Tektronix®
COMMITTED TO EXCELLENCE

PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

1502
TIME DOMAIN REFLECTOMETER

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

070-1792-01
Product Group 27

Serial Number _____

First Printing SEP 1975
Revised DEC 1981

Printed in U.S.A. Specification and price change privileges are reserved.

OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

TERMS

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

SYMBOLS

In This Manual

This symbol indicates where applicable cautionary or other information is to be found.

As Marked on Equipment

DANGER — High voltage.

Protective ground (earth) terminal.

ATTENTION — refer to manual.

Power Source

This product is intended to operate from a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Power Cord

Use only the power cord and connector specified for your product.

Use only a power cord that is in good condition.

Refer cord and connector changes to qualified service personnel.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating and current rating as specified in the parts list for your product.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

SPECIFICATION

General Information

The Tektronix 1502 is a portable Time Domain Reflectometer that uses pulses to test cables and provides a visual display of cable faults. The test pulses are transmitted via the CABLE output jack. Reflections are received at the same jack and displayed on the Cathode-Ray Tube (crt).

NOTE

All distances are shown in feet followed by metres in parenthesis. Metric units are not direct conversions from the measurements shown in feet, but represent the calibrated ranges of the metric option 1502.

Calibrated distance controls allow an operator to examine up to 100 feet (25 metres) of cable with segments as small as 1 foot (25 cm) displayed horizontally across the 10-division crt screen. Low-loss cables as long as 2000 feet (500 metres) may be examined at 100 feet (25 metres) per division or 200 feet (50 metres) per division. The horizontal crt scale is calibrated directly in distance units from 0.1 foot (2.5 cm) per division to 200 feet (50 metres) per division in a 1-2-5 sequence (1-2.5-5 sequence).

A 3-digit, direct reading dial indicates the distance to any cable discontinuity when the dial is used to horizontally position the discontinuity's reflection to a crt reference line.

Vertical (Y-axis) deflection of the crt beam is proportional to the amplitude of the reflected signal plus the incident step. The vertical scale is calibrated in units of rho (ρ) of the transmitted pulse amplitude. For a definition of rho, refer to section 2 of this manual. The sensitivity scale can be selected in 7 calibrated steps from 5 mρ/div to 500 mρ/div.

The transmitted pulse is a step-signal having an amplitude of approximately 225 mV. The risetime of the pulse generator and the equivalent bandwidth of the deflection circuits provide a system reflected risetime of 140 ps or less.

The 1502 plug-in compartment will accept either the X-Y OUTPUT MODULE or the TEKTRONIX Y-T Chart Recorder. The X-Y OUTPUT MODULE is a standard accessory for the 1502 and provides an interface for an X-Y recorder. The TEKTRONIX Y-T Chart Recorder is an optional accessory. This recorder uses a heated stylus to record on 4 cm wide, heat-sensitive chart paper. The chart recording length represents the entire crt screen and is controlled by the 1502.

The 1502 is a ruggedized portable instrument that can be used in the field as well as in the laboratory. The requirements for a Type III, Class 3, Style A instrument as specified in MIL-T-28800 were used as a guideline for the environmental specifications. The 1502 has a ruggedized case that provides protection when the instrument is stored in exposed areas. When the instrument is not being used, the accessories, including the Operators manual, may be packed in the instrument cover and latched tightly on the front of the instrument. Table 1-1 indicates which accessories may be placed in the cover of the 1502.

The characteristics given in Table 1-2 apply over an ambient temperature range from −15°C to +55°C after the instrument has been calibrated at +25°C, ±5°C. Under these conditions, the 1502 will perform to the requirements given in the Performance Check section of this manual.

Table 1-1

1502 ACCESSORIES

Accessories stored in the 1502 cover

Accessory	Tektronix Part Number
1 50 Ω BNC Terminator	011-0123-00
1 Precision 50 Ω Cable	012-0482-00
1 Viewing Hood	016-0297-00
1 Operators Manual	070-1790-00
1 BNC Connector, Female-to-Female	103-0028-00
2 Replacement Fuses (for front panel) For 115 V ac Operation or For 230 V ac Operation (Option 6)	159-0113-00 159-0029-00
1 Power Cord	161-0066-00
1 Filter, Mesh (crt)	378-0055-00

Accessories not stored in the 1502 cover

1 TDR Slide Rule	003-0700-00
1 X-Y Output Module	016-0606-00
1 Instruction Manual	070-1792-01

SPECIFICATION

The performance limits in this specification are valid with the following conditions:

The instrument must have been calibrated at an ambient temperature between +20° C and +30° C.

The instrument must have a warmup period of at least 20 minutes.

