	I_F	10	A
Dissipations:			
Power Dissipation (T_A = 25°C)*	P_T	170	mW
Power Dissipation (T_C = 25°C)**	P_T	1.3	W
Temperatures:			
Junction Temperature	T_J	-65°C to +150°C	
Storage Temperature	T_{stg}	-65°C to +150°C	
Lead Soldering Time		10 seconds at 260°C	

*Derate 1.36 mW/°C above 25°C ambient.
**Derate 10.4 mW/°C above 25°C case.

electrical characteristics: (25°C unless otherwise specified)

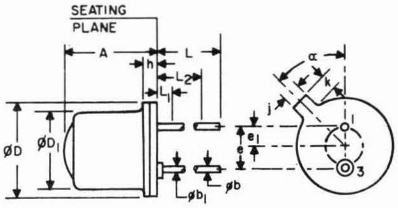
		MIN.	TYP.	MAX.	UNITS
Reverse Leakage Current (V_R = 3V)	I_R			10	μA
Forward Voltage (I_F = 100mA)	V_F		1.4	1.7	V

optical characteristics: (25°C unless otherwise specified)

		MIN.	TYP.	MAX.	UNITS
Total Power Output (note 1) (I_F = 100mA)					
CQX14-CQX15	P_O	5.4			mW
CQX16-CQX17		1.5			mW
Peak Emission Wavelength (I_F = 100mA)			940		nm
Spectral Shift with Temperature			.28		nm/°C
Spectral Bandwidth 50%			60		nm
Rise Time 0-90% of Output			1.0		μs
Fall Time 100-10% of Output			1.0		μs

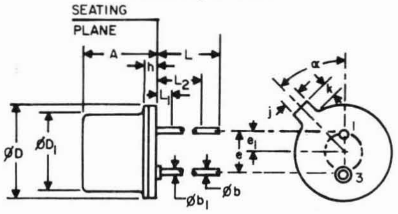
Note 1: Total power output, P_O, is the total power radiated by the device into a solid angle of 2 π steradians.

CQX14, CQX16



SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A		.255		6.47	
øb	.016	.021	.406	.534	1
øb1	.016	.019	.406	.483	1
øD	.209	.230	5.30	5.85	
øD1	.178	.195	4.52	4.96	
e	.100 NOM.		2.54 NOM.		3
e1	.050 NOM.		1.27 NOM.		3
h		.040		1.02	
j	.031	.044	.78	1.12	
k	.036	.046	.91	1.17	2
L	.500		12.7		1
L1		.050		1.27	1
L2	.250		6.35		1
α	45°		45°		4

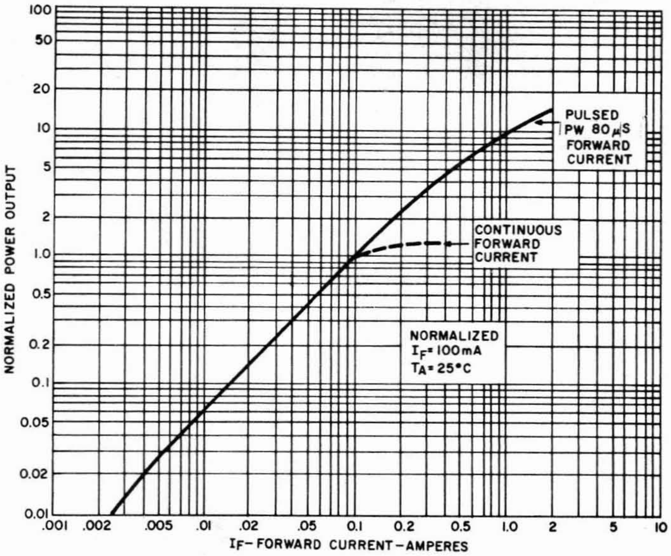
CQX15, CQX17



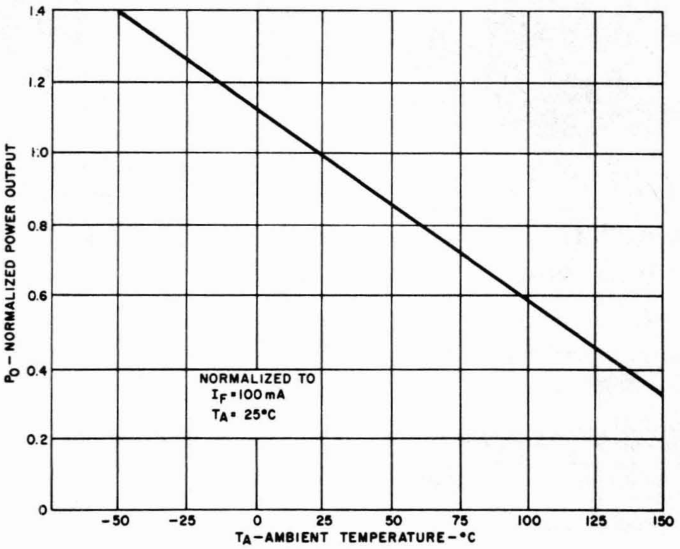
SYMBOL	INCHES MIN.	INCHES MAX	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A		.155		3.93	
øb	.016	.021	.406	.534	1
øb1	.016	.019	.406	.483	1
øD	.209	.230	5.30	5.85	
øD1	.178	.195	4.52	4.96	
e	.100 NOM.		2.54 NOM.		3
e1	.050 NOM.		1.27 NOM		3
h		.040		1.02	
j	.031	.044	.78	1.12	
k	.036	.046	.91	1.17	2
L	.500		12.7		1
L1		·050		1.27	1
L2	.250		6.35		1
α	45°		45°		4

1. øb_1 APPLIES BETWEEN L_1 AND L_2 øb APPLIES BETWEEN L_2 AND .500" (12.70 MM) FROM REFERENCE PLANE. DIAMETER IS UNCONTROLED IN L_1 AND BEYOND .500" (12.70 MM) FROM REFERENCE PLANE.
2. MEASURED FROM MAXIMUM DIAMETER OF DEVICE.
3. LEADS HAVING MAXIMUM DIAMETER .019" (.483 MM) MEASURED IN GAGING PLANE .054" + .001" - .000 (1.37 + .025 - .000 MM) BELOW THE REFERENCE PLANE OF THE DEVICE SHALL BE WITHIN .007" (.778 MM) THEIR TRUE POSITION RELATIVE TO A MAXIMUM WIDTH TAB.
4. FROM CENTERLINE TAB.

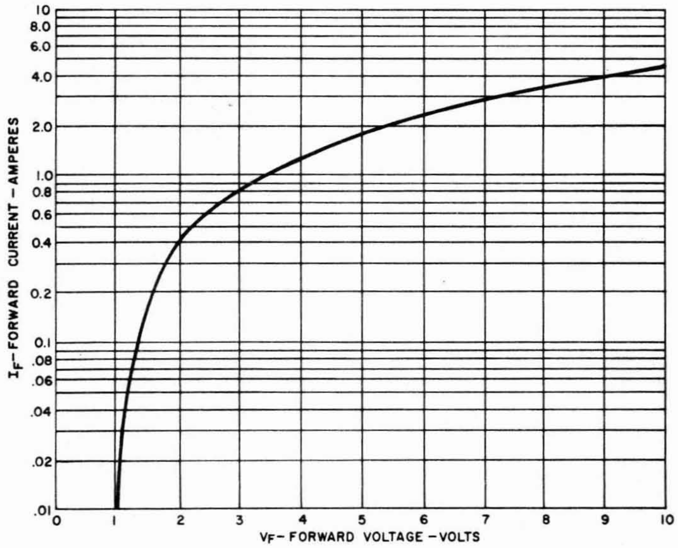
TYPICAL CHARACTERISTICS



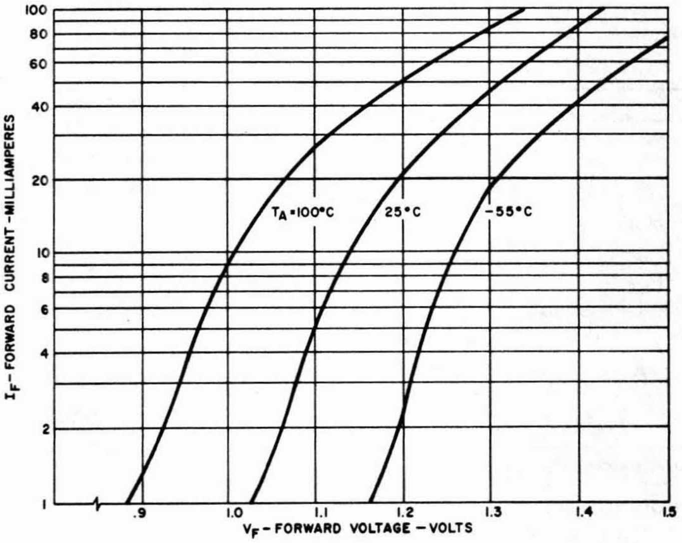
1. POWER OUTPUT VS. INPUT CURRENT



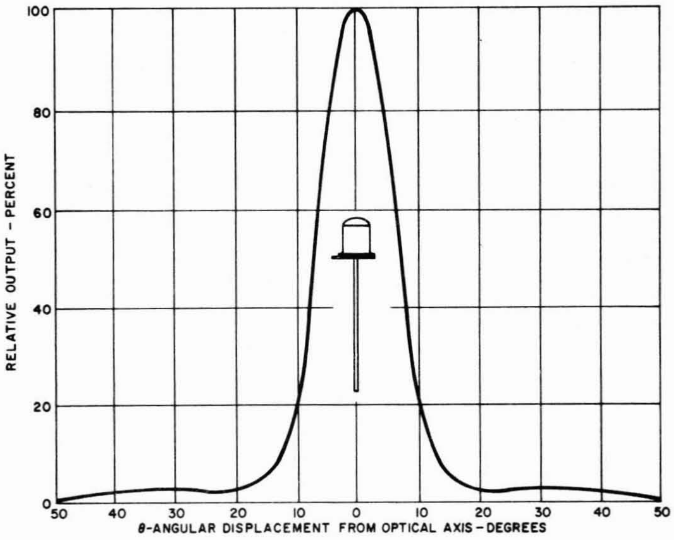
2. POWER OUTPUT VS. TEMPERATURE



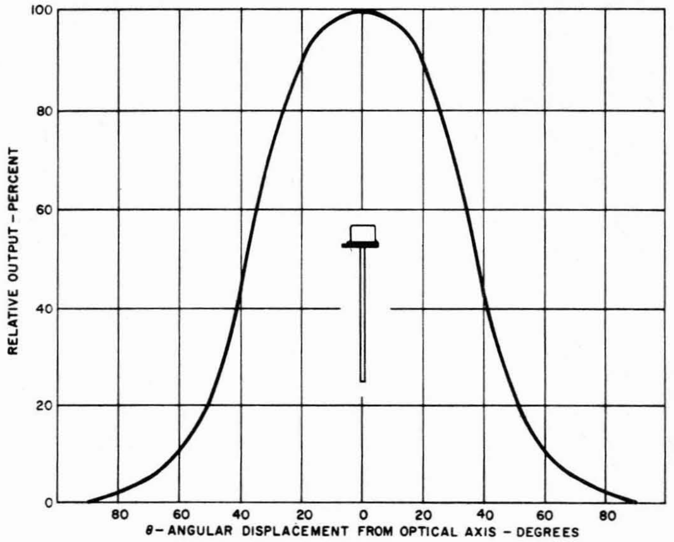
3. FORWARD VOLTAGE VS. FORWARD CURRENT



4. FORWARD VOLTAGE VS. FORWARD CURRENT



5. CQX14-CQX16 TYPICAL RADIATION PATTERN

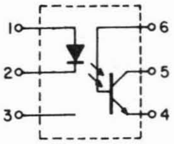


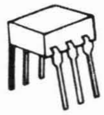
6. CQX15-CQX17 TYPICAL RADIATION PATTERN

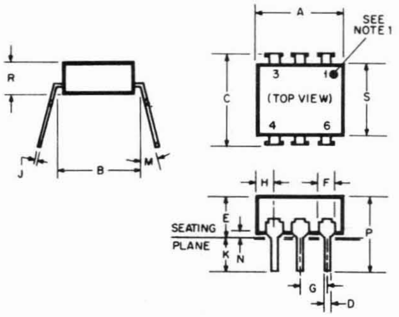
Photon Coupled Isolator CQY80

Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric CQY80 is a gallium arsenide, infrared emitting diode coupled with a silicon photo-transistor in a dual in-line package.







SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.57	4.70	
S	.225	.280	5.71	7.12	

NOTES:
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1 μsec 300 P Ps)	3	ampere
Reverse Voltage	5	volts

*Derate 1.33 mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
V_{CEO}	32	volts
V_{CBO}	70	volts
V_{ECO}	5	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0 mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55°C to +150°C

Operating Temperature -55°C to +100°C

Lead Soldering Time (at 260°C) 10 seconds

Surge Isolation Voltage (Input to Output) 4000 V_{RMS}

individual electrical characteristics:(25°C)

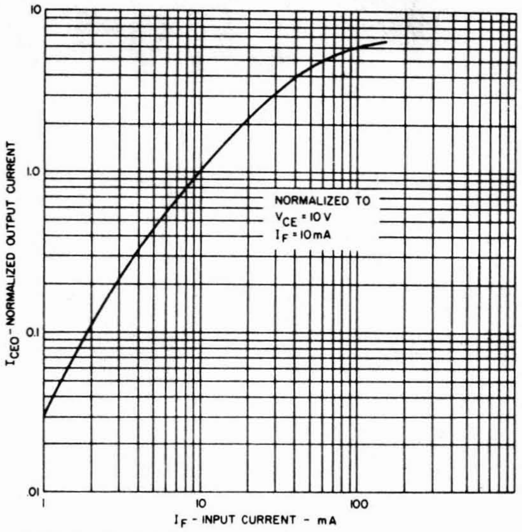
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.1	1.5	volts
Reverse Current (V_R = 3 V)	–	10	microamps
Capacitance (V = 0, f = 1 MHz)	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10 mA, I_F = 0)	32	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100 μA, I_F = 0)	70	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100 μA, I_F = 0)	5	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10 V, I_F = 0)	–	5	100	nanoamps
Capacitance (V_{CE} = 10 V, f = 1 MHz)	–	2	–	picofarads

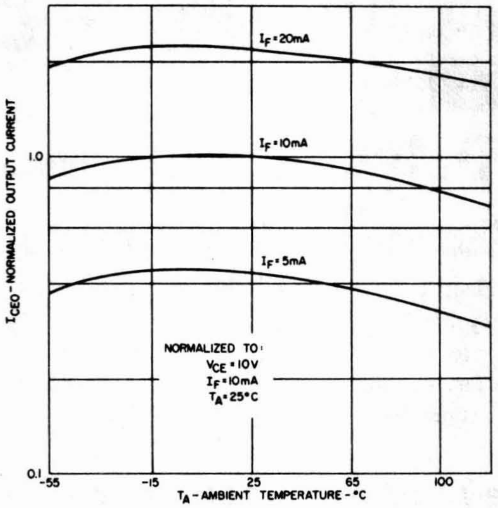
coupled electrical characteristics:(25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10 mA, V_{CE} = 5 V)	60	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10 mA, I_C = 0.5 mA)	–	0.1	0.4	volts
Isolation Resistance (Input to Output Voltage = 500 V_{DC})	100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0, f = 1 MHz)	–	–	2	picofarads
Switching Speeds: Rise/Fall Time (V_{CE} = 10 V, I_{CE} = 2 mA, R_L = 100 Ω)	–	2	–	microseconds

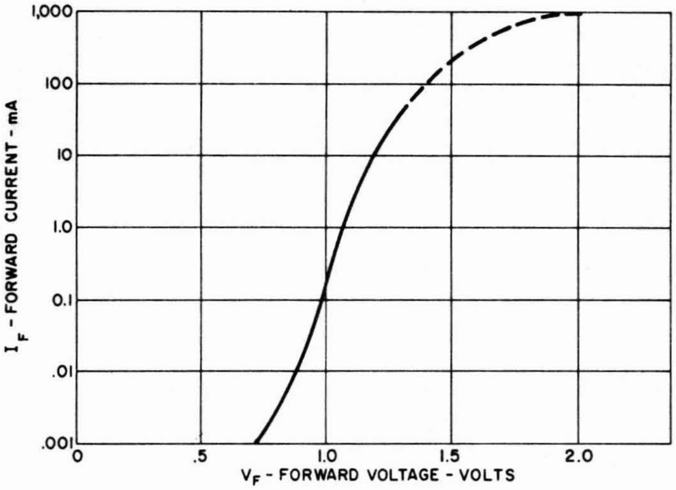
TYPICAL CHARACTERISTICS



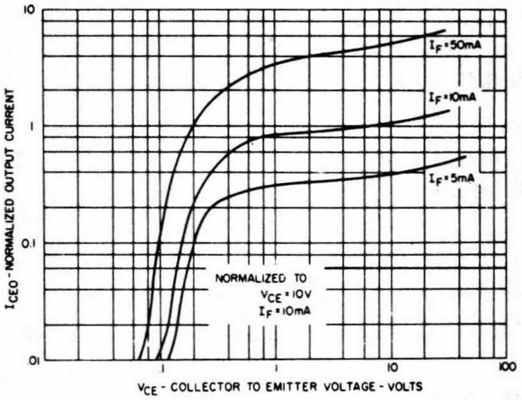
OUTPUT CURRENT VS. INPUT CURRENT



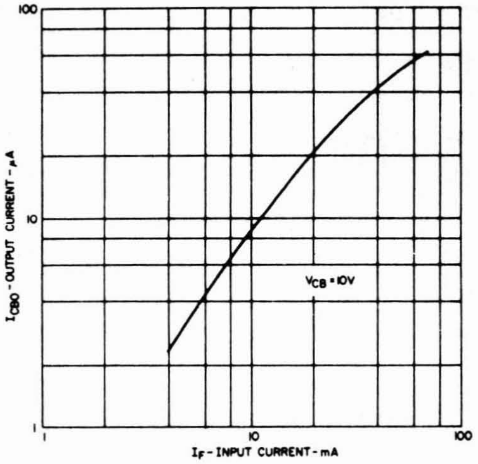
OUTPUT CURRENT VS. TEMPERATURE

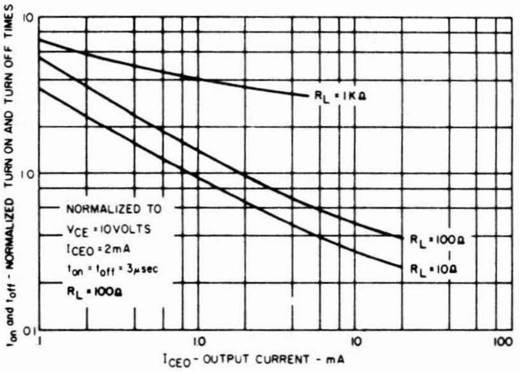


INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS





SWITCHING TIMES VS. OUTPUT CURRENT

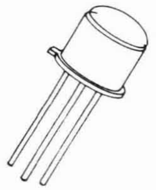
OUTPUT CURRENT (I_{CBO}) VS. INPUT CURRENT

SOLID STATE

OPTOELECTRONICS

Light Detector Planar Silicon Photo Transistor

NPN BPW36 , BPW37



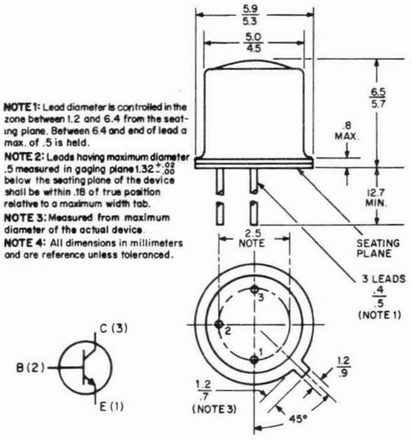
The General Electric BPW36 and BPW37 are highly sensitive NPN Planar Silicon Phototransistors. They are housed in a TO-18 style hermetically sealed package with lens cap. These devices are ideal for use in optoelectronic sensing applications where both high sensitivity and fast switching speeds are important parameters. Generally only the collector and emitter leads are used; a base lead is provided, however, to control sensitivity and gain of the device.

absolute maximum ratings: (25°C unless otherwise specified)

Voltages — Dark Characteristics			
Collector to Emitter Voltage	V_{CEO}	45	volts
Collector to Base Voltage	V_{CBO}	45	volts
Emitter to Base Voltage	V_{EBO}	5	volts
Currents			
Light Current	I_L	50	mA
Dissipations			
Power Dissipation (T_A = 25°C)*	P_T	300	mW
Power Dissipation (T_C = 25°C)**	P_T	600	mW
Temperatures			
Junction Temperature	T_J	+150	°C
Storage Temperature	T_{STG}	−65 to +150	°C

*Derate 2.4 mW/°C above 25°C ambient

**Derate 4.8 mW/°C above 25°C case



NOTE 1: Lead diameter is controlled in the zone between 1.2 and 6.4 from the seating plane. Between 6.4 and end of lead a max. of .5 is held.

NOTE 2: Leads having maximum diameter .5 measured in gaging plane $1.32^{+.02}_{-.00}$ below the seating plane of the device shall be within .18 of true position relative to a maximum width tab.