Table 1-2

ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
Excitation Step Pulse		Cable Dielectric set to AIR
Reflected Rise	≤0.07 feet (≤140 ps) ≤2.1 cm for metric	10% to 90%
Aberrations	±5% peak during 1st 10 feet (300 cm) after rise	
	±0.5% peak beyond 10 feet (300 cm)	Noise Filter "Out"
Jitter	≤0.02 feet (≤40 ps) ≤0.6 cm	Set at X.1 (Cable Dielectric set to AIR)
	≤0.1 feet (≤200 ps) ≤3 cm	Set at X1 (Cable Dielectric set to AIR)
Deflection Factor	5 mρ/div to 500 mρ/div	7 steps, 1-2-5 sequence
Accuracy	Within ±3%	
Gain	At least 3.5:1 from calibrated point	Screwdriver control
Display Noise	±5 mρ or less, NOISE FILTER switch "Out"	Peak
Low Noise Operation	±2 mρ or less, NOISE FILTER switch "In"	Peak
Distance Controls		0 to 2000 feet total
Distance Dial		
At X.1 Multiplier		
Range	0 to 100 feet 0 to 25 metres for metric	
Accuracy	Within ±2% ±0.05 feet Within ±2% ±0.05 metres for metric	from 2nd to 9th graticule lines
At X1 Multiplier		
Range	0 to 1000 feet 0 to 250 metres for metric	
Accuracy	Within ±2% ±0.5 feet Within ±2% ±0.5 metres for metric	from 2nd to 9th graticule lines

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
FEET/DIV Control		
At X.1 Multiplier		
Range	To 20 feet/div To 5 metres/div for metric	
Scales	.1 feet/div to 20 feet/div 0.025 m/div to 5 m/div for metric	8 steps, 1-2-5 sequence 8 steps, 1-2.5-5 sequence
At X1 Multiplier		
Range	To 200 feet/div To 50 metres/div for metric	DISTANCE dial disabled in 200 (FIND) position
Scales	1 foot/div to 200 feet/div 0.25 m/div to 50 m/div for metric	8 steps, 1-2-5 sequence 8 steps, 1-2-5 sequence
Dielectric Scales	SOLID PTFE, $V_p/V_{air} = 0.70$ SOLID POLY, $V_p/V_{air} = 0.66$ OTHER—VAR, $V_p/V_{air} = 0.55$ to 1	$_r = 2.04$ $_r = 2.31$ VAR is calibrated for air when turned to full cw position. All buttons released causes default mode and is cal. for air
Accuracy	Within ±2%	
External Recorder Interface for X-Y Recorders		
Horizontal	0.1 V/div	Source impedance 10 kΩ
Vertical	0.09 to 0.13 V/div (adjustable)	Source impedance 10 kΩ
Pen Lift		
Mode 1		
Source	$V_s = 5$ V Nominal with $R_s = 10$ kΩ	
Mode 2 (inverted Mode 1)		
Source	$V_s = 5$ V Nominal with $R_s = 10$ kΩ	
Y-T Plug-in Chart Recorder Interface		
Horizontal	0.4 V/div	Source impedance 200 Ω (switched)
Vertical	0.2 V/div	Source impedance 200 Ω (switched) The TEKTRONIX Chart Recorder, 016-0506-03 is designed to operate with the 1502. The chart uses a heat sensitive stylus to record on 4 cm chart paper. Chart recording length is controlled by the 1502.

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
Line Voltage	117 Vac ±20%, 48 to 410 Hz 234 Vac ±20%, 48 to 410 Hz	Fused at 0.5 A Fused at 0.3 A
Battery Pack		C size 9 cell
Operation	At least 5 hours	+20°C to +25°C charge and discharge temperature
Full Charge Time		16 hours
Typical Charge Capacity		
Charge Temperature		Discharge Temperature
		−15°C / +20°C to +25°C / +55°C
0°C		40% / 60% / 50%
+20°C to +25°C		65% / 100% / 85%
+40°C		40% / 65% / 55%
Temperature		
Operating	−15°C to +55°C	At temperatures other than 20°C—25°C, the battery efficiency becomes restricted
Non-Operating	−62°C to +85°C	With batteries removed. If stored with batteries storage range changed to −40°C to +55°C
Humidity	To 100%	
Altitude		
Operating	10,000 feet	
Non-Operating	50,000 feet	
Vibration	3.0 g, 5 to 55 Hz; Test time 45 minutes	
Shock, Mechanical		
Shock, Pulse	15 g, 1/2 sine shock waveform of 11 ms duration. Total of 18 shocks	
Bench Handling		
Operating	4 drops each fact at 4 inches or 45° with opposite edge as pivot	Case on
Non-Operating	4 drops each face at 4 inches or 45° with opposite edge as pivot. Satisfactory operation after drops.	Case off
Transit Drop	12 inch drop	