NOTE 3: Measured from maximum diameter of the actual device.

NOTE 4: All dimensions in millimeters and are reference unless toleranced.

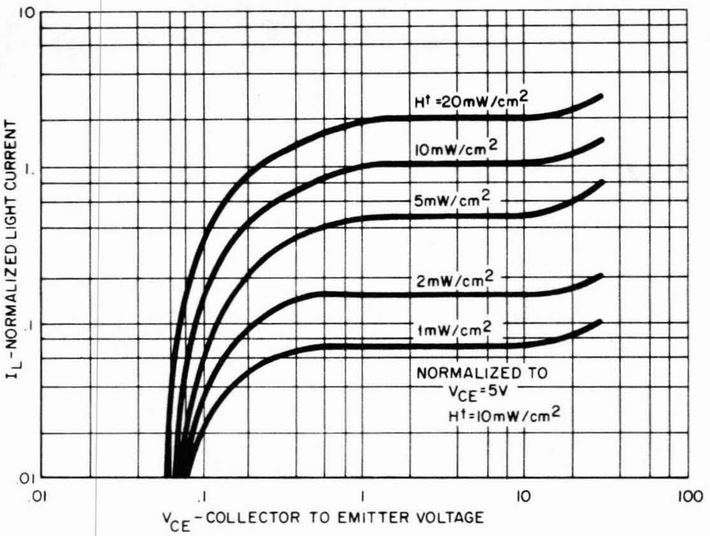
electrical characteristics: (25°C unless otherwise specified)

		BPW36		BPW37		
STATIC CHARACTERISTICS		**MIN.**	**MAX.**	**MIN.**	**MAX.**	
Light Current (V_{CE} = 5V, H† = 10mW/cm^2)	I_L	6		3		mA
Dark Current (V_{CE} = 10V, H = 0)	I_D		100		100	nA
Emitter-Base Breakdown Voltage (I_E = 100μA, I_C = 0, H = 0)	$V_{(BR)EBO}$	5		5		V
Collector-Base Breakdown Voltage (I_C = 100μA, I_E = 0, H = 0)	$V_{(BR)CBO}$	45		45		V
Collector-Emitter Breakdown Voltage (I_C = 10mA, H = 0)	$V_{(BR)CEO}$	45		45		V
Saturation Voltage (I_C = 10mA, I_B = 1mA)	$V_{CE(SAT)}$		0.4		0.4	V
Turn-On Time (V_{CE} = 10V, I_C = 2mA,	t_{on}		8		8	μsec
Turn-Off Time R_L = 100Ω)	t_{off}		7		7	μsec

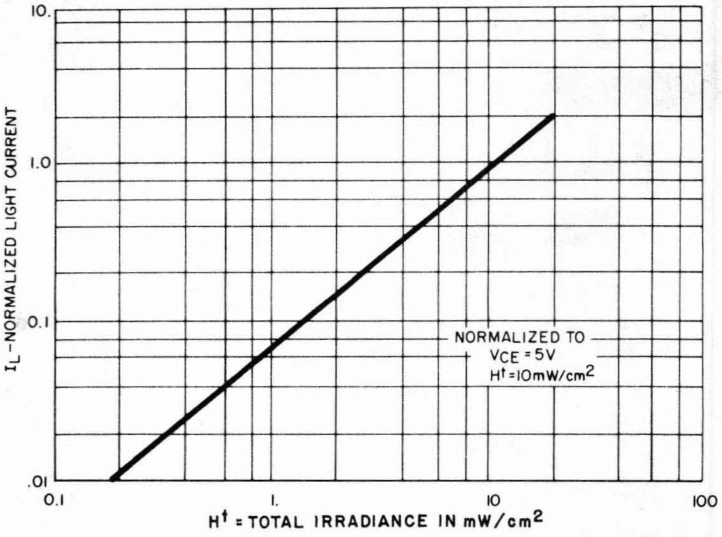
†H = Radiation Flux Density. Radiation source is on unfiltered tungsten filament bulb at 2870°K color temperature.

NOTE: A GaAs source of 3.0 mW/cm^2 is approximately equivalent to a tungsten source, at 2870°K, of 10 mW/cm^2.

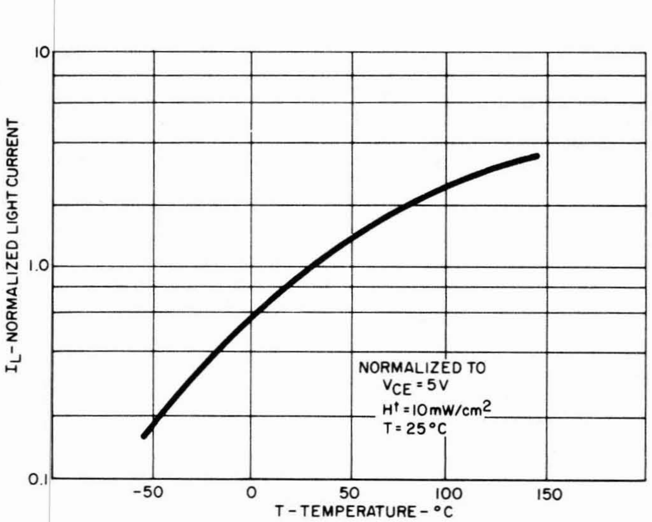
TYPICAL ELECTRICAL CHARACTERISTICS



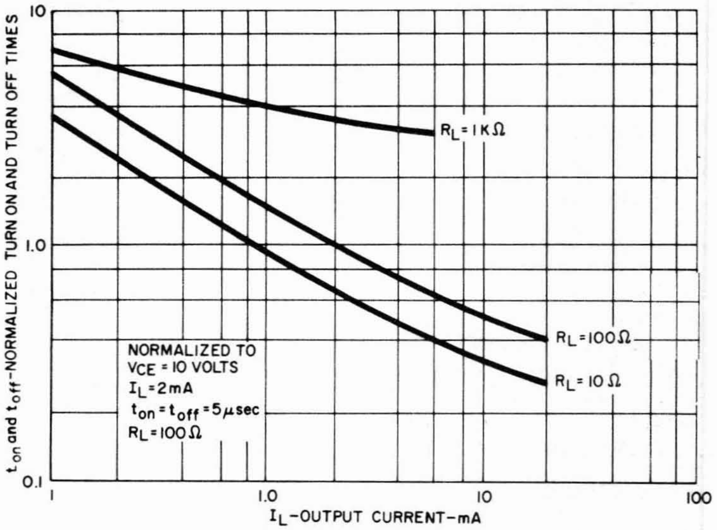
Light Current vs Collector to Emitter Voltage



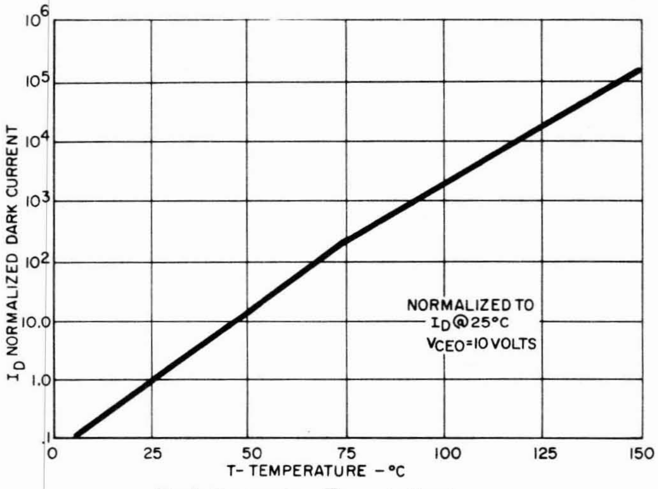
Normalized Light Current vs Radiation



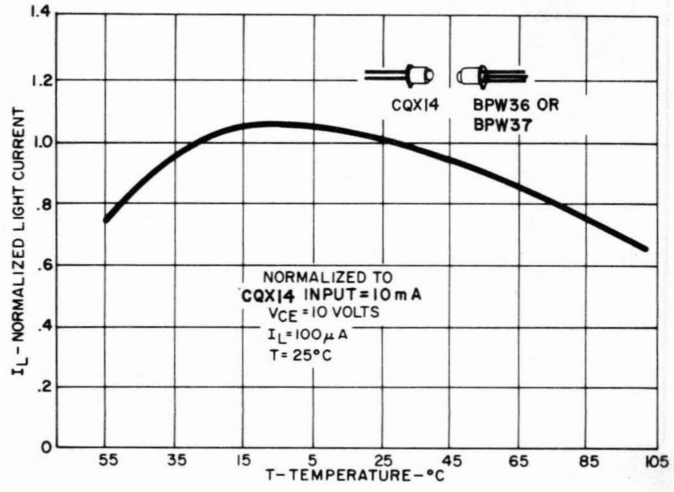
Normalized Light Current vs Temperature



Switching Times vs Output Current



Dark Current vs Temperature

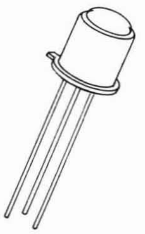


Normalized Light Current vs Temperature

Both Emitter (CQX14) and Detector
(BPW36 or BPW37)
at Same Temperature

Light Detector Planar Silicon Photo-Darlington Amplifier

NPN BPW38



The General Electric BPW38 is a supersensitive NPN Planar Silicon Photodarlington Amplifier. For many applications, only the collector and emitter leads are used; however, a base lead is provided to control sensitivity and the gain of the device. The BPW38 is a TO-18 Style hermetically sealed package with lens cap and is designed to be used in opto-electronic sensing applications requiring very high sensitivity.

absolute maximum ratings: (25°C unless otherwise specified)

VOLTAGES – DARK CHARACTERISTICS			
Collector to Emitter Voltage	V_{CEO}	25	volts
Collector to Base Voltage	V_{CBO}	25	volts
Emitter to Base Voltage	V_{EBO}	12	volts
CURRENTS			
Light Current	I_L	200	mA
DISSIPATIONS			
Power Dissipation ($T_A = 25°C$)*	P_T	300	mW
Power Dissipation ($T_C = 25°C$)**	P_T	600	mW
TEMPERATURES			
Junction Temperature	T_J	150	°C
Storage Temperature	T_{STG}	-65 to 150	°C

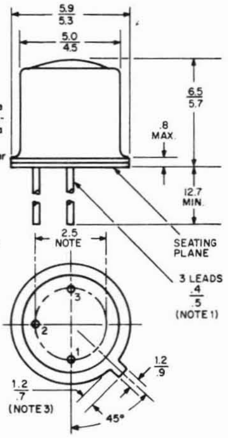
*Derate 2.4 mW/°C above 25°C ambient.
**Derate 4.8 mW/°C above 25°C case.

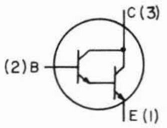
NOTE 1: Lead diameter is controlled in the zone between 1.2 and 6.4 from the seating plane. Between 6.4 and end of lead a max. of .5 is held.

NOTE 2: Leads having maximum diameter .5 measured in gaging plane $1.32^{+.02}_{-.00}$ below the seating plane of the device shall be within .18 of true position relative to a maximum width tab.

NOTE 3: Measured from maximum diameter of the actual device.

NOTE 4: All dimensions in millimeters and are reference unless toleranced.





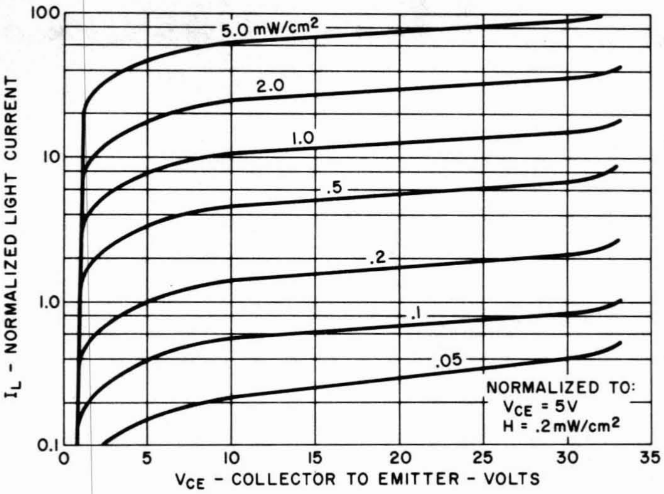
electrical characteristics: (25°C unless otherwise specified)

STATIC CHARACTERISTICS		MIN.	MAX.	
LIGHT CURRENT (V_{CE} = 5V, H† = 0.2 mW/cm^2)	I_L	3	–	mA
DARK CURRENT (V_{CE} = 12V, I_B = 0)	I_D	–	100	nA
EMITTER-BASE BREAKDOWN VOLTAGE (I_E = 100μA)	$V_{(BR)EBO}$	12	–	V
COLLECTOR-BASE BREAKDOWN VOLTAGE (I_C = 100μA)	$V_{(BR)CBO}$	25	–	V
COLLECTOR-EMITTER BREAKDOWN VOLTAGE (I_C = 10mA)	$V_{(BR)CEO}$	25	–	V
SWITCHING CHARACTERISTICS (see Switching Circuit)				
SWITCHING SPEEDS (V_{CC} = 10V, I_L = 10 mA, R_L = 100Ω)				
DELAY TIME	t_d	–	50	µsec
RISE TIME	t_r	–	300	µsec
STORAGE TIME	t_s	–	10	µsec
FALL TIME	t_f	–	250	µsec

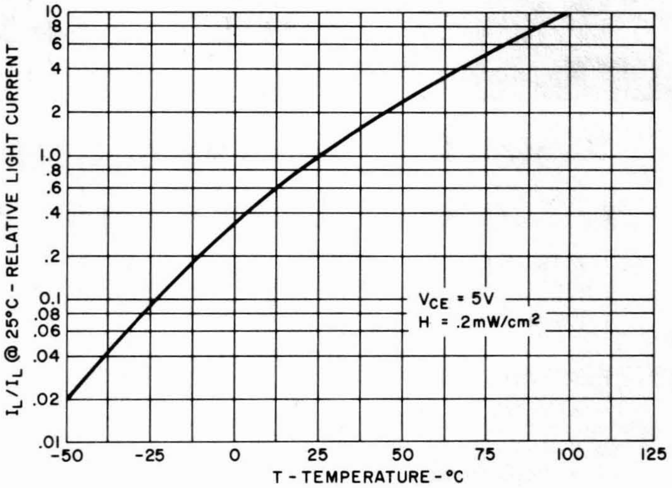
†H = Radiation Flux Density. Radiation source is an unfiltered tungsten filament bulb at 2870°K color temperature.

NOTE: The 2870°K radiation is 25% effective on the photodarlington; i.e., a GaAs source of 0.05 mW/cm^2 is equivalent to this 0.2 mW/cm^2 tungsten source.

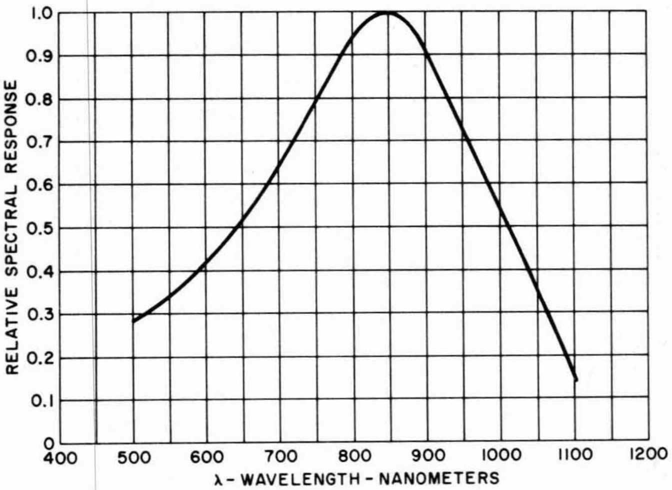
TYPICAL ELECTRICAL CHARACTERISTICS



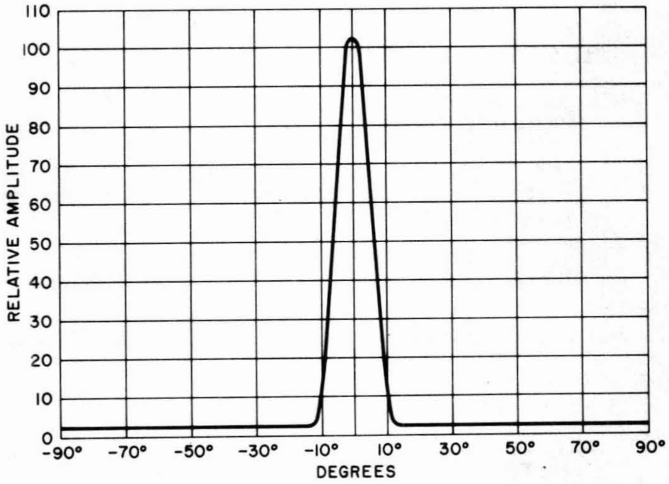
1. LIGHT CURRENT VS. COLLECTOR TO EMITTER VOLTAGE



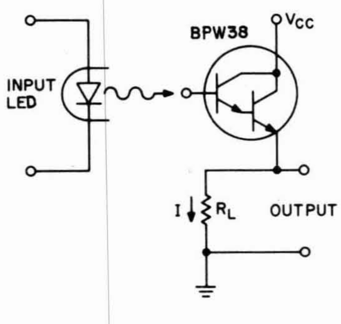
2. RELATIVE LIGHT CURRENT VS. AMBIENT TEMPERATURE



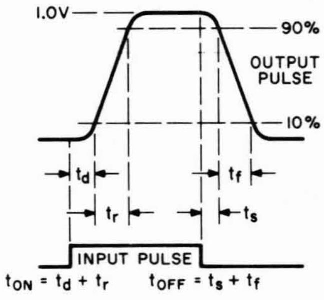
3. SPECTRAL RESPONSE CURVE



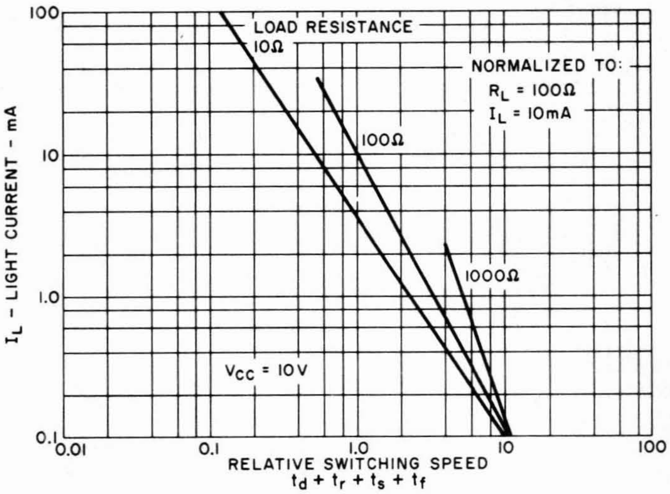
4. ANGULAR RESPONSE



5. TEST CIRCUIT



6. WAVE FORMS



7. LIGHT CURRENT VS. RELATIVE SWITCHING SPEED

SOLID STATE
OPTOELECTRONICS

Photon Coupled Isolator CNY17

Ga As Infrared Emitting Diode & npn Silicon Photo - Transistor

The General Electric CNY17 consists of a gallium arsenide infrared emitting diode coupled with a silicon photo transistor in a dual in-line package.

FEATURES:

- Fast switching speeds
- High DC current transfer ratio
- High isolation resistance
- High isolation voltage
- I/O compatible with integrated circuits

SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF.	7.62	REF.	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES:

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

Creepage Distance 8.2mm min.
Air Gap 7.6mm min.

absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE		
Power Dissipation – T_A	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1μs, 300 P Ps)	3	ampere
Reverse Voltage	3	volts

*Derate 1.33 mW/°C above 25°C

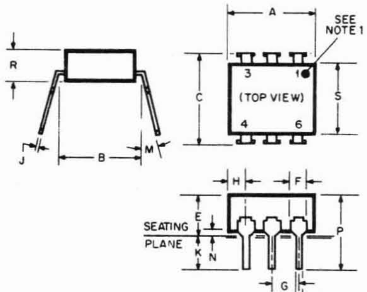
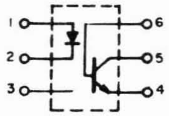


PHOTO-TRANSISTOR		
Power Dissipation – T_A	**150	milliwatts
V_{CEO}	70	volts
V_{CBO}	70	volts
V_{ECO}	7	volts
Collector Current (Continuous	150	milliamps

**Derate 2.0 mW/°C above 25°C



TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).
5000V$_{(peak)}$ 3000V$_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
4000V$_{(peak)}$ 2830V$_{(RMS)}$

individual electrical characteristics (25°C) (unless otherwise specified)

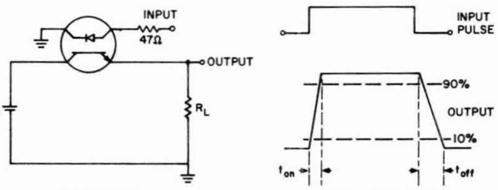
INFRARED EMITTING DIODE	MIN.	MAX.	UNITS
Forward Voltage – V_F (I_F = 60 mA)	.8	1.65	volts
Reverse Current – I_R (V_R = 3V)	–	10	microamps
Capacitance – C_J (V = 0,f = 1 MHz)	–	100	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	70	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	70	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_F = 100μA, I_F = 0)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	50	nanoamps
Capacitance – C_{CE} (V_{CE} = 10V, f = 1 MHz)	–	2	–	picofarads

coupled electrical characteristics (25°C) (unless otherwise specified)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 5V)	CNY17 I	40	–	80	%
	CNY17 II	63	–	125	%
	CNY17 III	100	–	200	%
	CNY17 IV	160	–	320	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 2.5mA)		–	–	0.3	volts
Isolation Resistance (V_{IO} = 500V_{DC}) (See Note 1)		100	–	–	gigaohms
Input to Output Capacitance (V_{IO} = 0,f = 1 MHz) (See Note 1)		–	–	2.5	picofarads
Turn-On Time – t_{on} (V_{CC} = 10V, I_C = 2mA, R_L = 100Ω) (See Figure 1)		–	5	10	microseconds
Turn-Off Time – t_{off} (V_{CC} = 10V, I_C = 2mA, R_L = 100Ω) (See Figure 1)		–	5	10	microseconds

Note 1: Tests of input to output isolation current resistance, and capacitance are performed with the input terminals (diode) shorted together and the output terminals (transistor) shorted together.



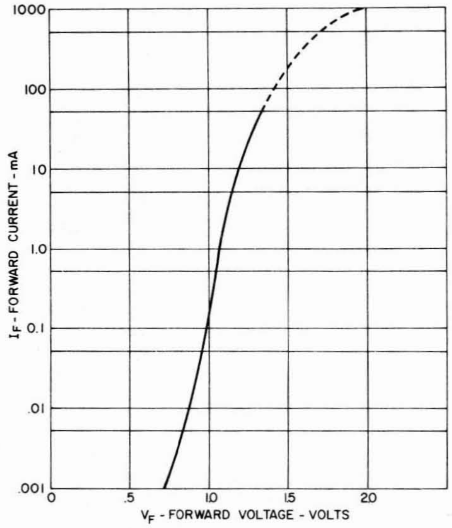
TEST CIRCUIT

VOLTAGE WAVE FORMS

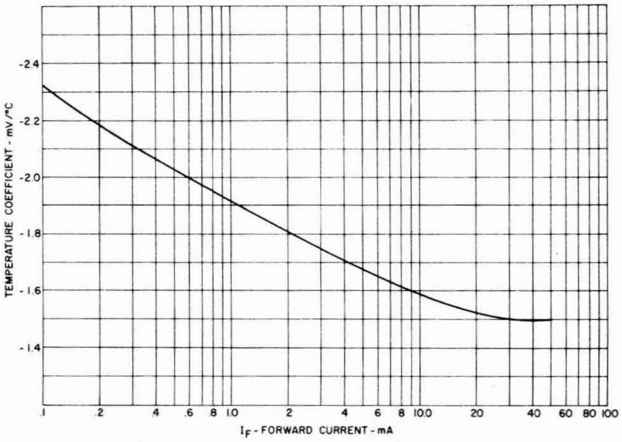
Adjust Amplitude of Input Pulse for Output (I_C) of 2 mA

FIGURE 1

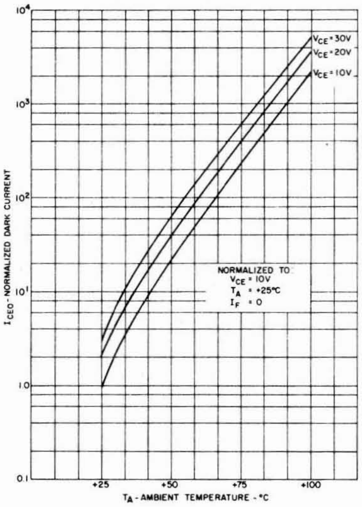
TYPICAL CHARACTERISTICS



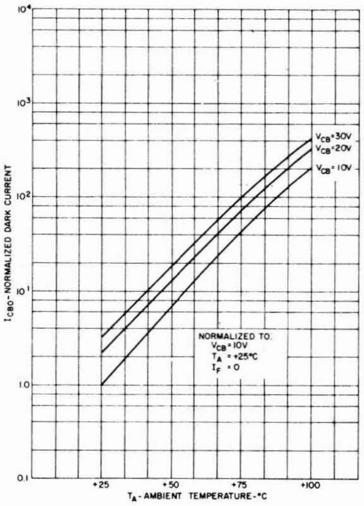
1. INPUT CHARACTERISTICS



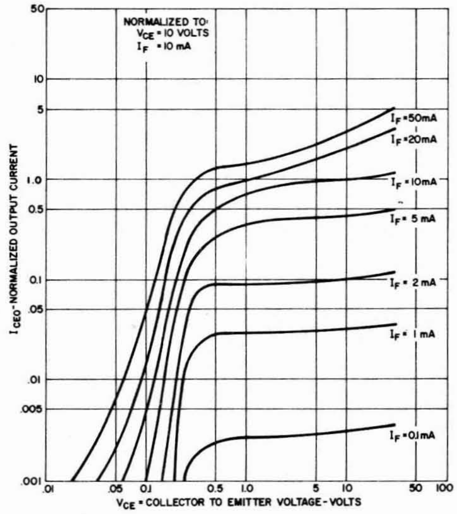
2. FORWARD VOLTAGE TEMPERATURE COEFFICIENT



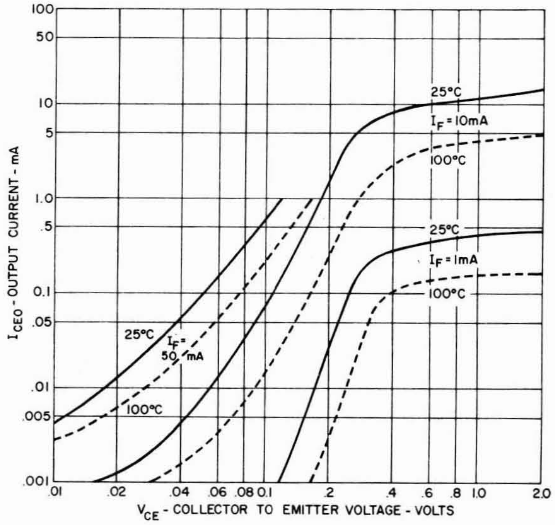
3. DARK I_{CEO} CURRENT VS TEMPERATURE



4. I_{CBO} VS TEMPERATURE

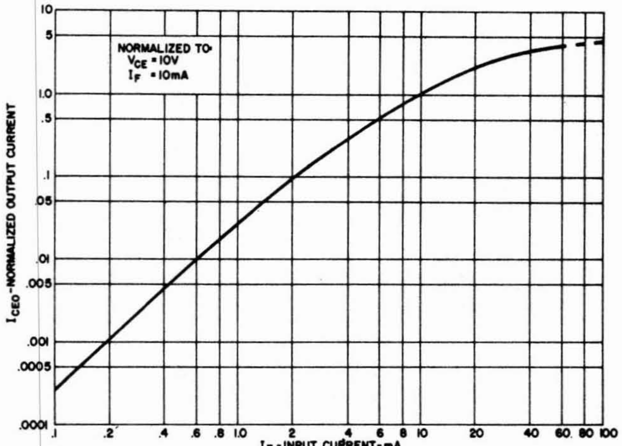


5. OUTPUT CHARACTERISTICS

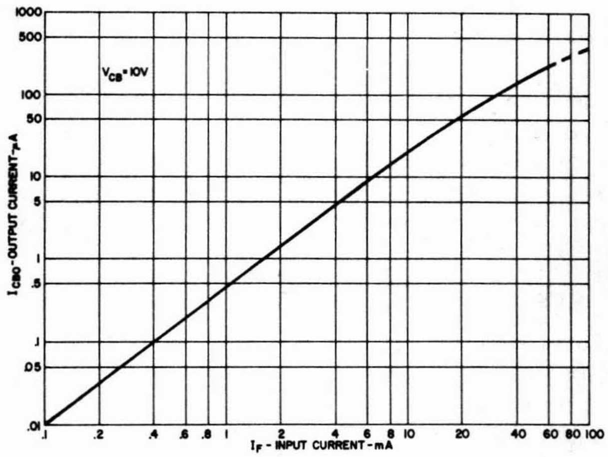


6. OUTPUT CHARACTERISTICS

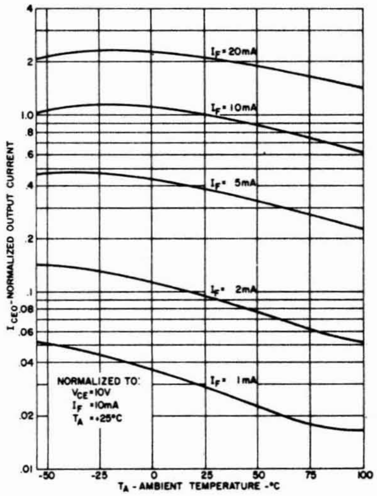
TYPICAL CHARACTERISTICS



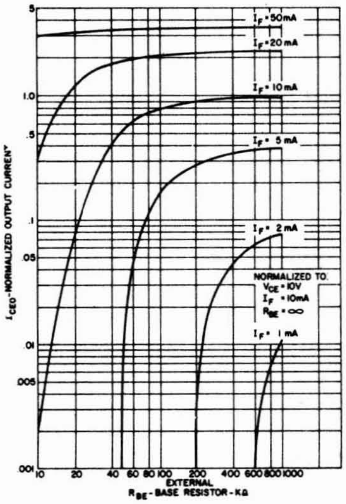
7. OUTPUT CURRENT VS INPUT CURRENT



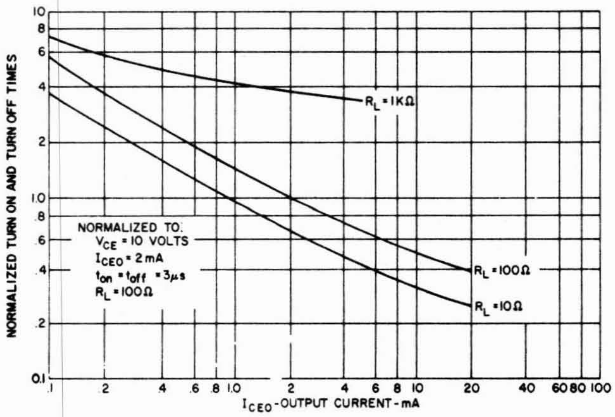
8. OUTPUT CURRENT – COLLECTOR TO BASE VS INPUT CURRENT



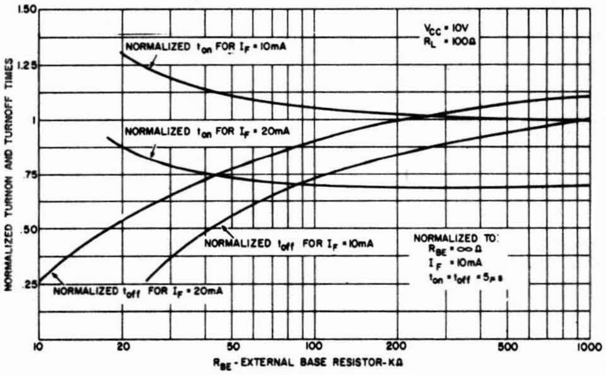
9. OUTPUT CURRENT VS TEMPERATURE



10. OUTPUT CURRENT VS BASE EMITTER RESISTANCE

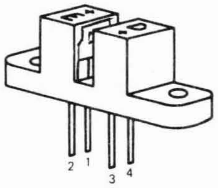


11. SWITCHING TIMES VS OUTPUT CURRENT

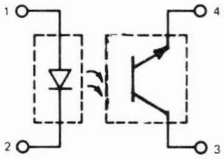


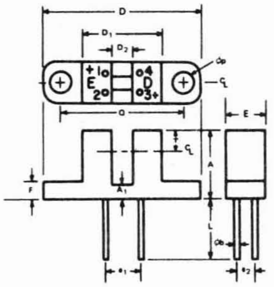
12. SWITCHING TIME VS R_{BE}

Photon Coupled Interrupter Module CNY28



The General Electric CNY28 is a gallium arsenide infrared emitting diode coupled with a silicon photo-transistor in a plastic housing. The gap in the housing provides a means of interrupting the signal with tape, cards, shaft encoders, or other opaque material, switching the output transistor from an "ON" into an "OFF" state.





FEATURES:

- Low cost, plastic module
- Non-contact switching
- Fast switching speeds
- Solid state reliability
- I/O compatible with integrated circuits

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	.390	.400	9.91	10.16	
A_1	.075	.085	1.91	2.15	
φb	.016	.019	.407	.482	1
D	.954	.984	24.24	24.99	
D_1	.475	.495	12.07	12.57	
D_2	.120	.130	3.05	3.30	
e_1	.205	.235	5.21	5.96	
e_2	.090	.110	2.29	2.79	
E		.250		6.35	
F	.095	.105	2.42	2.66	
L	.300		7.62		1
φp	.120	.130	3.05	3.30	
Q	.745	.755	18.93	19.17	
T	.110 NOM.		2.79 NOM.		2

NOTES:

1. Four leads. Lead diameter controlled between .050" (1.27 MM) from the seating plane and the end of the leads.
2. The sensing area falls within a .060" (1.52 MM) square on this centerline.

absolute maximum ratings: (25°C) (unless otherwise specified)

Storage and Operating Temperature -55° to 85°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (peak, 100µs, 1% duty cycle)	1	amp
Reverse Voltage	3	volts

*Derate 1.67mW/°C above 25°C ambient

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
Collector Current (Continuous)	100	milliamps
V_{CEO}	30	volts
V_{ECO}	5	volts

**Derate 2.5mW/°C above 25°C ambient

individual electrical characteristics (25°C)

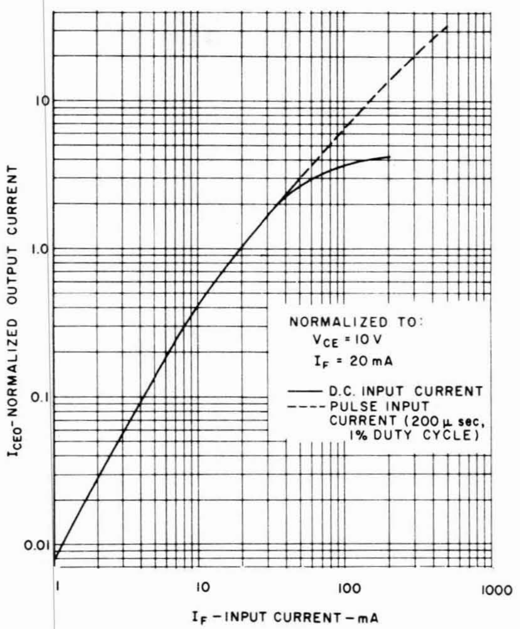
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.2	1.7	volts
Reverse Current (V_R = 2V)	–	10	µamps
Capacitance (V = O, f = 1 Mhz)	150	–	pf

PHOTO-TRANSISTOR	MIN.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ (I_C = 10 mA)	30	–	volts
Breakdown Voltage $V_{(BR)ECO}$ (I_E = 100µA)	5	–	volts
Collector Dark Current I_{CEO} (V_{CE} = 10V, I_F = O, H=O)	–	100	nA

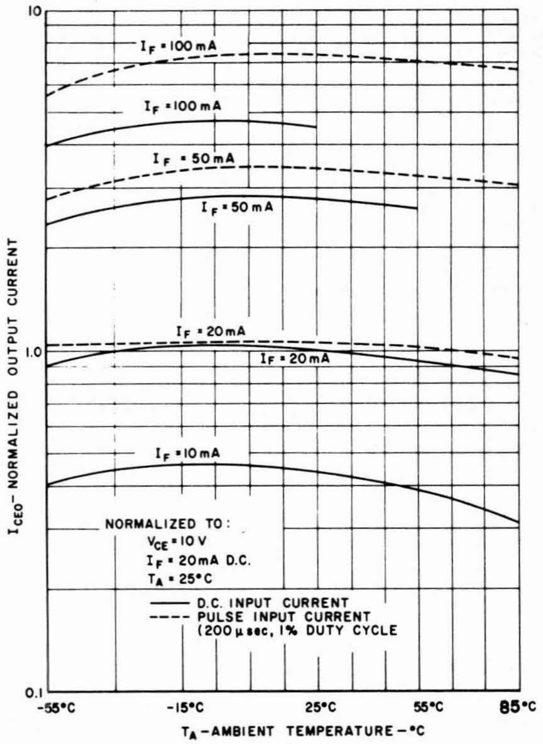
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
Output Current (I_F = 20mA, V_{CE} = 10V)	200	400	–	µamps
Saturation Voltage (I_F = 20mA, I_C = 25µA)	–	0.2	0.4	volts
Switching Speeds (V_{CE} = 10V, I_C = 2mA, R_L = 100Ω)				
On Time ($t_d + t_r$)	–	5	–	µsec
Off Time ($t_s + t_f$)	–	5	–	µsec

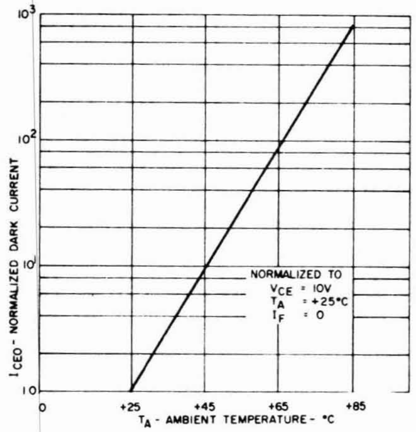
TYPICAL CHARACTERISTICS



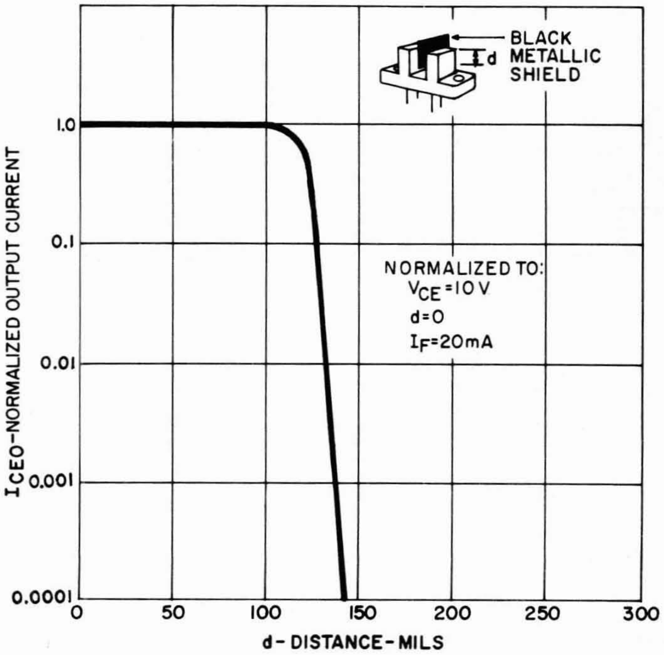
OUTPUT CURRENT VS INPUT CURRENT



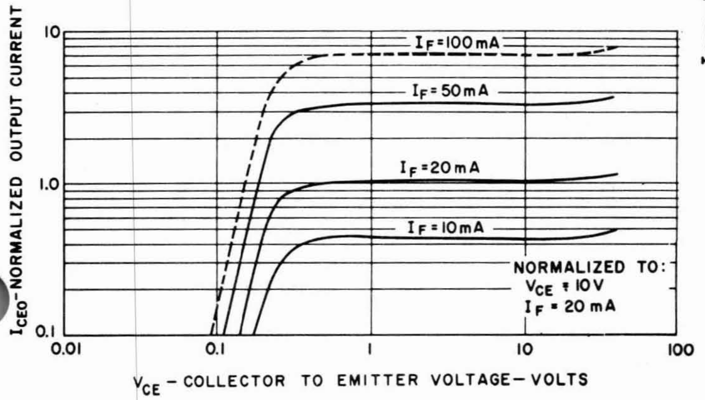
OUTPUT CURRENT VS TEMPERATURE



NORMALIZED DARK CURRENT VS TEMPERATURE



OUTPUT CURRENT VS SHIELD DISTANCE

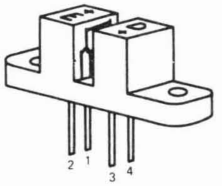


OUTPUT CHARACTERISTICS

SOLID STATE

OPTOELECTRONICS

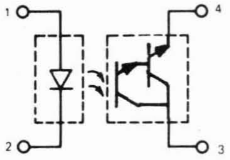
Photon Coupled Interrupter Module CNY29

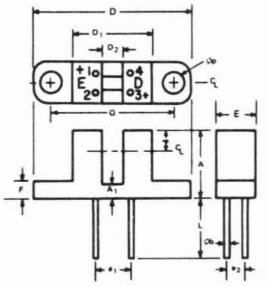


The General Electric CNY29 is gallium arsenide infrared emitting diode coupled with a silicon photo-darlington in a plastic housing. The gap in the housing provides a means of interrupting the signal with tape, cards, shaft encoders, or other opaque material, switching the output transistor from an "ON" into an "OFF" state.