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
Water Resistance		
Operating	Splashproof and drip proof with cover off and instrument operating	
Non-Operating	Watertight with three feet of water above top of the case	Cover on
Salt Atmosphere		
Structural Parts	Withstand 48 hours exposure to 20% solution without corroding	
Explosive Atmosphere	Operation does not cause ignition of an ambient-explosive-gaseous mixture with air	
Sand and Dust	Operates after non-operating, cover removed, exposure to dust test of MIL-STD-810, Method 510, Proc. I	
Washability	Capable of being washed	
Electromagnetic Compatability		
Electromagnetic Interference (EMI)	Meets requirements specified in Table X of MIL-T-28800A	
Magnetic Environment		
DC	Performs satisfactorily when 20 oersted dc applied	
AC	Performs satisfactorily when 5 oersted RMS ac applied	
Fungus Inert	Materials used are fungus inert	
Weight		
With Panel Cover and Accessories	18 pounds (8.2 kg)	
Without Panel Cover and Accessories	16.0 pounds (7.3 kg)	
Domestic Shipping Weight	24.4 pounds (11.1 kg)	
Export Shipping Weight	Approximately 36.0 pounds (16.4 kg)	
Height	5.0 inches (12.7 cm)	
Width		
With Handle	12.4 inches (31.5 cm)	
Without Handle	11.8 inches (29.9 cm)	

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
Depth		
Including Panel Cover	16.5 inches (41.9 cm)	
Handle Extended	18.7 inches (47.4 cm)	

OPERATING INSTRUCTIONS

This section of the manual contains the basic information required for the operation of the 1502 Time Domain Reflectometer. Included is a brief description of the purpose of each front panel control, general operating information, care of the instrument, and basic applications.

FRONT COVER AND HANDLE

The watertight front cover protects the front panel when the instrument is not in use and the cover is latched in place. Standard accessories stored in the cover are indicated on the storage compartment lid. Special operating instructions and cautions are printed on the lid. These cautions should be followed at all times to avoid damage to the instrument.

The cover is released from the unit by pulling forward on the side latches. To secure the cover over the front panel, place the cover into the grooved portion of the front panel and push the latches backwards toward the instrument. If the unit is accidentally left on, it will be turned off when the cover is secured over the front panel.

The handle is a friction disc design and will rotate 325°. When the handle is turned so that it is beneath the unit, it will serve as a stand (see Fig. 2-1).

POWERING THE 1502

This equipment has a 3-wire power cord with a 3-contact plug for connection to the power source and to protective ground. The plug protective-ground contact connects (through the cord protective-grounding conductor) to the accessible metal parts of the equipment. For electric-shock protection, insert this plug into a socket outlet that has a securely grounded protective-ground contact.

CAUTION

Do not operate or charge the battery in the 1502 from an inverter that produces a square wave output. It can damage the instrument.

For confirmation that the socket-outlet ground contact is securely grounded, refer to qualified service personnel.

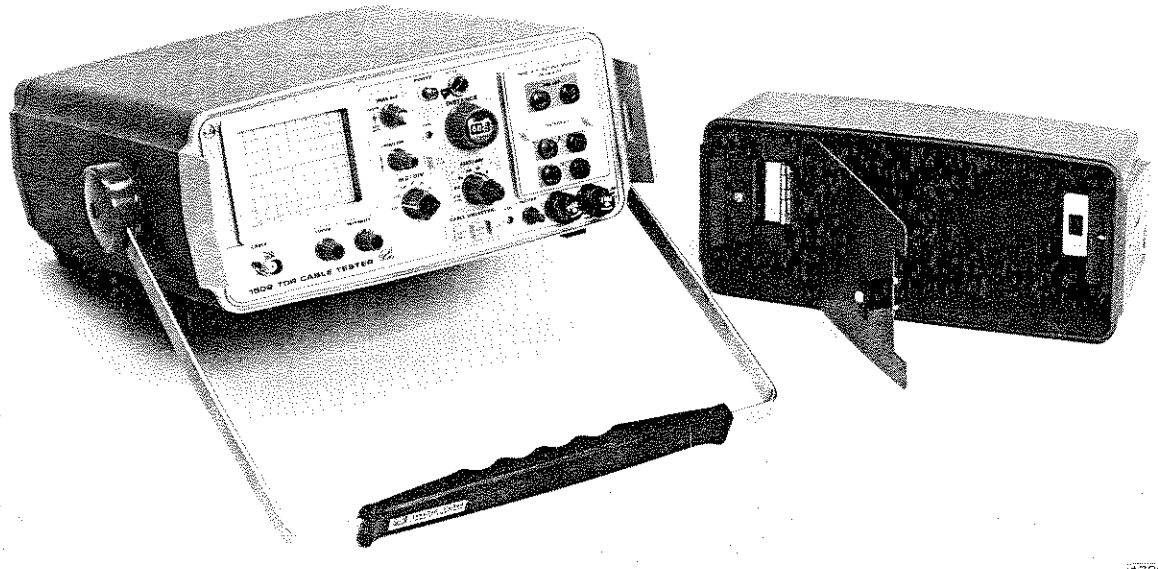


Fig. 2-1. 1502 TDR with Cover.

The 1502 operates from the battery supply for a minimum of 5 hours (including 20 chart recordings). If a TEKTRONIX Y-T Chart Recorder is used, the 5 hours operating time will decrease by about 3 minutes for each recording made beyond the 20 specified.

Charging the Battery

The battery pack can be charged at any temperature between 0°C and +40°C. It can be operated at any temperature between −20°C and +55°C. For maximum charge capacity, the cells should be charged at +20°C to +25°C.

The battery pack is fully charged in 16 hours when connected to an ac power source and the unit is switched off. The 1502 may be operated while the battery pack is charging, however, the charging time will increase. The batteries will not overcharge if the charger is left on longer than 16 hours. The 1502 can remain connected to an ac source without damaging the batteries. Approximately once a month or every 15 charge-discharge cycles, the batteries should be charged for approximately 24 hours. Approximately 30 minutes of operating time can be expected from a 1 hour partial charge. To avoid reverse charging, the full 16 hour charge should be completed in preference to a partial charge cycle whenever possible.

A battery can be damaged by reverse charging. This can occur if an individual cell becomes completely discharged and the current from the other cells flow in a reverse direction through the discharged cell. Such a case can develop due to cell aging, partial charging, or if a cell is replaced. The battery charger uses SCR protection circuits to prevent accidental reverse charging. The SCR protection circuits automatically shut off the instrument whenever battery voltage falls below about 10 V.

CAUTION

When the Anti-Deep-Discharge circuit is operating, the voltage circuits are turned off, but there is still a small amount of current drawn from the batteries. This will further discharge the batteries (at a slower rate) if the POWER switch is not turned off.

A 12 V dc power supply may be substituted for the 1502 battery pack by removing the pack from the unit and connecting the power supply to the terminals inside the battery pack compartment.

CAUTION

When substituting a dc power supply or external battery for the battery pack, be sure the polarity is correct. See Fig. 2-2.

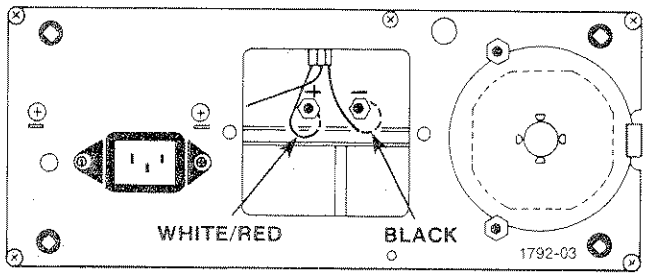


Fig. 2-2. Battery Connector Polarity.

The power pack can be stored at any temperature between −40°C and +50°C with the battery cells either fully or partially charged. The self-discharge rate of the cells increases with increased temperature. A fully charged battery will lose about 50% of its charge in 3 to 4 months if stored at +20°C to +25°C. Therefore, the battery pack should be completely recharged before using if it has been stored without power supplied to its charging circuit for more than a month.

FRONT PANEL CONTROLS AND CONNECTORS

A brief description of the purpose of each front panel connector, pushbutton, control, and screwdriver adjustment follows. A description of the controls of the plug-in modules is also included. Refer to Fig. 2-3 for their location.

1. CABLE	BNC Connector—delivers pulse to the test cable and receives the reflected return pulse.
2. FOCUS	Adjusts the focus of the crt electron beam.
3. INTENSITY	Controls the brightness of crt display.
4. POSITION/FINE	Vertical position control of the crt display. The outer control is a course adjustment and the inner control is a fine adjustment.
5. mρ/DIV	Selects the vertical deflection factor—5 mρ/div to 500 mρ/div (5-2-1 sequence).
6. POWER	Push-off, pull-on switch —does not affect the battery charging circuit.