FEATURES:

- Low cost, plastic module
- Non-contact switching
- Solid-state reliability
- I/O compatible with integrated circuits





SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A	.390	.400	9.91	10.16	
A_1	.075	.085	1.91	2.15	
φb	.016	.019	.407	.482	1
D	.954	.984	24.24	24.99	
D_1	.475	.495	12.07	12.57	
D_2	.120	.130	3.05	3.30	
e_1	.205	.235	5.21	5.96	
e_2	.090	.110	2.29	2.79	
E		.250		6.35	
F	.095	.105	2.42	2.66	
L	.300		7.62		1
φp	.120	.130	3.05	3.30	
Q	.745	.755	18.93	19.17	
T	.110 NOM.		2.79 NOM.		2

NOTES:

1. Four leads. Lead diameter controlled between .050" (1.27 MM) from the seating plane and the end of the leads.
2. The sensing area falls within a .060" (1.52 MM) square on this centerline.

absolute maximum ratings: (25°C) (unless otherwise specified)

Storage and Operating Temperature -55° to 85°C. Lead Soldering Time (at 260°C) 10 seconds.

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (peak, 100 μs, 1% duty cycle)	1	amp
Reverse Voltage	3	volts
*Derate 1.67mW/°C above 25°C ambient		

PHOTO-DARLINGTON		
Power Dissipation	**150	milliwatts
Collector Current (Continuous)	100	milliamps
V_{CEO}	25	volts
V_{ECO}	7	volts
**Derate 2.5mW/°C above 25°C ambient		

individual electrical characteristics (25°C)

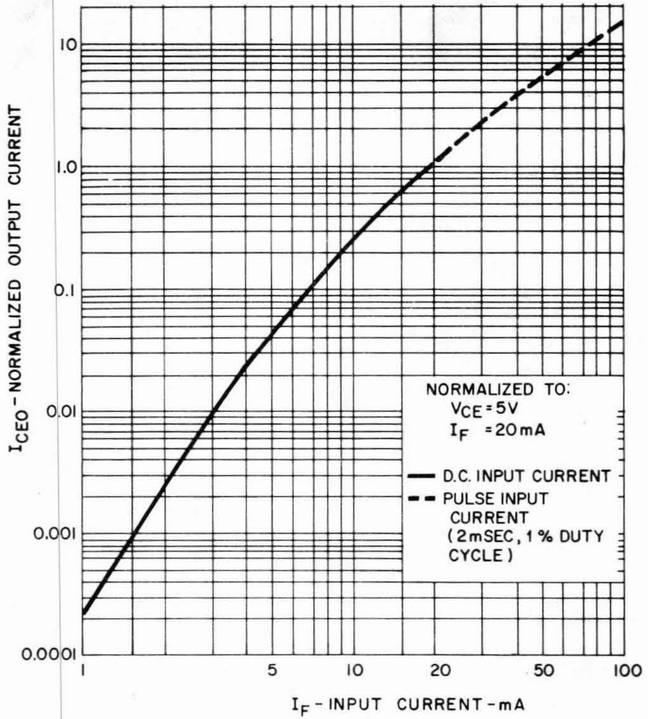
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.2	1.7	volts
Reverse Current (V_R = 2V)	–	10	μamps
Capacitance (V = O, f = 1 MHz)	150	–	pf

PHOTO-DARLINGTON	MIN.	MAX.	UNITS
Breakdown Voltage $V_{(BR)CEO}$ (I_C = 10 mA)	25	–	volts
Breakdown Voltage $V_{(BR)ECO}$ (I_E = 100μa)	7	–	volts
Collector Dark Current I_{CEO} (V_{CE}= 10V, I_F=O, H=O)	–	100	nA

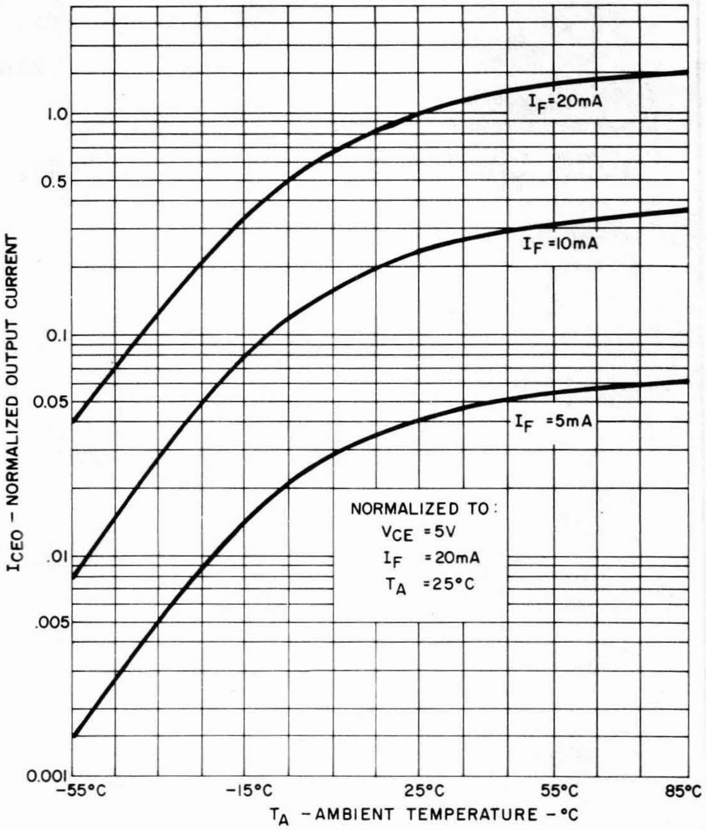
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
Output Current (I_F = 20mA, V_{CE} = 5V)	2500	–	–	μamps
Saturation Voltage (I_F = 20mA, I_C = 0.5 mA)	–	–	1.2	volts
Switching Speeds (V_{CE} = 10V, I_C = 2 mA, R_L = 100Ω)				
On Time ($t_d + t_r$)	–	150	–	μsecs
Off Time ($t_s + t_f$)	–	150	–	μsecs

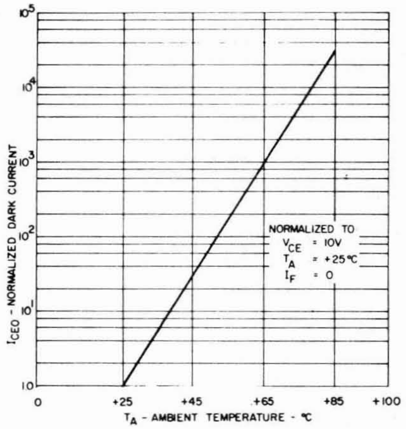
TYPICAL CHARACTERISTICS



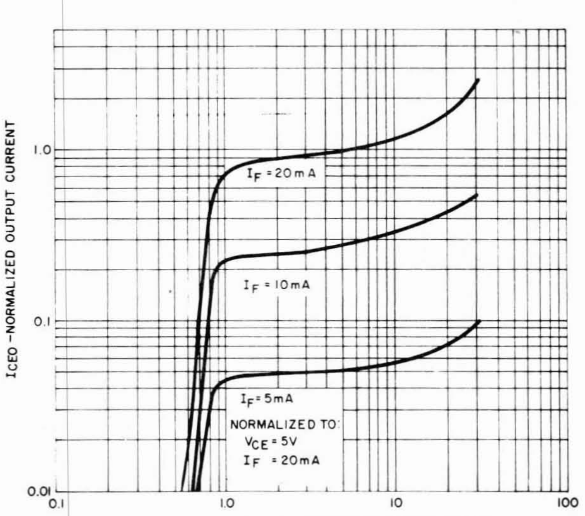
OUTPUT CURRENT VS INPUT CURRENT



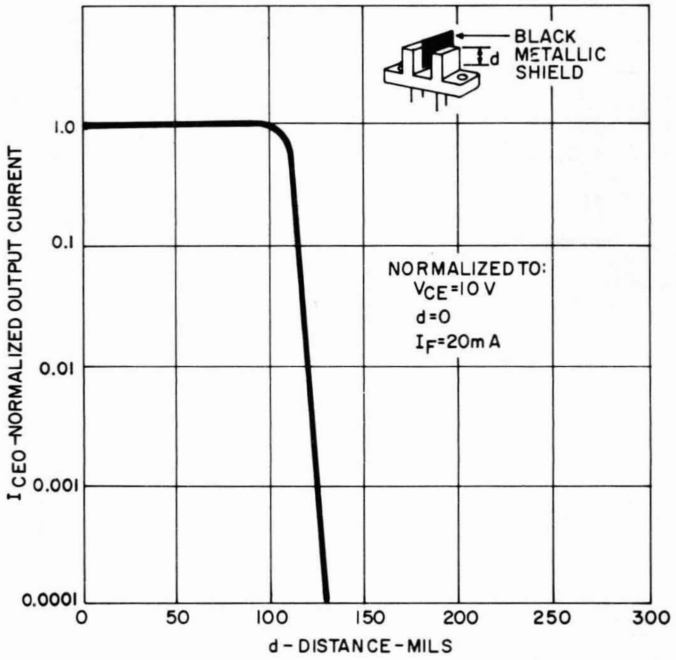
OUTPUT CURRENT VS TEMPERATURE



NORMALIZED DARK CURRENT VS TEMPERATURE



OUTPUT CHARACTERISTICS



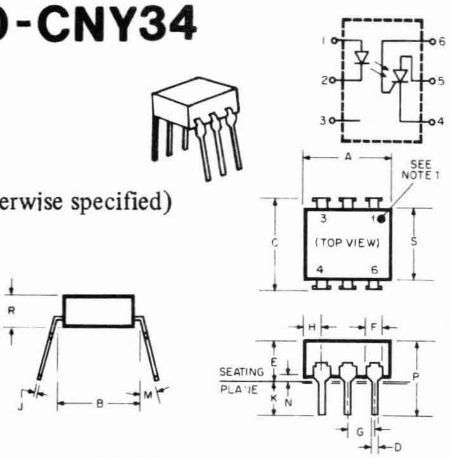
OUTPUT CURRENT VS SHIELD DISTANCE

SOLID STATE
OPTOELECTRONICS

Photon Coupled Isolator CNY30 - CNY34

Ga As Infrared Emitting Diode & Light Activated SCR

The General Electric CNY30 and CNY34 consist of a gallium arsenide, infrared emitting diode coupled with a light activated silicon controlled rectifier in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE		
Power Dissipation (-55°C to 50°C)	*100	milliwatts
Forward Current (Continuous) (-55°C to 50°C)	60	milliamps
Forward Current (Peak) (-55°C to 50°C) (100 μs 1% duty cycle)	1	ampere
Reverse Voltage (-55°C to 50°C)	6	volts

*Derate 2.0mW/°C above 50°C.

PHOTO-SCR			
Off-State and Reverse Voltage	CNY30	200	volts
(-55°C to 100°C)	CNY34	400	volts
Peak Reverse Gate Voltage (-55°C to 50°C)		6	volts
Direct On-State Current (-55°C to 50°C)		300	milliamps
Surge (non-rep) On-State Current (-55°C to 50°C)		10	amps
Peak Gate Current (-55°C to 50°C)		10	milliamps
Output Power Dissipation (-55°C to 50°C)**		400	milliwatts

**Derate 8mW/°C above 50°C.

TOTAL DEVICE

Storage Temperature Range -55°C to 150°C
Operating Temperature Range -55°C to 100°C
Normal Temperature Range (No Derating) -55°C to 80°C
Soldering Temperature (10 seconds) 260°C
Total Device Dissipation (-55°C to 50°C), 450 milliwatts
Linear Derating Factor (above 50°C), 9.0mW/°C
Surge Isolation Voltage (Input to Output).
2500$V_{(peak)}$ 1770$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
1500$V_{(peak)}$ 1060$V_{(RMS)}$

individual electrical characteristics (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE		TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	V_F	1.1	1.5	volts
Reverse Current (V_R = 3V)	I_R	–	10	microamps
Capacitance (V = 0,f = 1 MHz)		50	–	picofarads

PHOTO-SCR		MIN.	MAX.	UNITS
Peak Off-State Voltage–V_{DM}	CNY30	200	–	volts
(R_{GK} = 10KΩ, T_A = 100°C)	CNY34	400	–	volts
Peak Reverse Voltage–V_{RM}	CNY30	200	–	volts
(T_A = 100°C)	CNY34	400	–	volts
On-State Voltage–V_T (I_T = 300mA)			1.3	volts
Off-State Current–I_D (V_D=200V, T_A=100°C, I_F=0, R_{GK}=10K)	CNY30		50	microamps
Off-State Current–I_D (V_D=400V, T_A=100°C, I_F=0, R_{GK}=10K)	CNY34		150	microamps
Reverse Current–I_R (V_R = 200V, T_A = 100°C, I_F = 0)	CNY30		50	microamps
Reverse Current–I_R (V_R = 400V, T_A = 100°C, I_F = 0)	CNY34		150	microamps

coupled electrical characteristics (25°C)

			MIN.	MAX.	UNITS
Input Current to Trigger	V_{AK} = 50V, R_{GK} = 10KΩ	I_{FT}	–	20	milliamps
	V_{AK} = 100V, R_{GK} = 27KΩ	I_{FT}	–	11	milliamps
Isolation Resistance	V_{IO} = 500V_{DC}	r_{IO}	100	–	gigaohms
Turn-On Time – V_{AK} = 50V, I_F = 30mA, R_{GK}= 10KΩ, R_L = 200Ω		t_{on}	–	50	microseconds
Coupled dv/dt, Input to Output (See Figure 13)			500	–	volts microsec.
Input to Output Capacitance (V_{IO} = 0,f = 1 MHz)			–	2	picofarads

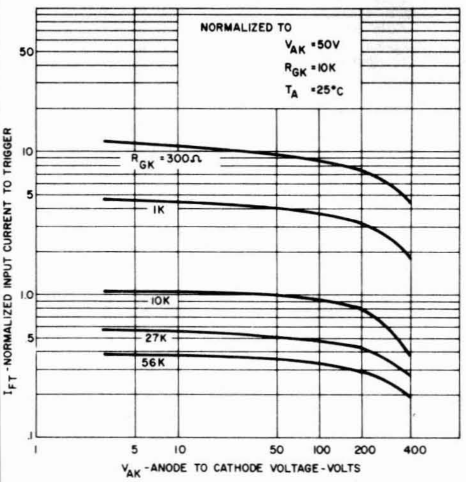


FIGURE 1. INPUT CURRENT TO TRIGGER VS. ANODE-CATHODE VOLTAGE

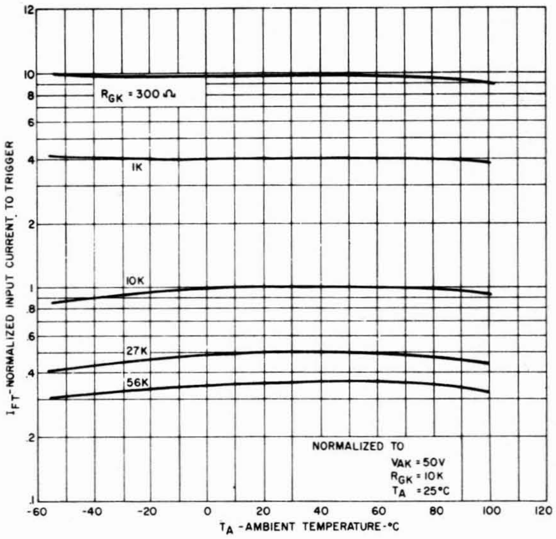


FIGURE 2. INPUT CURRENT TO TRIGGER VS. TEMPERATURE

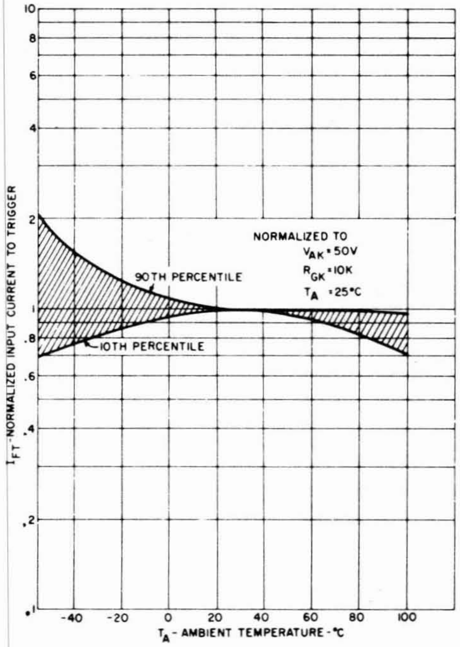


FIGURE 3. INPUT CURRENT TO TRIGGER DISTRIBUTION VS. TEMPERATURE

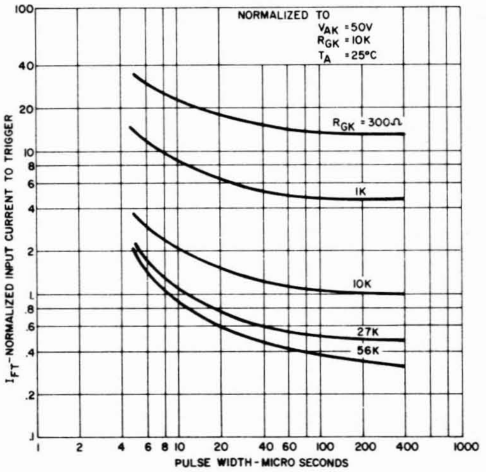


FIGURE 4. INPUT CURRENT TO TRIGGER VS. PULSE WIDTH

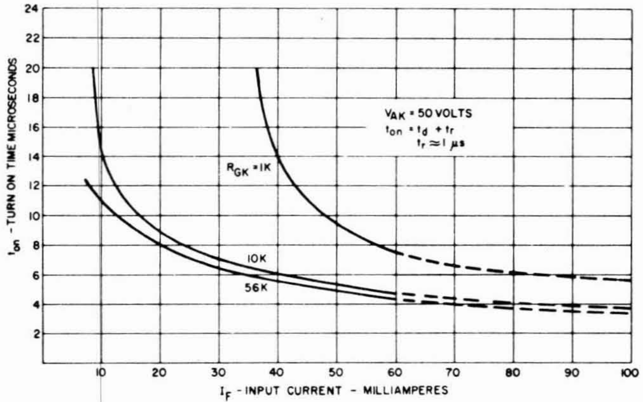


FIGURE 5. TURN-ON TIME VS. INPUT CURRENT

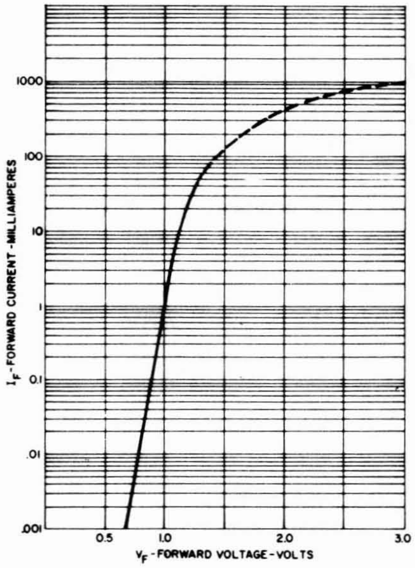


FIGURE 6. INPUT CHARACTERISTICS I_F VS. V_F

TYPICAL CHARACTERISTICS OF OUTPUT (SCR)

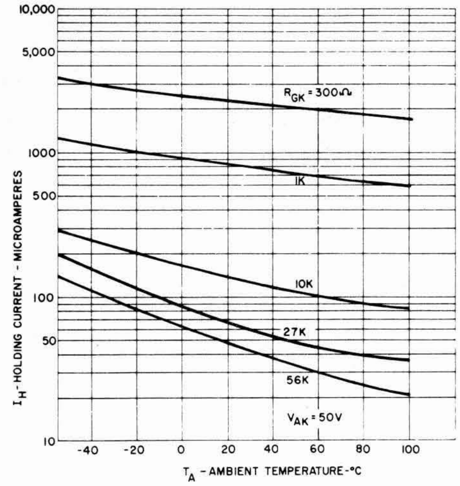


FIGURE 7. HOLDING CURRENT VS. TEMPERATURE

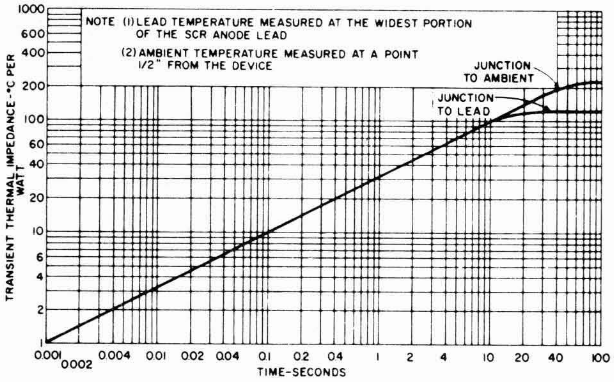


FIGURE 8. MAXIMUM TRANSIENT THERMAL IMPEDANCE

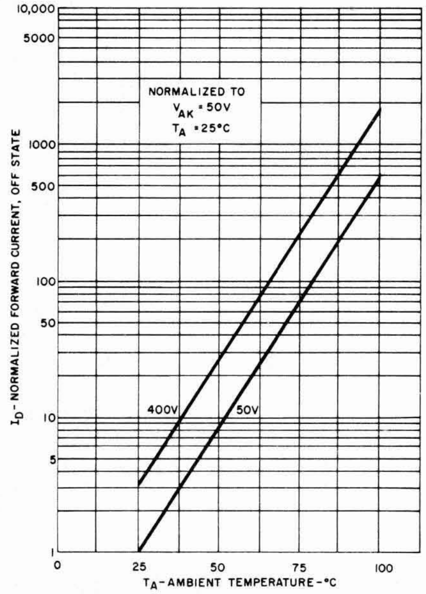


FIGURE 9. OFF-STATE FORWARD CURRENT VS. TEMPERATURE

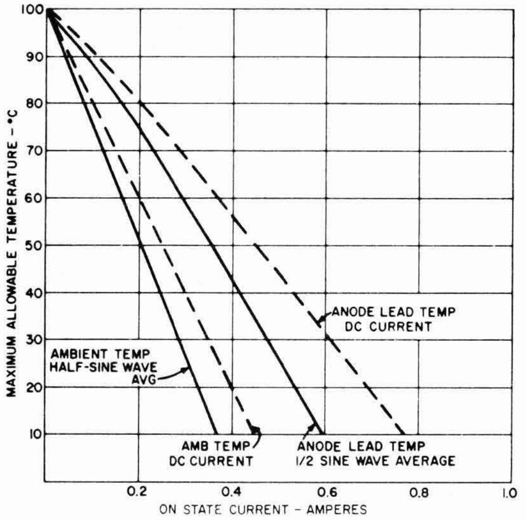


FIGURE 10. ON-STATE CURRENT VS. MAXIMUM ALLOWABLE TEMPERATURE

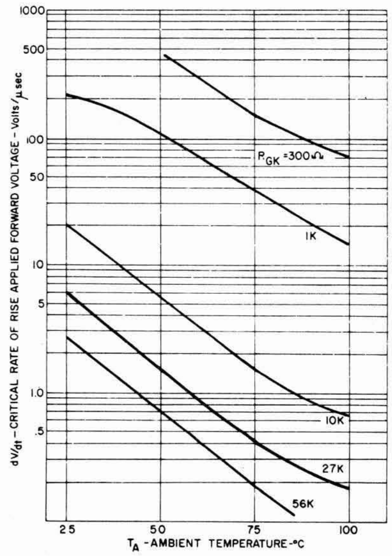


FIGURE 11. dv/dt VS. TEMPERATURE

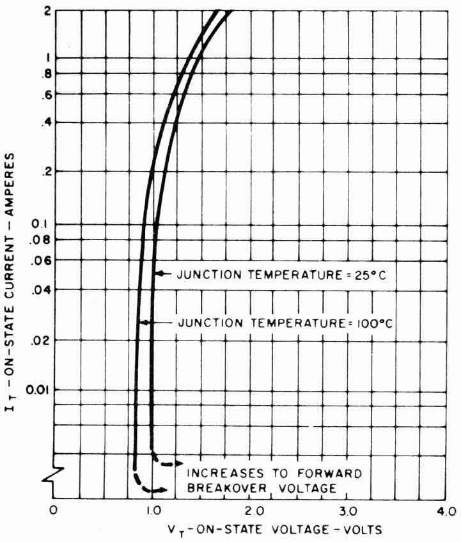
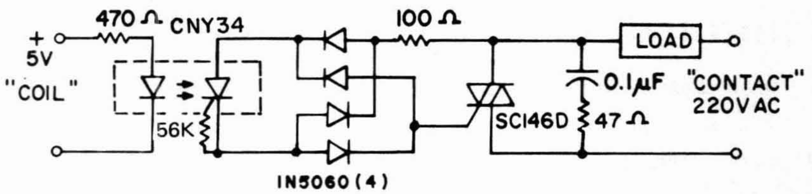


FIGURE 12. ON-STATE CHARACTERISTICS

TYPICAL APPLICATIONS

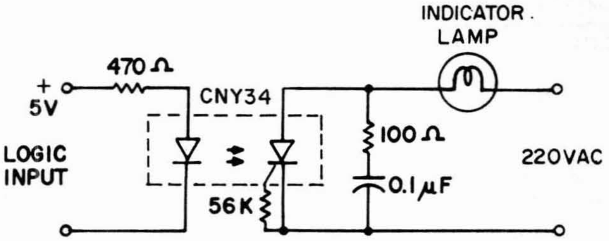
10A, T^{2}L COMPATIBLE, SOLID STATE RELAY

Use of the CNY34 for high sensitivity, 2500V isolation capability, provides this highly reliable solid state relay design. This design is compatible with 74, 74S and 74H series T^{2}L logic systems inputs and 220V AC loads up to 10A.



25W LOGIC INDICATOR LAMP DRIVER

The high surge capability and non-reactive input characteristics of the device allow it to directly couple, without buffers, T^{2}L and DTL logic to indicator and alarm devices, without danger of introducing noise and logic glitches.



400V SYMMETRICAL TRANSISTOR COUPLER

Use of the high voltage PNP portion of the CNY34 provides a 400V transistor capable of conducting positive and negative signals with current transfer ratios of over 1%. This function is useful in remote instrumentation, high voltage power supplies and test equipment. Care should be taken not to exceed the CNY34 400 mW power dissipation rating when used at high voltages.

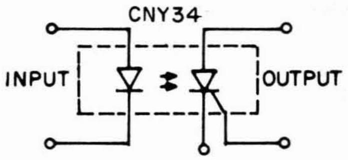
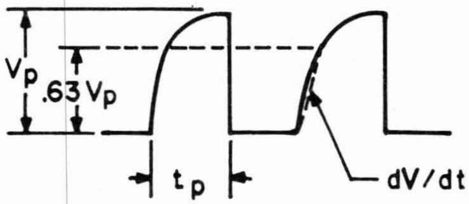
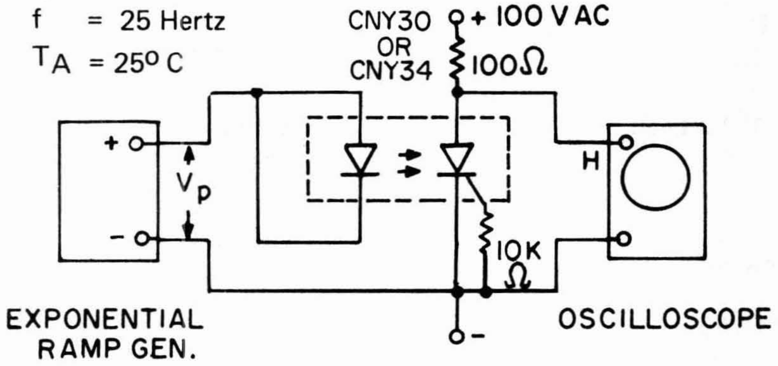


FIGURE 13
COUPLED dv/dt – TEST CIRCUIT

V_p = 800 Volts
t_p =.010 Seconds
f = 25 Hertz
T_A = 25° C

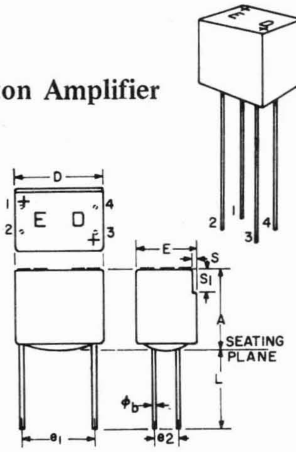


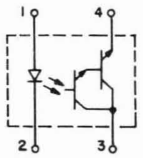


Photon Coupled Isolator CNY31

Ga As Infrared Emitting Diode & NPN Silicon Photo-Darlington Amplifier

The General Electric CNY31 is a gallium arsenide, infrared emitting diode coupled with silicon photo-darlington amplifier in a low cost plastic package with lead spacing, compatible to dual in-line package.





SYMBOL	INCHES MIN.	INCHES MAX.	MILLIMETERS MIN.	MILLIMETERS MAX.	NOTES
A		.350		8.89	
φb	.016	.019	.407	.482	1
D		.375		9.52	
e_1	.285	.315	7.24	8.00	
e_2	.090	.110	2.29	2.79	
E		.250		6.35	
L	.300		7.62		1
S	.010	.020	.26	.50	
S_1	.085	.105	2.16	2.66	

NOTES:

1. FOUR LEADS. LEAD DIAMETER CONTROLLED BETWEEN .050" (1.27MM) FROM THE SEATING PLANE AND THE END OF THE LEADS.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1 μsec 300 pps)	3	ampere
Reverse Voltage	3	volts

*Derate 1.67 mW/°C above 25°C ambient.

PHOTO-DARLINGTON		
Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{ECO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.5 mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 85°C
Operating Temperature -55 to 85°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).
5650$V_{(peak)}$ 4000$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
3500$V_{(peak)}$ 2500$V_{(RMS)}$

individual electrical characteristics (25°C)

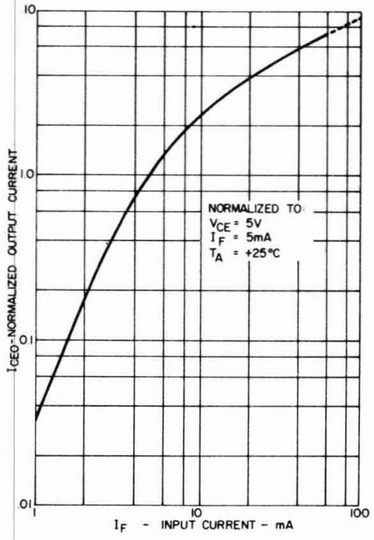
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.7	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = O,f = 1 MHz)	50	–	picofarads

PHOTO-DARLINGTON	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = O)	30	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = O)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = O)	–	5	100	nanoamps
Capacitance (V_{CE} = 10V, f = 1 MHz)	–	6	–	picofarads

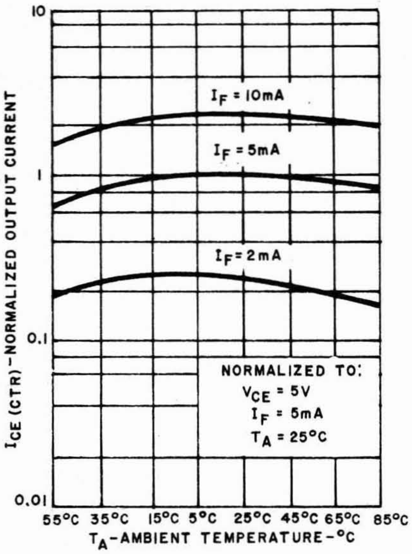
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 5 mA, V_{CE} = 5V)	400	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 5 mA, I_C = 2 mA)	–	0.8	1.4	volts
Isolation Resistance (Input to Output Voltage = 500V_{DC})	100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = O,f = 1 MHz)	–	–	2	picofarads
Switching Speeds: Turn-On Time – (V_{CE} = 10V, I_C = 10mA, R_L = 100Ω)	–	125	–	microseconds
Turn-Off Time – (V_{CE} = 10V, I_C = 10mA, R_L = 100Ω)	–	100	–	microseconds

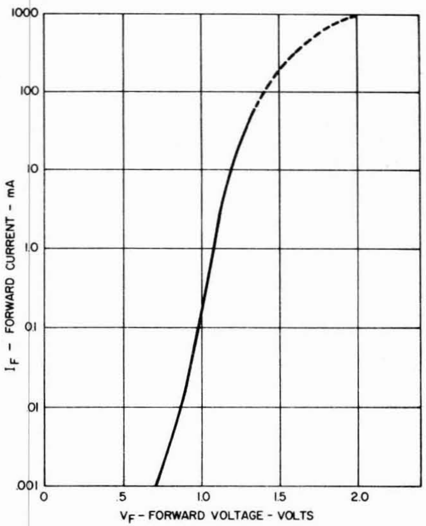
TYPICAL CHARACTERISTICS



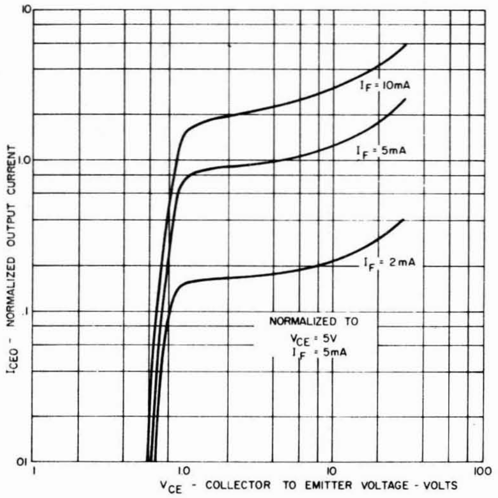
OUTPUT CURRENT VS INPUT CURRENT



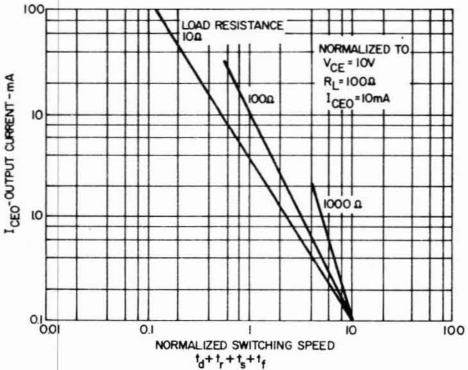
OUTPUT CURRENT VS TEMPERATURE



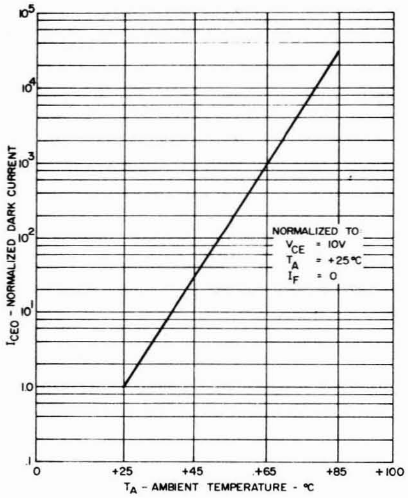
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS



SWITCHING SPEED VS OUTPUT CURRENT

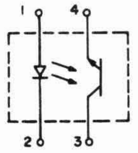


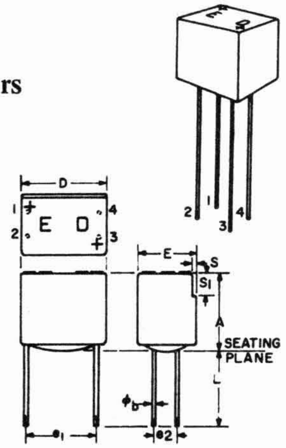
NORMALIZED DARK CURRENT VS TEMPERATURE

Photon Coupled Isolator CNY32

Ga As Infrared Emitting Diodes & NPN Silicon Photo-Transistors

The General Electric CNY32 is a gallium arsenide, infrared emitting diode coupled with a silicon photo transistor in a low cost plastic package with lead spacing, compatible to dual in-line package.





SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN.	MAX.	MIN.	MAX.	
A		.350		8.89	
ϕb	.016	.019	.407	.482	1
D		.375		9.52	
e_1	.285	.315	7.24	8.00	
e_2	.090	.110	2.29	2.79	
E		.250		6.35	
L	.300		7.62		1
S	.010	.020	.26	.50	
S_1	.085	.105	2.16	2.66	

NOTES:

1. FOUR LEADS. LEAD DIAMETER CONTROLLED BETWEEN .050" (1.27MM) FROM THE SEATING PLANE AND THE END OF THE LEADS.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	Milliamps
Forward Current (Peak) (Pulse width 1 μsec 300 pps)	3	ampere
Reverse Voltage	3	volts

*Derate 1.67 mW/° above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{ECO}	5	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.5 mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -55 to 85°C
Operating Temperature -55 to 85°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output)
$5650V_{(peak)}$ $4000V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
$3500V_{(peak)}$ $2500V_{(RMS)}$

individual electrical characteristics (25°C)

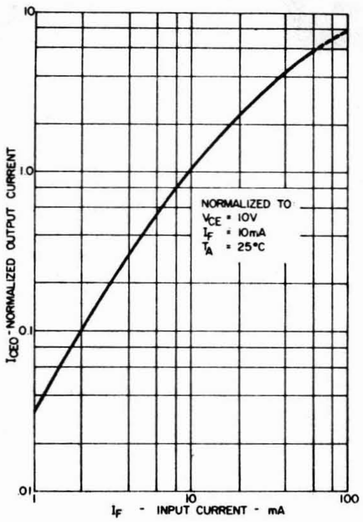
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.7	volts
Reverse Current (V_R = 3V)	–	10	micoramps
Capacitance (V = 0,f = 1 MHz)	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)ECO}$ (I_E = 100μA, I_F = 0)	5	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	100	nanoamps
Capacitance (V_{CE} = 10V, f = 1MHz)	–	3.5	–	picofarads

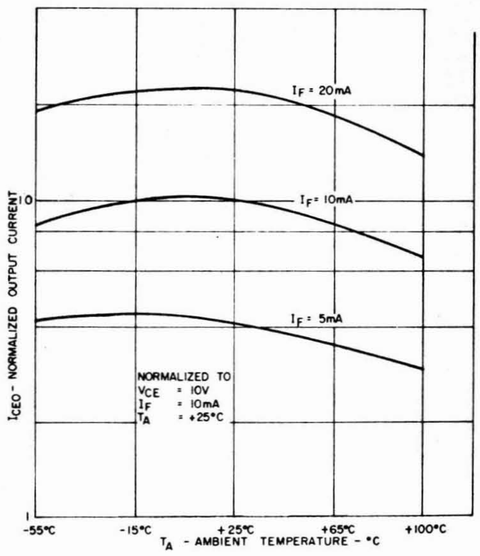
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V)	20	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 0.5mA)	–	0.2	0.4	volts
Isolation Resistance (Input to Output Voltage = $500V_{DC}$)	100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0,f = 1 MHz)	–	–	2	picofarads
Switching Speeds: Turn-On Time – (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)	–	3	–	microseconds
Turn-Off Time – (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)	–	3	–	microseconds

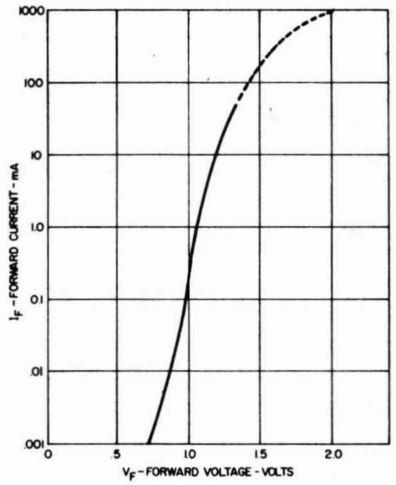
TYPICAL CHARACTERISTICS



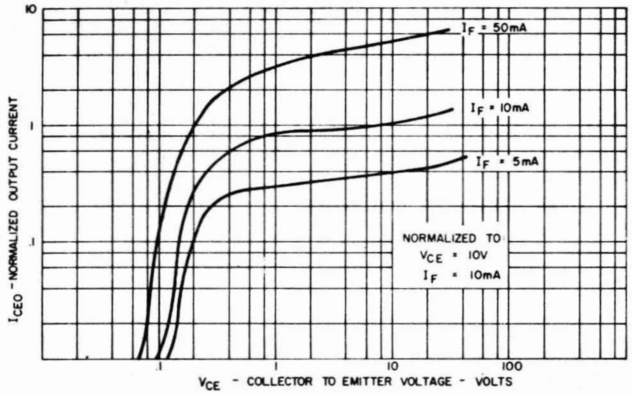
OUTPUT CURRENT VS INPUT CURRENT



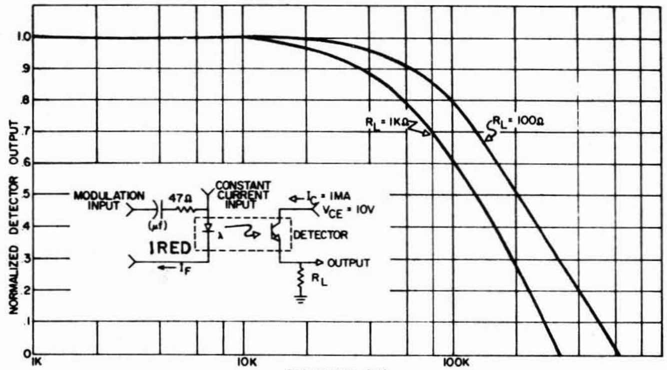
OUTPUT CURRENT VS TEMPERATURE



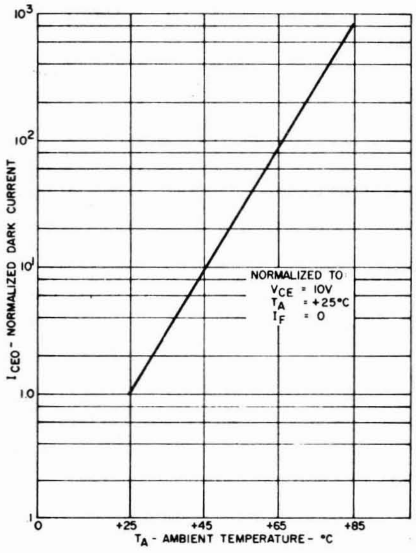
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS

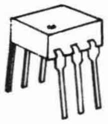


FREQUENCY VS DETECTOR OUTPUT



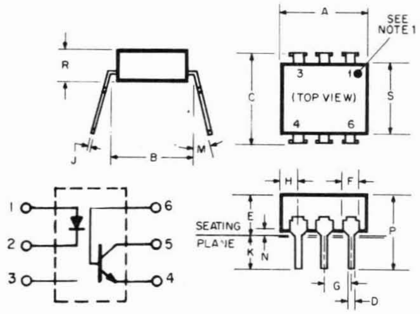
NORMALIZED DARK CURRENT VS TEMPERATURE

Photon Coupled Isolator CNY33



Ga As Infrared Emitting Diode & NPN Silicon High Voltage Photo-Transistor

The General Electric CNY33 is a gallium arsenide, infrared emitting diode coupled with silicon high voltage photo-transistors in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1 μsec 300 pps)	3	ampere
Reverse Voltage	6	volts

*Derate 1.33mW/°C above 25°C ambient.