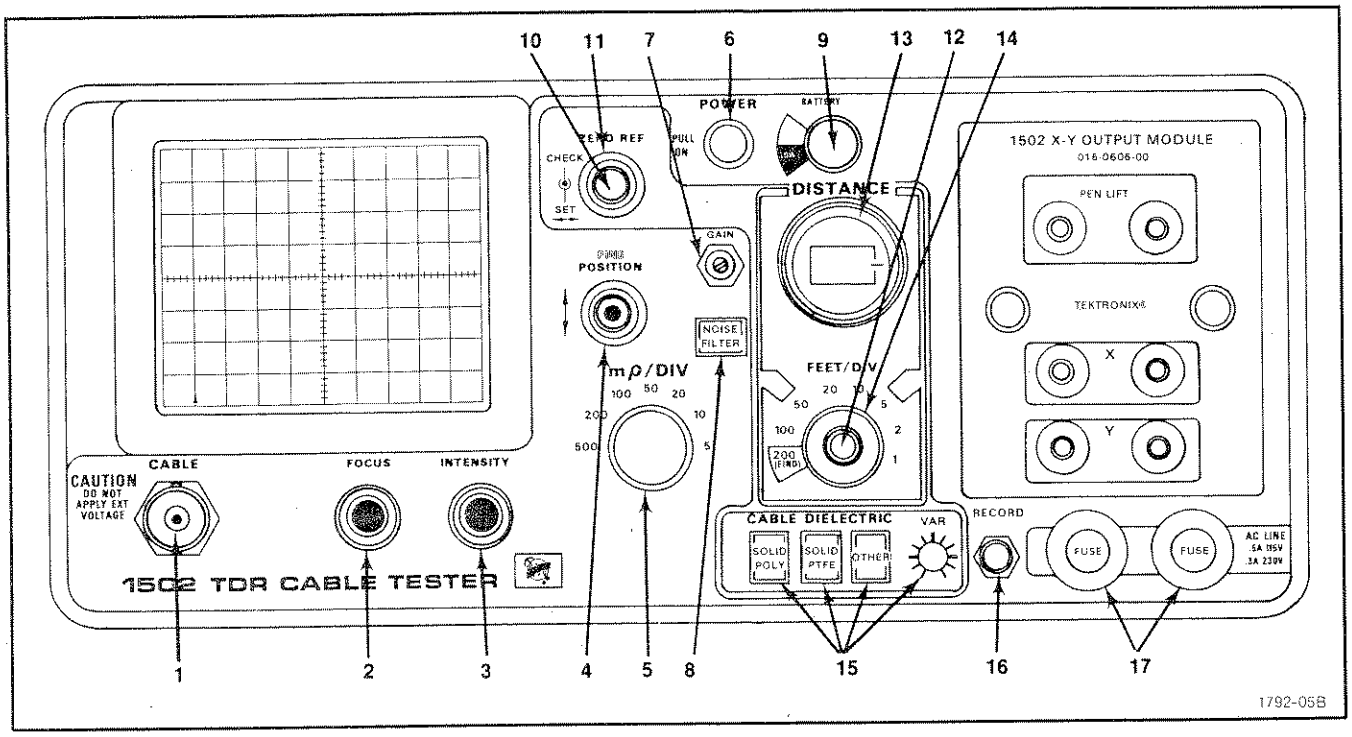


Fig. 2-3. 1502 Front Panel Controls.

7. GAIN — Screwdriver adjust to set the gain of the vertical amplifier.

8. NOISE FILTER — Reduces displayed noise. Display rate is reduced by a factor of 10.

9. BATTERY — Meter to indicate the relative charge of the power pack.

10. ZERO REF CHECK — Momentary contact pushbutton. When pushed, checks the horizontal location of the incident pulse on the crt when the DISTANCE dial is being used.

11. ZERO REF SET — Horizontal pulse position control for crt display. Sets the incident pulse edge to a vertical reference line of the crt when the DISTANCE dial is at 000 or the ZERO REF CHECK button is pushed.

12. MULTIPLIER — Two-position switch (red control) for X.1 or X1 multiplier. Affects both the DISTANCE dial and the FEET/DIV (METRES/DIV) control.

13. DISTANCE — Indicates the distance from the 1502 to the point on the cable where the display window begins. Two ranges: 100 feet (25 m) at X.1 or 1000 feet (250 m) at X1. Disabled when the FEET/DIV (METRES/DIV) is at 200 (FIND) (50).

14. FEET/DIV (METRES/DIV) — Selects the horizontal deflection factor:

X1 = 1 — 200 ft/div (25 cm — 50 m/div).

X.1 = 0.1 — 20 ft/div (2.5 cm — 5 m/div).