PHOTO-TRANSISTOR		
Power Dissipation	**300	milliwatts
V_{CEO}	300	volts
V_{CBO}	300	volts
V_{EBO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 4.0mW/°C above 25° ambient.

TOTAL DEVICE

Storage Temperature -55 to 150°C

Operating Temperature -55 to 100°C

Lead Soldering Time (at 260°C) 10 seconds.

Surge Isolation Voltage (Input to Output).

$2500V_{(peak)}$ $1770V_{(RMS)}$

Steady-State Isolation Voltage (Input to Output).

$1500V_{(peak)}$ $1060V_{(RMS)}$

individual electrical characteristics (25°C)

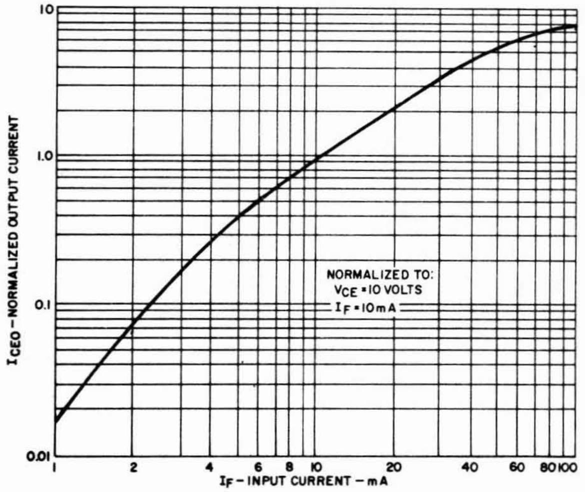
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.5	volts
Reverse Current (V_R = 6V)	–	10	microamps
Capacitance (V = 0,f = 1 MHz)	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 1mA; I_F = 0)	300	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA; I_F = 0)	300	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ (I_E = 100μA; I_F = 0)	7	–	volts
Collector Dark Current – I_{CEO}			
(V_{CE}=200V; I_F=0, T_A= 25°C)	–	100	nanoamps
(V_{CE}=200V; I_F=0; T_A=100°C)	–	250	microamps

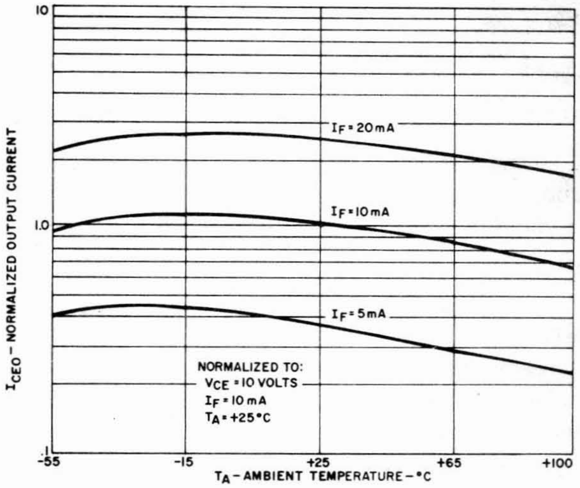
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE}= 10V)	20	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 0.5mA)	–	0.1	0.4	volts
Isolation Resistance (V_{IO} = $500V_{DC}$)	100	–	–	gigaohms
Input to Output Capacitance (V_{IO} = 0,f = 1MHz)	–	–	2	picofarads
Switching Speeds: Turn-On Time – (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)	–	5	–	microseconds
Turn-Off Time – (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)	–	5	–	microseconds

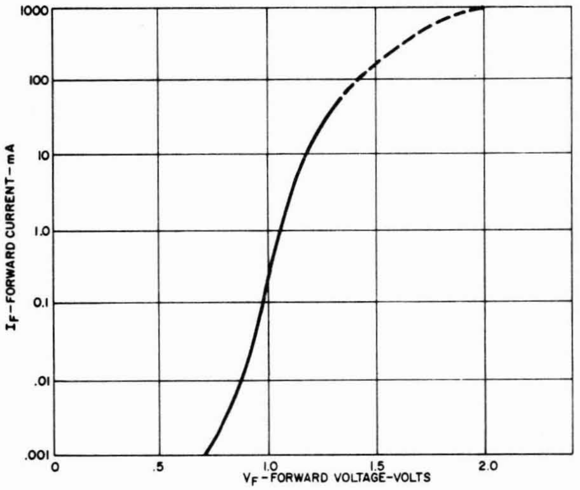
TYPICAL CHARACTERISTICS



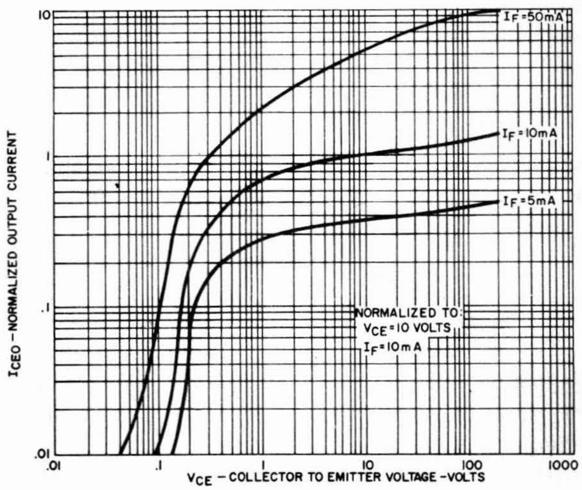
1. OUTPUT CURRENT VS INPUT CURRENT



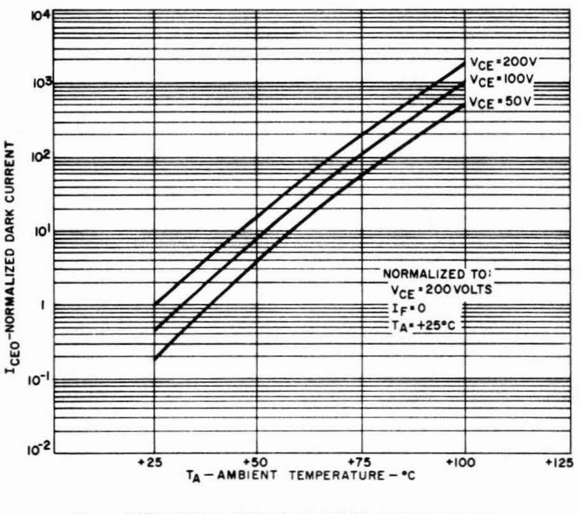
2. OUTPUT CURRENT VS. TEMPERATURE



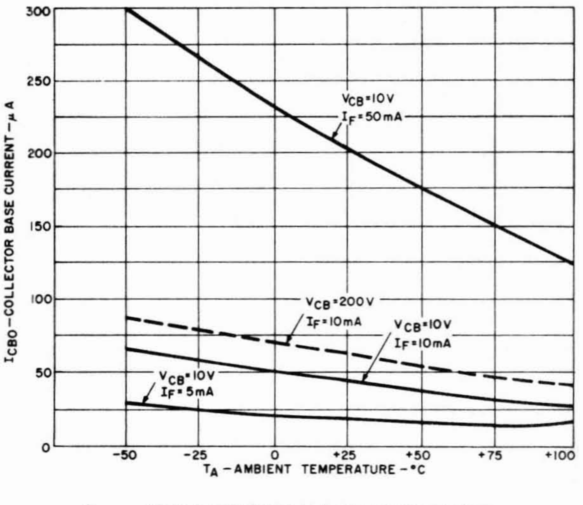
3. INPUT CHARACTERISTICS



4. OUTPUT CHARACTERISTICS



5. NORMALIZED DARK CURRENT
VS. TEMPERATURE



6. COLLECTOR BASE CURRENT
VS. TEMPERATURE

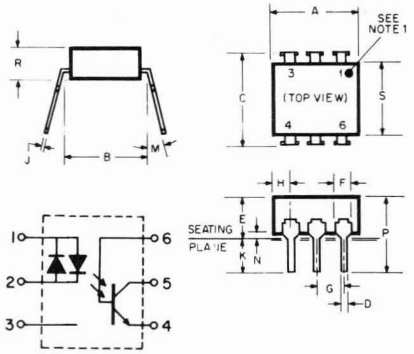
AC Input Photon Coupled Isolator CNY35

Ga As Infared Emitting Diodes & NPN Silicon Photo-Transistor

The General Electric CNY35 consists of two gallium arsenide, infrared emitting diodes connected in inverse parallel and coupled with a silicon photo-transistor in a dual in-line package.

FEATURES:

- AC or polarity insensitive inputs
- Fast switching speeds
- Built-in reverse polarity input protection
- High isolation voltage
- High isolation resistance
- I/O compatible with integrated circuits



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES

1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE		
Power Dissipation – $T_A = 25^\circ C$	*100	milliwatts
Power Dissipation – $T_A = 25^\circ C$ (T_C indicates collector lead temperature 1/32″ from case)	*100	milliwatts
Input Current (RMS)	60	milliamps
Input Current (Peak) (Pulse width 1 μs, 300 pps)	±1	ampere

*Derate 1.33 mW/°C above 25°C

PHOTO-TRANSISTOR		
Power Dissipation – $T_A = 25^\circ C$	**300	milliwatts
Power Dissipation – $T_A = 25^\circ C$ (T_C indicates collector lead temperature 1/32″ from case)	***500	milliwatts
V_{CEO}	30	volts
V_{CBO}	70	volts
V_{EBO}	5	volts
Collector Current Continuous)	100	milliamps

**Derate 4.0 mW/°C above 25°C
***Derate 6.7 mW/°C above 25°C

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output)
$1500V_{(peak)}$ $1060V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output)
$950V_{(peak)}$ $660V_{(RMS)}$

individual electrical characteristics (25°C) (unless otherwise specified)

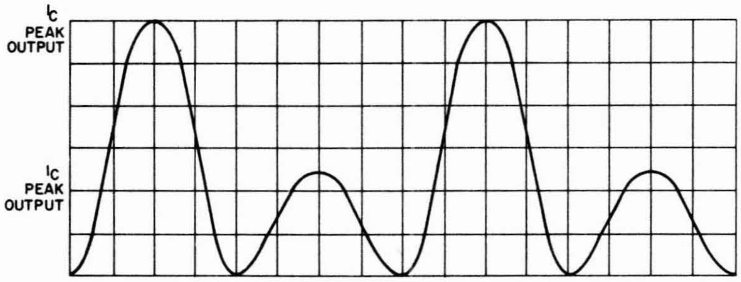
INFRARED EMITTING DIODE	MAX.	UNITS
Input Voltage – V_F ($I_F = \pm 10mA$)	1.8	volts
Capacitance (V = 0, f = 1 MHz)	100	picofarads

PHOTO-TRANSISTOR	MIN.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ ($I_C = 10mA$, $I_F = 0$)	30	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ ($I_C = 100\mu A$, $I_F = 0$)	70	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ ($I_E = 100\mu A$, $I_F = 0$)	5	–	volts
Collector Dark Current – I_{CEO} ($V_{CE} = 10V$, $I_F = 0$)	–	200	nanoamps

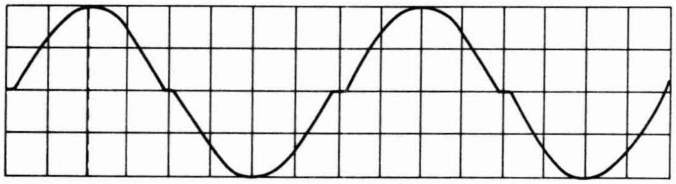
coupled electrical characteristics (25°C) (unless otherwise specified)

	MIN.	MAX.	UNITS
Current Transfer Ratio (V_{CE} = 10V, I_F = ± 10mA)	10	–	percent
Saturation Voltage – Collector to Emitter (I_{CEO} = 0.5 mA, I_F = ± 10mA)	–	0.4	volts
Isolation Resistance V_{IO} = 500V (note 1)	100	–	gigaohms

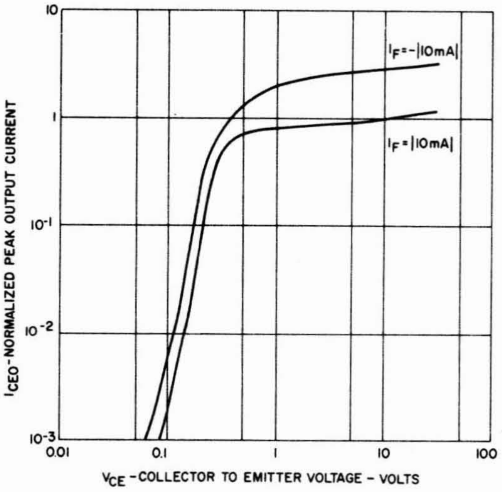
Note 1: Tests of input to output isolation current resistance, and capacitance are performed with the input terminals (diode) shorted together and the output terminals (transistor) shorted together.



$I_{(CEO)}$ OUTPUT WAVE FORM (SEE NOTE 2) AT V_{CE} = 5V

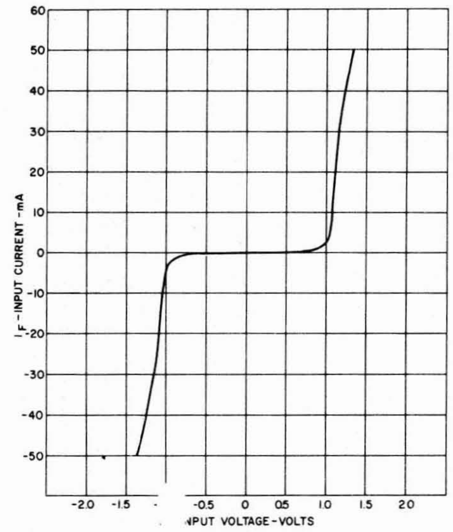


I_F INPUT WAVE FORM

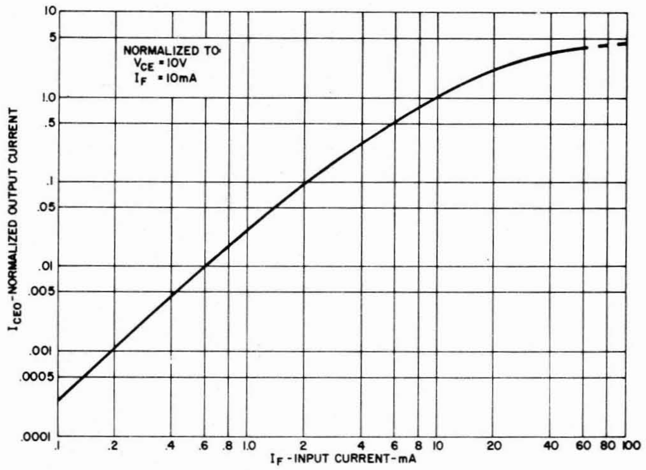


Note 2: These waveforms and curves are exaggerated in amplitude differences to indicate the outputs corresponding to the positive and negative input polarities will not be identical. Typical differences in amplitude is 10% to 20%.

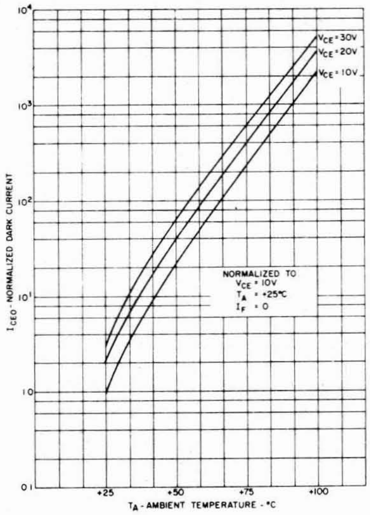
TYPICAL CHARACTERISTICS



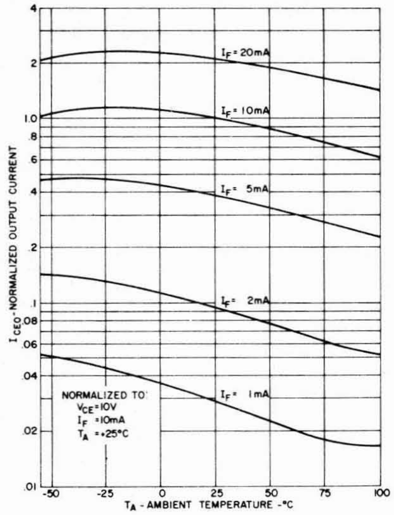
1. INPUT CHARACTERISTICS



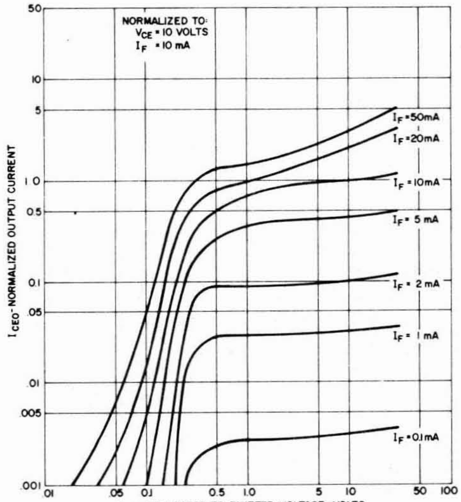
2. OUTPUT CURRENT VS INPUT CURRENT



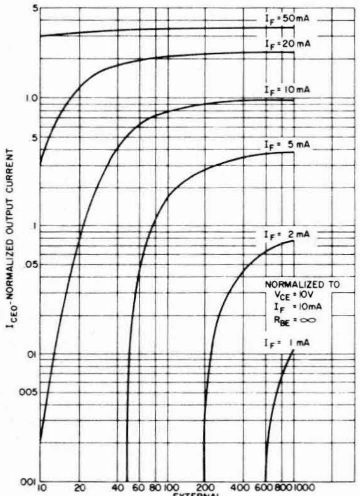
3. DARK I_{CEO} CURRENT VS TEMPERATURE



4. OUTPUT CURRENT VS TEMPERATURE

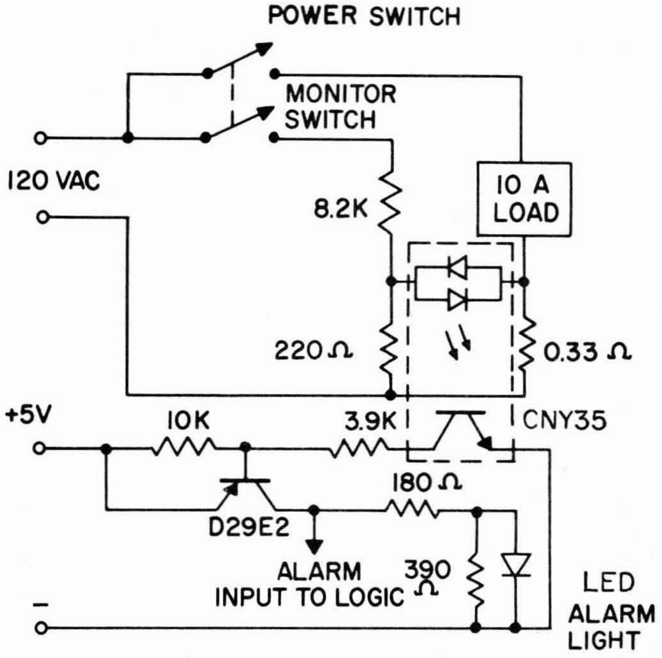


5. OUTPUT CHARACTERISTICS



6. OUTPUT CURRENT VS BASE EMITTER RESISTANCE

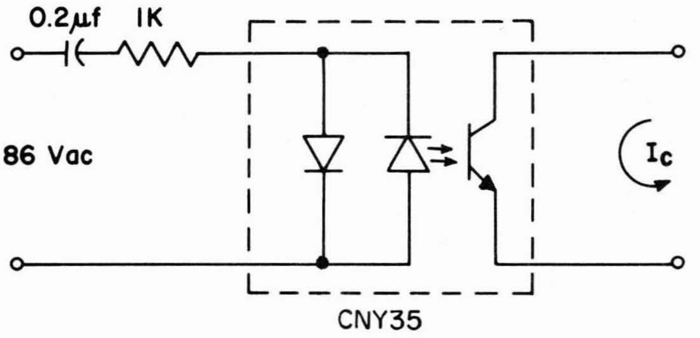
LOAD MONITOR AND ALARM



In many computer controlled systems where AC power is controlled, load dropout due to filament burnout, fusing, etc. or the opposite situation - load power when uncalled for due to switch failure can cause serious systems or safety problems. This circuit provides a simple AC power monitor which lights an alarm lamp and provides a "1" input to the computer control in either of these situations while maintaining complete electrical isolation between the logic and the power system.