15. CABLE DIELECTRIC
SOLID POLY
SOLID PTFE
OTHER VAR — Three pushbuttons and a screwdriver adjust. Selects the proper velocity of propagation. VAR from 0.55 to 1.0 when the OTHER pushbutton is pressed. Fully CW is for air dielectric. VAR control has reference marks every 30° to indicate relative propagation constants.

16. RECORD — Two-position lever switch; pushed up and then released, it initiates X-Y recorder or a chart recorder.

17. AC LINE FUSES — Protection fuses for line power and battery charging circuits (0.5 A fuses for 115 V ac; 0.3 A fuses for 230 V ac).

PLUG-IN Controls and Connectors

1. X-Y OUTPUT MODULE — The standard plug-in module for the 1502. Used to drive an external X-Y Chart Recorder.

   X, Y, and PEN LIFT — Six front panel jacks used for driving an external X-Y recorder. X jacks are for horizontal drive. Y jacks are for vertical drive. PEN LIFT jacks are for pen control.

2. Y-T CHART RECORDER — An optional TEKTRONIX Y-T Chart Recorder which replaces the X-Y OUTPUT MODULE.

OPERATIONAL CHECKOUT

To check the operation of the 1502, follow these step-by-step procedures:

1. Preset the front panel controls as follows:

FOCUS	Midrange
INTENSITY	Midrange
ZERO REF	Fully cw
POSITION	Midrange
mρ/DIV	500
DISTANCE	000
FEET/DIV	1
(METRES/DIV)	(.25)
X1 - X.1	X1
CABLE DIELECTRIC	SOLID POLY

2. Adjust the INTENSITY and FOCUS controls for a clear bright trace.

3. Adjust the POSITION controls to set the trace 2 divisions below the horizontal centerline.

4. Attach the precision 50 Ω cable (012-0482-00) to the CABLE connector.

5. Turn the ZERO REF SET button ccw until the incident pulse edge is located on a vertical reference line. The incident pluse edge is the initial rise of the step pulse. The vertical reference line may be any line you choose from the center line to the left side of the crt graticule. We have added an arrow in the second vertical line to indicate a commonly used reference line.

The reflected pulse from the open end of the 50 Ω cable should appear 3 horizontal divisions to the right of the reference line in the non-metric version only. The open end of the cable is indicated by the start of a second rise in the trace (see Fig. 2-4).

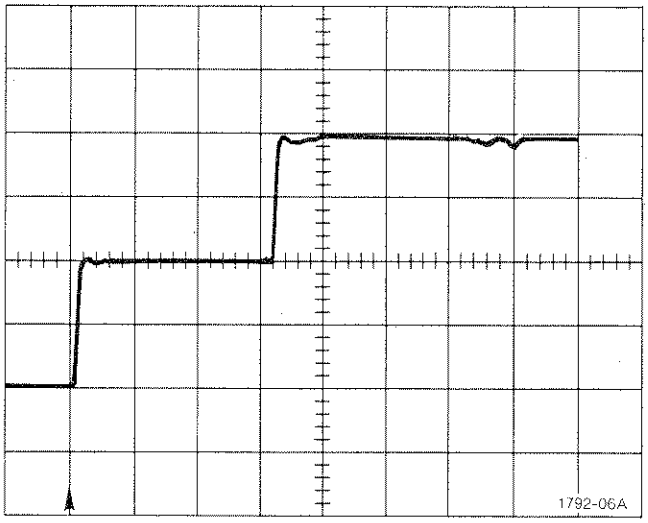


Fig. 2-4. Incident and Reflected Pulses.

6. Turn the ZERO REF SET control throughout its range to see the incident pulse edge can be set on any vertical graticule line. Set the incident pulse edge on the vertical reference line.

7. Set the DISTANCE dial to 050 and check that the top of the step (open cable reflection) is displayed.

8. Press the ZERO REF CHECK button and check that the incident pulse edge returns to the vertical reference line of the graticule. Reset the DISTANCE dial to 000.

9. Change mρ/DIV to 50 and adjust the POSITION controls so the top of the incident pulse is on the horizontal centerline.

10. Press the NOISE FILTER Pushbutton and check for a reduction in the displayed noise as well as a reduction in the scan rate. Reset mρ/DIV to 500, and release (by depressing a second time) the NOISE FILTER button.

11. Lift up and hold the RECORD switch. Check that a bright spot appears at the left edge of the crt.

12. Release the RECORD switch. The slow scan of the spot will trace the displayed waveform. When the scan is complete. The 1502 will automatically return to its normal mode of scanning.

CONNECTING A TEST CABLE TO THE 1502

CAUTION

Do not connect live circuit cables to the input of the 1502. Voltages in excess of 5 V can damage the sampling gate or tunnel diode. If both the sampling bridge and tunnel diodes are destroyed at the same time, an improper use is indicated. If such simultaneous damage occurs, repair charges will be assessed to the customer regardless of the equipment warranty period.

Bleeding of cables before connecting them to the 1502 will remove static charge from them. The 50 Ω termination and BNC adapter supplied may be used to bleed any cable charge.

When testing antennas, be sure that you are not close to transmitters that can be keyed at the antennas receiving frequency. Keying of transmitters in close proximity can cause damage to the 1502.

Connect cables to be tested by the 1502 to the BNC connector (CABLE) on the front panel. Table 2-1 lists optional connectors/adapters that can be used with the 1502.

Table 2-1

OPTIONAL CONNECTORS/ADAPTERS FOR THE 1502

Type	Tektronix Part Number
Terminator, 75 Ω BNC	011-0102-00
Adapter, 50 to 125 Ω	017-0090-00
Adapter, 50 to 75 Ω	017-0091-00
Adapter, 50 to 93 Ω	017-0092-00
BNC Connector, Female to Clip Leads	013-0076-00
BNC Connector, Female to GR	017-0063-00
BNC Connector, Male to GR	017-0064-00
BNC Connector, Female to UHF Male	103-0015-00
BNC Connector, Male to UHF Female	103-0032-00
BNC Connector, Male to Dual Binding Post	103-0035-00
BNC Connector, Female to N Male	103-0045-00
BNC Connector, Male to N Female	103-0058-00
BNC Connector, Female to Dual Banana Jack	103-0090-00
BNC Connector, Male to Male	103-0029-00

LOCATING A DISCONTINUITY IN A CABLE

The DISTANCE dial and the FEET/DIV (METRES/DIV) control make it possible to evaluate cables as long as 2000 feet (500 metres). The entire length can be displayed directly on the crt if desired. If a chart recorder is used, only that portion of the trace seen on the crt will be recorded on the graph.

To check cables using only the crt display, the FEET/DIV (METRES/DIV) control and the X1/X.1 control must be set so that the crt display window is longer than the cable. For example, if the cable is 150 feet (46 m) long, set the FEET/DIV (METRES/DIV) to 200 (50) and the multiplier at X.1.

NOTE

Use the X.1 multiplier whenever possible to lessen the effects of jitter.

This setting of the FEET/DIV (METRES/DIV) control ensures that the reflected signal will appear in the display window. Measure the distance between the incident pulse rise and the reflected pulse rise.

NOTE

The distance from the sampling bridge to the CABLE connector (2.5 inches or 6.35 cm) should be taken into account when measuring cables less than 2 feet (50 cm) in length.

To more accurately locate the discontinuity, set the FEET/DIV (METRES/DIV) control to a lower setting. (The reflected pulse does not need to be in the display window). Push the ZERO REF CHECK button and adjust the ZERO REF SET control so that the incident pulse rise is set at a convenient vertical reference graticule line. The ZERO REF SET control may have to be readjusted when changing the FEET/DIV (METRES/DIV) control.

NOTE

Always set the incident and reflected pulse to the 10% points of their amplitude (see Fig. 2-5).

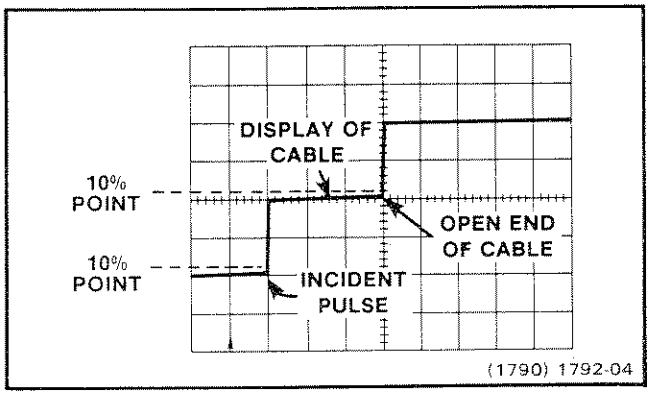


Fig. 2-5. CRT Display of Pulse.

Now turn the DISTANCE dial clockwise until the reflected pulse is located on the reference graticule line. The reading on the DISTANCE dial times the multiplier gives the length from the CABLE connector to the end of the cable (or to the discontinuity).