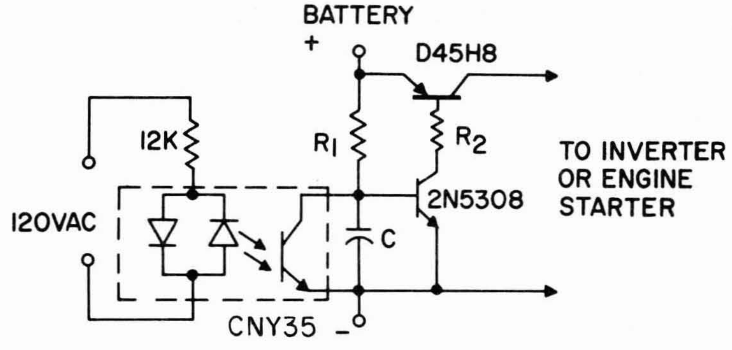
Note that for other than resistive loads, phase angle correction of the monitoring voltage divider is required.

RING DETECTOR



In many telecommunications applications it is desirable to detect the presence of a ring signal in a system without any direct electrical contact with the system. When the 86 Vac ring signal is applied, the output transistor of the CNY35 is turned on indicating the presence of a ring signal in the isolated telecommunications system.

UPS SOLID STATE TURN-ON SWITCH



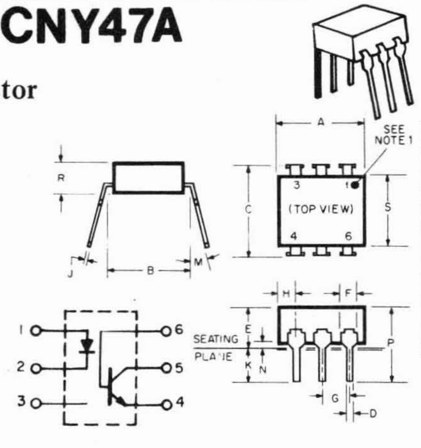
Interruption of the 120 VAC power line turns off the CNY35, allowing C to charge and turn on the 2N5308-D45H8 combination which activates the auxiliary power supply. This system features low standby drain, isolation to prevent ground loop problems and the capability of ignoring a fixed number of "dropped cycles" by choice of the value of C.

SOLID STATE
OPTOELECTRONICS

Photon Coupled Isolator CNY47, CNY47A

Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric CNY47 and CNY47A are gallium arsenide infrared emitting diodes coupled with a silicon photo-transistor in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	4.70	
S	.225	.280	5.71	7.12	

NOTES
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	30	milliamps
Forward Current (Peak) (Pulse width 1 μs 300 pps)	3	ampere
Reverse Voltage	3	volts

*Derate 1.33mW/°C above 25°C ambient

PHOTO-TRANSISTOR		
Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{CBO}	50	volts
V_{EBO}	4	volts
Collector Current (Continuous)	30	milliamps

**Derate 2.0mW/°C above 25°C ambient

TOTAL DEVICE

Storage Temperature -55 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).
2828$V_{(peak)}$ 2000$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
1695$V_{(peak)}$ 1200$V_{(RMS)}$

individual electrical characteristics (25°C)

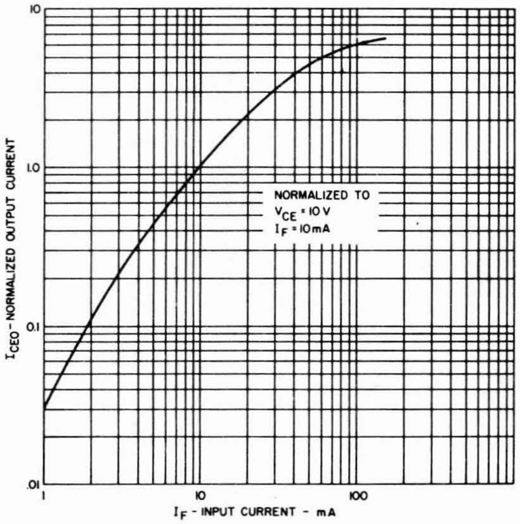
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10 mA)	1.1	1.5	volts
Reverse Current (V_R = 3 V)	–	100	microamps
Capacitance (V = 0, f = 1 MHz)	50	–	picofarads

PHOTO-TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage–$V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	30	–	–	volts
Breakdown Voltage–$V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	50	–	–	volts
Breakdown Voltage–$V_{(BR)EBO}$ (I_E = 100μA, I_F = 0)	4	–	–	volts
Collector Dark Current–I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	100	nanoamps
Collector Dark Current–I_{CBO} (V_{CB} = 10V, I_F = 0)	–	–	20	nanoamps
Capacitance (V_{CE} = 10V, F = 1 MHz)	–	2	–	picofarads

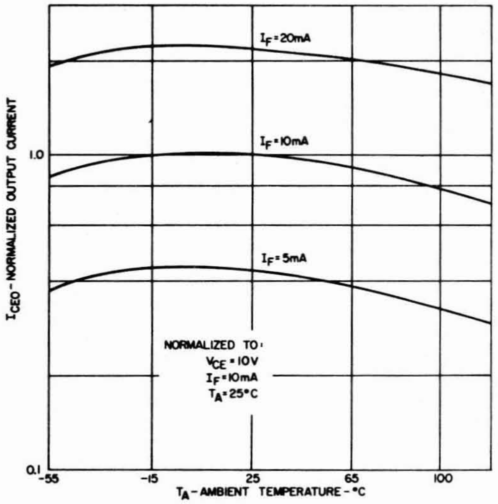
coupled electrical characteristics (25°C)

		MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = .4V)	CNY47	20	–	60	%
	CNY47A	40	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 10mA, I_C = 2mA)	CNY47	–	0.1	0.4	volts
(I_F = 10mA, I_C = 4mA)	CNY47A			0.4	volts
Isolation Resistance (V_{IO} = 500V_{DC})		100	–		gigaohms
Input to Output Capacitance (V_{IO} = 0, f = 1 MHz)		–	–	2	picofarads
Switching Speeds:					
Rise/Fall Time (V_{CE} = 10V, I_{CE} = 2mA, R_L = 100Ω)		–	2	–	microseconds
Rise/Fall Time (V_{CB} = 10V, I_{CB} = 50μA, R_L = 100Ω)		–	300	–	nanoseconds

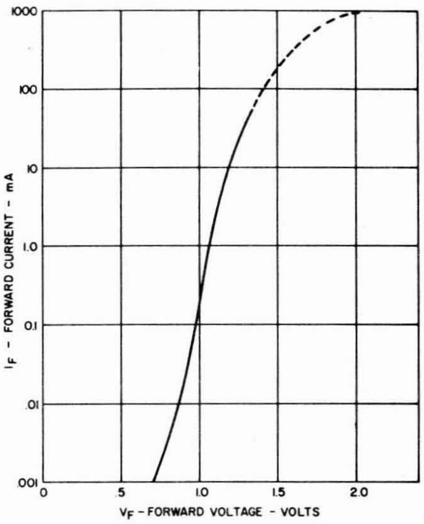
TYPICAL CHARACTERISTICS



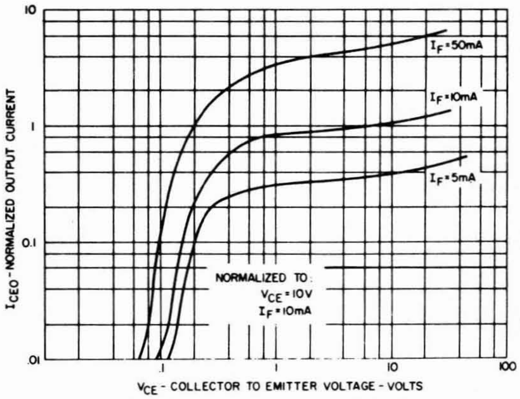
OUTPUT CURRENT VS INPUT CURRENT



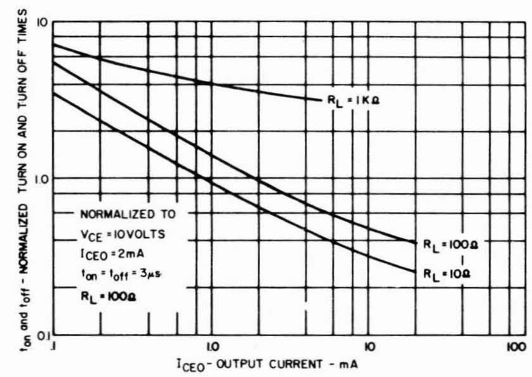
OUTPUT CURRENT VS TEMPERATURE



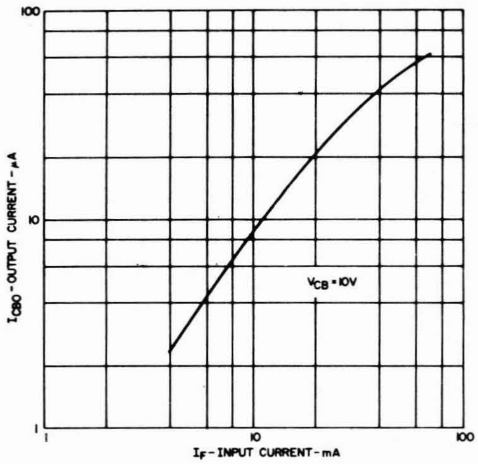
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS



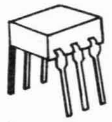
SWITCHING TIMES VS OUTPUT CURRENT



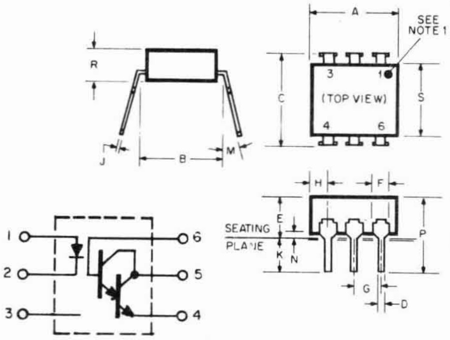
OUTPUT CURRENT (I_{CBO}) VS INPUT CURRENT

Photon Coupled Isolator CNY48

Ga As Infrared Emitting Diode & NPN Silicon Photo-Darlington Amplifier



The General Electric CNY48 consists of a gallium arsenide, infrared emitting diode coupled with a silicon photo-darlington amplifier in a dual in-line package.



SYMBOL	INCH MIN.	INCH MAX.	MILLIMETER MIN.	MILLIMETER MAX.	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES
1. There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1.
2. Installed position lead centers.
3. Overall installed dimension.
4. These measurements are made from the seating plane.
5. Four places.

absolute maximum ratings: (25°C)

INFRARED EMITTING DIODE		
Power Dissipation	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak)	3	ampere
(Pulse width 1 μs 300 pps)		
Reverse Voltage	3	volts

*Derate 1.33mW/°C above 25°C ambient.

PHOTO-DARLINGTON		
Power Dissipation	**150	milliwatts
V_{CEO}	30	volts
V_{CBO}	30	volts
V_{EBO}	6	volts
Collector Current (Continuous)	100	milliamps

**Derate 2.0mW/°C above 25°C ambient.

TOTAL DEVICE

Storage Temperature -65 to 150°C
Operating Temperature -55 to 100°C
Lead Soldering Time (at 260°C) 10 seconds
Surge Isolation Voltage (Input to Output).
2120$_{(peak)}$ 1500V$_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
1270V$_{(peak)}$ 900V$_{(RMS)}$

individual electrical characteristics (25°C)

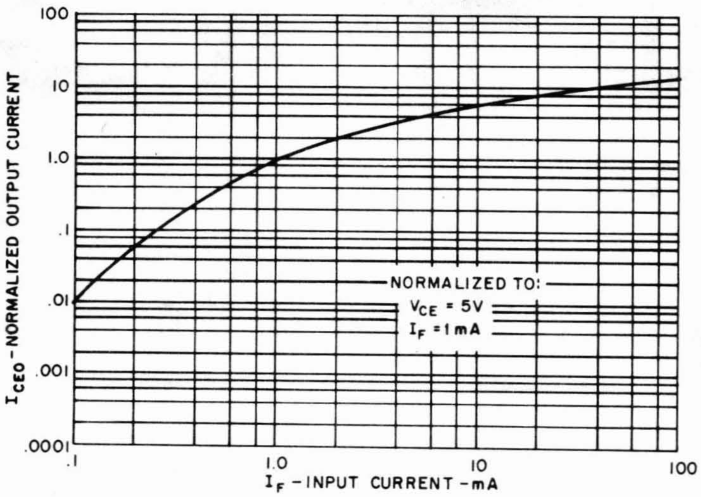
INFRARED EMITTING DIODE	TYP.	MAX.	UNITS
Forward Voltage (I_F = 10mA)	1.1	1.3	volts
Reverse Current (V_R = 3V)	–	10	microamps
Capacitance (V = 0,f = 1 MHz)	50	–	picofarads

PHOTO-DARLINGTON	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage–$V_{(BR)CEO}$ (I_C = 10mA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)CBO}$ (I_C = 100μA, I_F = 0)	30	–	–	volts
Breakdown Voltage – $V_{(BR)EBO}$ (I_F = 100μA, I_F = 0)	6	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = 0)	–	5	100	nanoamps
Capacitance (V_{CE} = 10V,f = 1 MHz)	–	6	–	picofarads

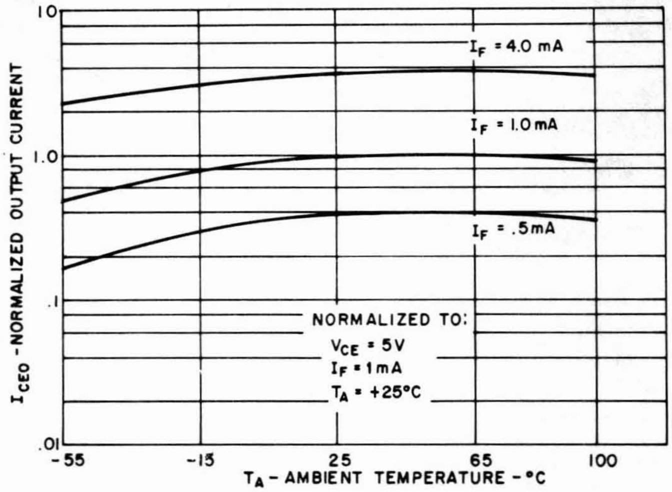
coupled electrical characteristics (25°C)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 1V)	600	–	–	%
Saturation Voltage–Collector to Emitter (I_F = 1mA I_C = 2mA)	–	–	.8	volts
(I_F = 5mA I_C = 10mA)	–	–	.8	volts
(I_F = 10mA, I_C = 60mA)	–	–	1.0	volts
Isolation Resistance (V_{IO} = 500V_{DC})	100	–	–	gigaohms
Input to Output Capacitance (V_{IO} = 0,f = 1MHz)	–	-	2	picofarads
Switching Speeds: (V_{CE} = 10V, I_C = 10mA, R_L = 100Ω) On-Time	–	125	–	microseconds
Off-Time	–	100		microseconds

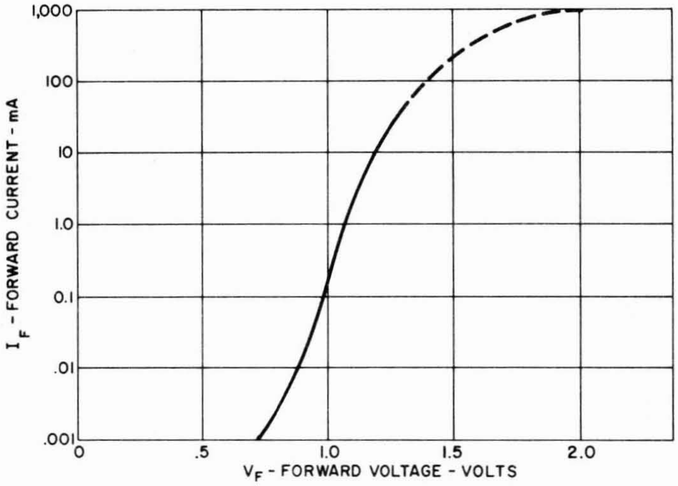
TYPICAL CHARACTERISTICS



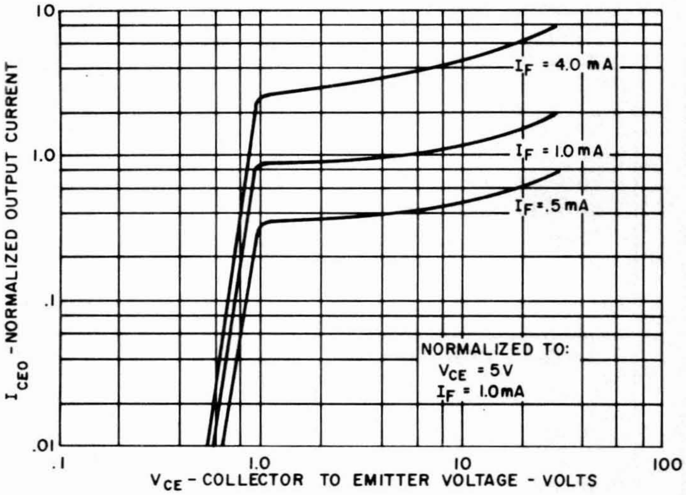
OUTPUT CURRENT VS INPUT CURRENT



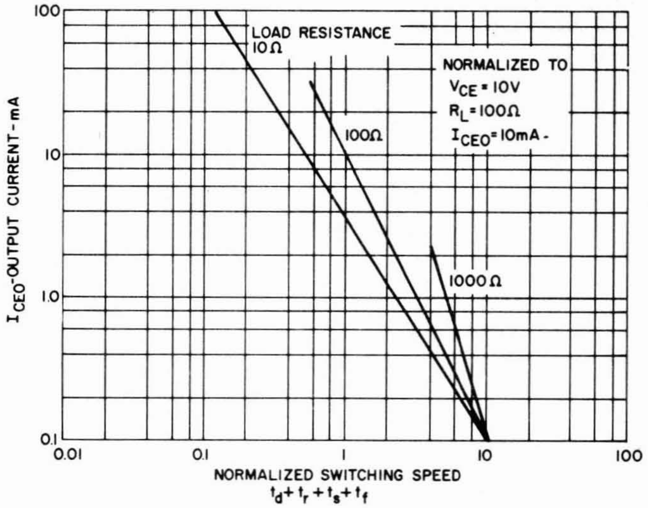
OUTPUT CURRENT VS TEMPERATURE



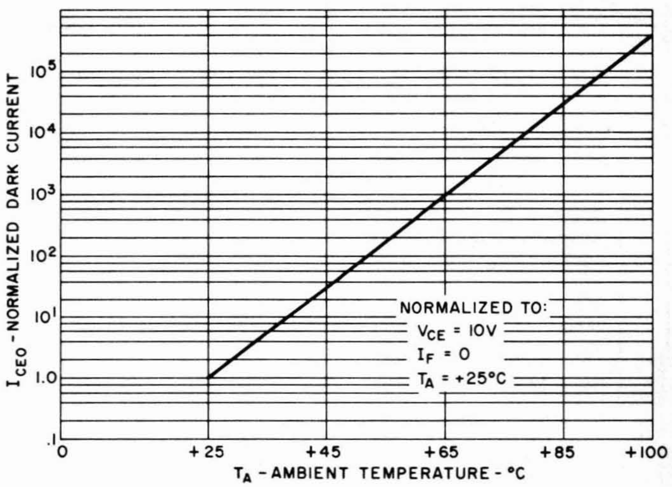
INPUT CHARACTERISTICS



OUTPUT CHARACTERISTICS



SWITCHING SPEED VS OUTPUT CURRENT

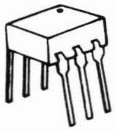


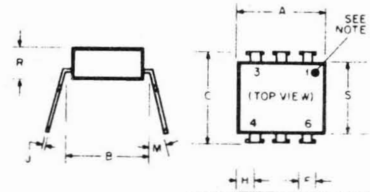
NORMALIZED DARK CURRENT VS TEMPERATURE

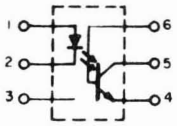
Photon Coupled Isolator CNY51

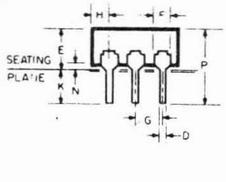
Ga As Infrared Emitting Diode & NPN Silicon Photo-Transistor

The General Electric CNY51 consists of a gallium arsenide, infrared emitting diode coupled with a silicon photo-transistor in a dual in-line package.









FEATURES:

- High isolation voltage, 5000V minimum.
- General Electric unique patented glass isolation construction.
- High efficiency liquid epitaxial IRED.
- High humidiy resistant silicone encapsulation.
- Fast switching speeds.

SYMBOL	INCH MIN	INCH MAX	MILLIMETER MIN.	MILLIMETER MAX	NOTES
A	.330	.350	8.38	8.89	
B	.300	REF	7.62	REF	2
C		.340		8.64	3
D	.016	.020	.406	.508	
E		.200		5.08	4
F	.040	.070	1.01	1.78	
G	.090	.110	2.28	2.79	
H		.085		2.16	5
J	.008	.012	.203	.305	
K	.100		2.54		3
M		15°		15°	
N	.015		.381		3
P		.375		9.53	
R	.100	.185	2.54	.470	
S	.225	.280	5.71	7.12	

NOTES
1 There shall be a permanent indication of terminal orientation in the quadrant adjacent to terminal 1
2 Installed position lead centers
3 Overall installed dimension
4 These measurements are made from the seating plane
5 Four places

Creepage Distance 8.2mm min.
Air Gap 7.6mm min.

absolute maximum ratings: (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE

Power Dissipation – T_A = 25°C	*100	milliwatts
Forward Current (Continuous)	60	milliamps
Forward Current (Peak) (Pulse width 1 μsec, 300 pps)	3	amperes
Reverse Voltage	6	volts

*Derate 1.33mW/°C above 25°C.

PHOTO-TRANSISTOR

Power Dissipation – T_A = 25°C	**300	milliwatts
V_{CEO}	70	volts
V_{CBO}	70	volts
V_{EBO}	7	volts
Collector Current (Continuous)	100	milliamps

**Derate 4.0mW/°C above 25°C.

TOTAL DEVICE

Storage Temperature -55 to 150°C.
Operating Temperature -55 to 100°C.
Lead Soldering Time (at 260°C) 10 seconds.
Surge Isolation Voltage (Input to Output). See Note 2.
5656$V_{(peak)}$ 4000$V_{(RMS)}$
Steady-State Isolation Voltage (Input to Output).
See Note 2.
5000$V_{(DC)}$ 3000$V_{(RMS)}$

individual electrical characteristics (25°C) (unless otherwise specified)

INFRARED EMITTING DIODE	MIN.	MAX.	UNITS
Forward Voltage – V_F (I_F = 60mA)	–	1.65	volts
Forward Voltage – V_F (I_F = 10mA)	.8	1.5	volts
Forward Voltage – V_F (I_F = 10mA) T_A = -55°C	.9	1.7	volts
Forward Voltage – V_F (I_F = 10mA) T_A = +100°C	.7	1.4	volts
Reverse Current – I_R (V_R = 6V)	–	10	microamps
Capacitance – C_J (V = O,f = 1MHz)	–	100	picofarads

PHOTO–TRANSISTOR	MIN.	TYP.	MAX.	UNITS
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 10mA, I_F = O)	70	–	–	volts
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 100μA, I_F = O)	70	–	–	volts
Breakdown Voltage – $V_{(BR)CEO}$ (I_C = 100μA, I_F = O)	7	–	–	volts
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = O)	–	5	50	nano-amps
Collector Dark Current – I_{CEO} (V_{CE} = 10V, I_F = O) T_A = 100° C	–	–	500	micro-amps
Capacitance – C_{CE} (V_{CE} = 10V, f = 1MHz)	–	2	–	pico farads

coupled electrical characteristics (25°C) (unless otherwise specified)

	MIN.	TYP.	MAX.	UNITS
DC Current Transfer Ratio (I_F = 10mA, V_{CE} = 10V) CYN51	100	–	–	%
Saturation Voltage – Collector to Emitter (I_F = 20mA, I_C = 2mA)	–	–	0.4	volts
Isolation Resistance (Input to Output Voltage = 500V_{DC}. See Note 1)	100	–	–	gigaohms
Input to Output Capacitance (Input to Output Voltage = 0, f = 1 MHz. See Note 1)	–	–	2.0	picofarads
Turn-On Time – t_{on} (V_{CC} = 10V, I_C = 2mA, R_L = 100Ω). (See Figure 1)	–	5	10	microseconds
Turn-Off Time – t_{off} (V_{CC} = 10V, I_C = 2mA, R_L = 100Ω). (See Figure 1)	–	5	10	microseconds

NOTE 1:

Tests of input to output isolation current resistance, and capacitance are performed with the input terminals (diode) shorted together and the output terminals (transistor) shorted together.

NOTE 2:

Surge Isolation Voltage

a. Definition:

This rating is used to protect against transient over-voltages generated from switching and lightning-induced surges. Devices shall be capable of withstanding this stress, a minimum of 100 times during its useful life. Ratings shall apply over entire device operating temperature range.

b. Specification Format:

Specification, in terms of peak and/or RMS, 60 Hz voltage, of specified duration (e.g., 5656V_{peak}/4000V_{RMS} for one second).

c. Test Conditions:

Application of full rated 60 Hz sinusoidal voltage for one second, with initial application restricted to zero voltage (i.e., zero phase), from a supply capable of sourcing 5mA at rated voltage.

Steady-State Isolation Voltage

a. Definition:

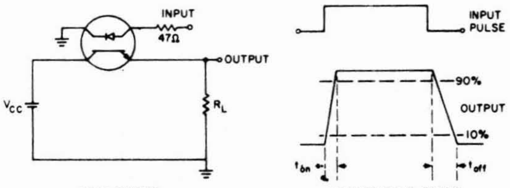
This rating is used to protect against a steady-state voltage which will appear across the device isolation from an electrical source during its useful life. Ratings shall apply over the entire device operating temperature range and shall be verified by a 1000 hour life test.

b. Specification Format:

Specified in terms of D.C. and/or RMS 60 Hz sinusoidal waveform.

c. Test Conditions:

Application of the full rated 60 Hz sinusoidal voltage, with initial application restricted to zero voltage (i.e., zero phase), from a supply capable of sourcing 5mA at rated voltage, for the duration of the test.

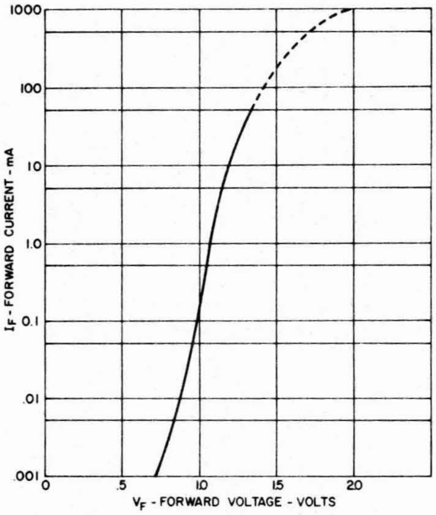


TEST CIRCUIT

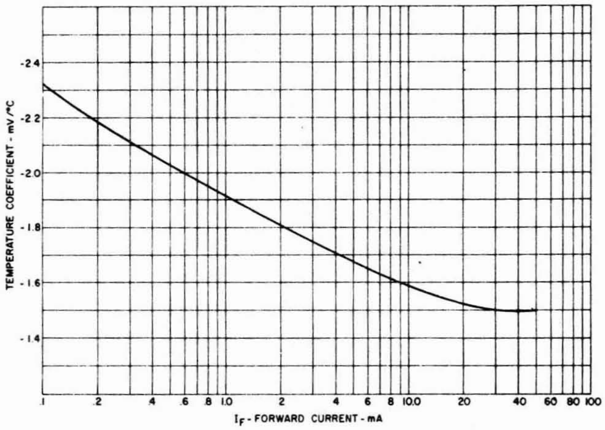
VOLTAGE WAVE FORMS

FIGURE 1: Adjust Amplitude of Input Pulse for Output (I_C) of 2mA

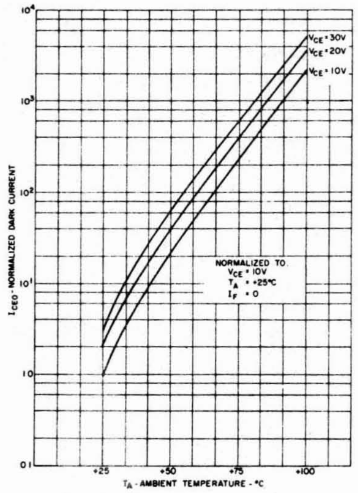
TYPICAL CHARACTERISTICS



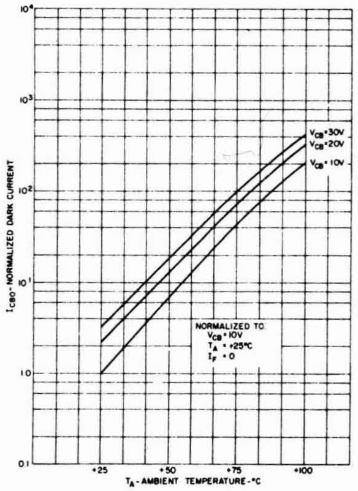
1. INPUT CHARACTERISTICS



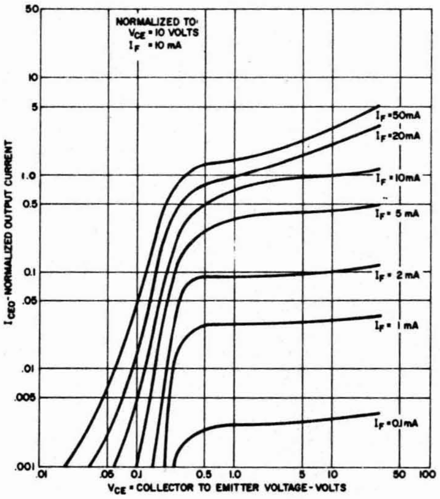
2. FORWARD CURRENT TEMPERATURE COEFFICIENT



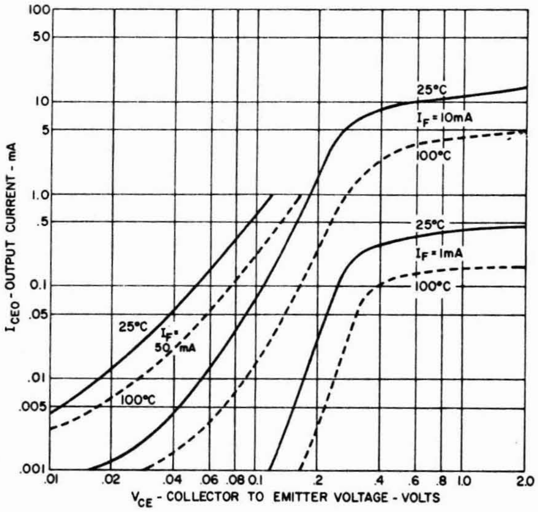
3. DARK I_{CEO} CURRENT VS TEMPERATURE



4. I_{CBO} VS TEMPERATURE

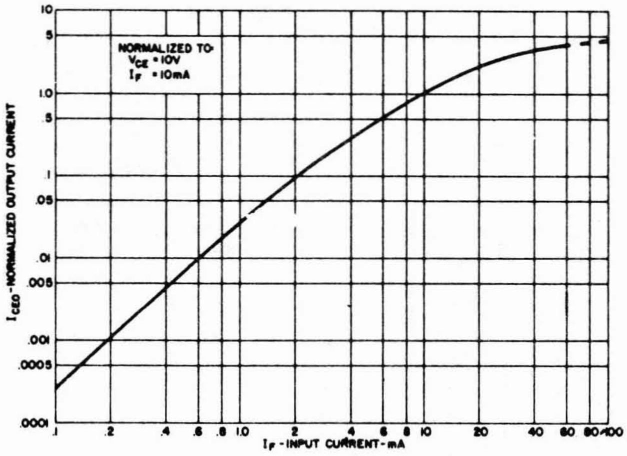


5. OUTPUT CHARACTERISTICS

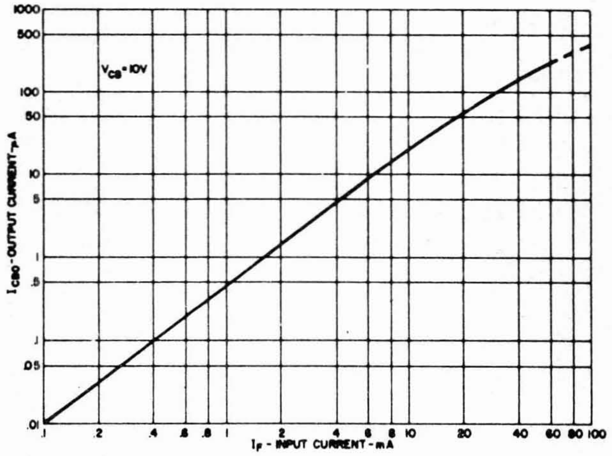


6. OUTPUT CHARACTERISTICS

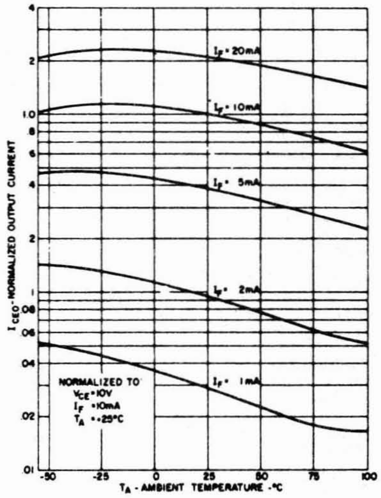
TYPICAL CHARACTERISTICS



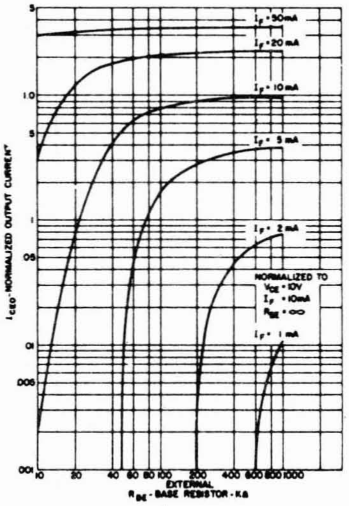
7. OUTPUT CURRENT VS. INPUT CURRENT



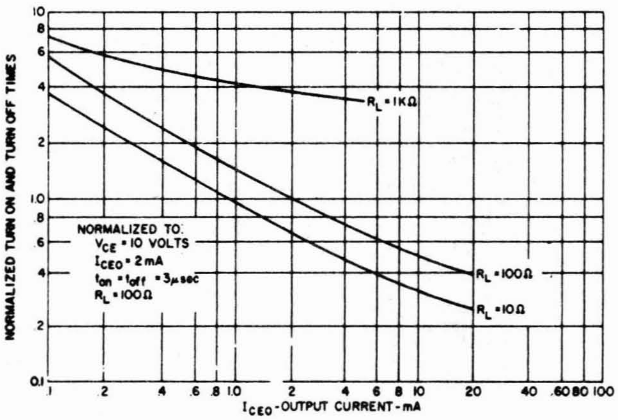
8. OUTPUT CURRENT – COLLECTOR-TO-BASE VS. INPUT CURRENT



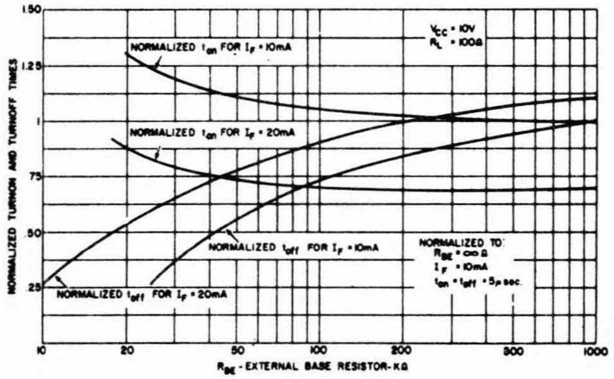
9. OUTPUT CURRENT VS. TEMPERATURE



10. OUTPUT CURRENT VS. BASE EMITTER RESISTANCE



11. SWITCHING TIMES VS. OUTPUT CURRENT



12. SWITCHING TIME VS. R_{BE}

OPTOELECTRONICS CROSS REFERENCE

**The suggested replacements represent what we believe to be equivalents for the products listed. GE assumes no responsibility and does not guarantee that the replacements are exact, but only that the replacements will meet the terms of its applicable published written product warranties. The pertinent GE product specification sheets should be used as the key tool for actual replacements.*

COMPETITIVE TYPE NUMBER	NEAREST GENERAL ELECTRIC PART NUMBER
4N25	4N25
4N25A	4N25A
4N26	4N26
4N27	4N27
4N28	4N28
4N29	4N29
4N30	4N30
4N31	4N31
4N32	4N32
4N33	4N33
4N35	4N35
4N36	4N36
4N37	4N37
4N38	4N38
4N38A	4N38A
4N39	4N39
4N40	4N40
CL100	LED56
CL12	H11A5
CL13	4N37
CLI5	H11A2
CLI10	H11B1
CLI20	H11A2
CLI200	H22A1
CLI25	H11AA1
CLI26	H11AA1
CLI506	H11A4
CLI510	4N37
CLI511	4N37
FCD810	H11A5
FCD810C	H11A520
FCD810D	H11A520
FCD811	H11A3
FCD820	H11A2
FCD820C	H11A520
FCD820D	H11A520
FCD825C	H11A550
FCD825D	H11A550
FCD830C	H11A520
FCD830D	H11A520
FCD831C	H11A520
FCD831D	H11A520
FCD836C	H11A520
FCD836D	H11A520
IL1	H11A3
IL5	H11A1
IL12	H11A5
IL15	H11A5
IL16	H11A5
IL74	H11A5
ILA30	H11B3
ILA55	H11B255
ILCA2-30	H11B3
ILCA2-55	H11B255
MCA8	H13B1
MCA81	H13B2
MCA230	H11B3
MCA231	H11B2
MCA255	H11B255
MCT2	H11A2
MCT2E	H11A3
MCT8	H13A1
MCT26	H11A5
MCT81	H13A2
MCS2	H11C3
MCS2400	H11C6
MOC1000	4N26
MOC1001	4N25
MOC1002	4N27
MOC1003	4N28
MOC1005	H11A520
MOC1006	H11A520
MOC1200	4N30
MRD300	L14G1
MRD310	L14G2
MRD3050	L14G2
MRD3051	L14G2
MRD3052	L14G2
MRD3053	L14G2
MRD3054	L14G2
MRD3055	L14G2
MRD3056	L14G1
NCT200	H11A5

OPTOELECTRONICS CROSS REFERENCE (Continued)

COMPETITIVE TYPE NUMBER	NEAREST GENERAL ELECTRIC PART NUMBER
NCT260	H11A5
OP130	LED56
OP131	LED55B
OP132	LED55C
OP133	LED55C
OPB120	H13A1
OPB242	H13A1
OPB243	H13B1
OPB800	H13A1
OPB800S	H13A1
OPB803	H13B1
OPB806	H13A1
OPB813	H21A1
OPB814	H21A2
OPB815	H21A2
OPI2150	H11A4
OPI2151	H11A4
OPI2152	H11A2
OPI2153	H11A1
OPI2250	H11A3
OPI2251	H11A3
OPI2252	H11A3
OPI2253	H11A1
OPI2500	H11AA2
OPI3150	H11B2
OPI3151	H11B2
OPI3152	H11B3
OPI3153	H11B1
OPI3250	H11B1
OPI3251	H11B1
OPI3252	H11B1
OPI3253	H11B1
OPI6000	H11D2
OPI6100	H11D4
SD5410-1	L14F1
SD5410-2	L14F1
SD5410-3	L14F1
SD5440-1	L14G2
SD5440-2	L14G2
SD5440-3	L14G2
SD5440-4	L14G1
SD5440-5	L14G1
SE3450-1	LED56F
SE3450-2	LED56F
SE3450-3	LED56F
SE3451-1	LED56F
SE3451-2	LED55BF
SE3451-3	LED55CF
SE3453-1	LED56F
SE3453-2	LED56F
SE3453-3	LED55BF
SE3453-4	LED55CF
SE3455-1	LED55BF
SE3455-2	LED55CF
SE5450-1	LED56
SE5450-2	LED56
SE5450-3	LED55B
SE5451-1	LED56
SE5451-2	LED55B
SE5451-3	LED55B
SE5453-1	LED56
SE5453-2	LED55B
SE5453-3	LED55B
SE5453-4	LED55B
SE5455-1	LED55B
SE5455-2	LED55C
SE5455-3	LED55C
SE5455-4	LED55C
SG1009	LED55B
SG1009A	LED55C
SPX2	H11A550
SPX2E	H11A550
SPX4	H11A550
SPX5	H11A550
SPX6	H11A5100
SPX26	H11A520
SPX28	H11A520
SPX35	H11A5100
SPX36	H11A5100
SPX37	H11A5100
SPX1873-1	H13A1
SPX1873-2	H21A1
SPX1873-3	H13B1
SPX1873-4	H21A3
SPX1876-1	H13A1
SPX1876-2	H13A1
SPX1876-3	H13B1
TIL31	LED55B
TIL33	LED55B
TIL34	LED56
TIL81	L14G1
TIL111	H11A4
TIL112	H11A5
TIL113	H11B2
TIL114	H11A3
TIL115	H11A3
TIL116	H11A3
TIL117	H11A1
TIL118	H11A5
TIL119	H11B2
TIL138	H13A1
TIL143	H13A1
TIL144	H13A2
TIL145	H13B1
TIL146	H13B2
TIL147	H22A3
TIL148	H22A1

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320-3031

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Area Code: 716
461-5400

Syracuse 13221
Bldg. 1, Room 227
Electronics Pk.
Area Code: 315
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298-0311

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943-9015

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271-5000

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S.A. General Electric Ltd.
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Ultimo, N.S.W., 2007
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Tel: 537-4481

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Tel: 225-52-32

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International General Electric
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County Louth
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Tel.: 4987224/4986281

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Tokyo, 106 Japan
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General Electric De Mexico, S.A.
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Marina Nacional No. 365
Mexico 17 D.F.
Tel: 545-63-60

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