NOTE

When checking cables longer than 1000 feet (250 metres), adjust the DISTANCE dial until the reflected pulse reaches the right-hand edge of the graticule, then add the graticule display distance to that on the DISTANCE dial for the total length. The reading of the DISTANCE dial, plus the number of divisions (from the reference line) across the graticule times the FEET/DIV (METRES/DIV) setting gives the total length of the cable. Remember that in the 200 FEET/DIV (50 METRES/DIV) setting the DISTANCE dial is inoperative.

The CABLE DIELECTRIC pushbuttons allow the 1502 to accurately locate discontinuities in cables of various relative propagation velocity constant (V_p). The SOLID POLY button is calibrated to check solid polyethylene dielectrics, which have a V_p of 0.66. the SOLID PTFE button is calibrated to check solid polytetrafluoroethylene (Teflon), which has a V_p of 0.70. The OTHER button is variable from 0.55 to 1.00 and is controlled by the screwdriver adjustment control VAR. When this screwdriver control is turned to the fully clockwise position, it is calibrated for air dielectrics, which have a V_p of 1.00. If all three of the CABLE DIELECTRIC buttons are released, a default condition leaves the instrument calibrated for air dielectric ($V_p = 1.00$).

EVALUATING A DISCONTINUITY

The mρ/DIV control determines the vertical deflection that can be seen on the crt or recorded on a graph if a chart recorder is used. This control is calibrated to measure the ratio of the reflected signal amplitude to the incident signal amplitude in rho (ρ), which is called the voltage reflection coefficient. Rho (ρ) is the measurement of reflected signal amplitude and can be used to determine the impedance of a discontinuity. Note that no reflection is obtained from a cable that has no discontinuities if the cable is terminated with its characteristic impedance. If a cable has an open, i.e., a break (infinite impedance), the reflected step amplitude is $+1\ \rho$; and if a cable has a short (zero impedance), the reflected step amplitude is $-1\ \rho$.

Fig. 2-6 shows the two parts of a TDR display labeled to identify the incident and reflected voltage signals. When $\rho=0$, the transmission line is terminated by a resistance equal to its characteristic impedance (Z_0) which, in this case, is 50 Ω. When ρ equals +1, the transmission line load is an open circuit. When ρ equals −1, the transmission line load is a short. If the line is terminated by $R_L > 50\ \Omega$, ρ is positive and if the line is terminated by $R_L < 50\ \Omega$, ρ is negative.

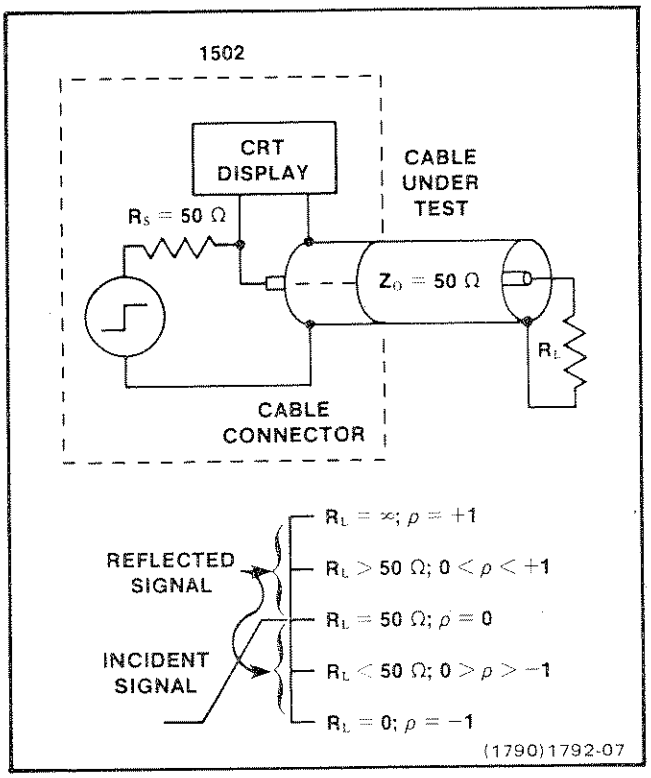


Fig. 2-6. TDR Display of R_L vs Z_0.

Fig. 2-7 is a chart for converting reflected pulse amplitude to impedance. Rho is dependent on the characteristic impedance, Z_0, of the cable under test and the load (or the impedance of the discontinuity), R_L, on the cable. Therefore, ρ can also be defined as:

$$\rho = \frac{R_L - Z_0}{R_L + Z_0}$$

This relationship was used to develop the chart shown in Fig. 2-7.

TYPICAL CABLE PROBLEMS

A few of the cable problems that can be analyzed with the 1502 include opens, shorts, pin-holes in the cable shield, opens in the shield, kinks in the cable, mismatched connectors, and corroded connectors. Figures 2-8 through 2-11 show typical examples of these problems.

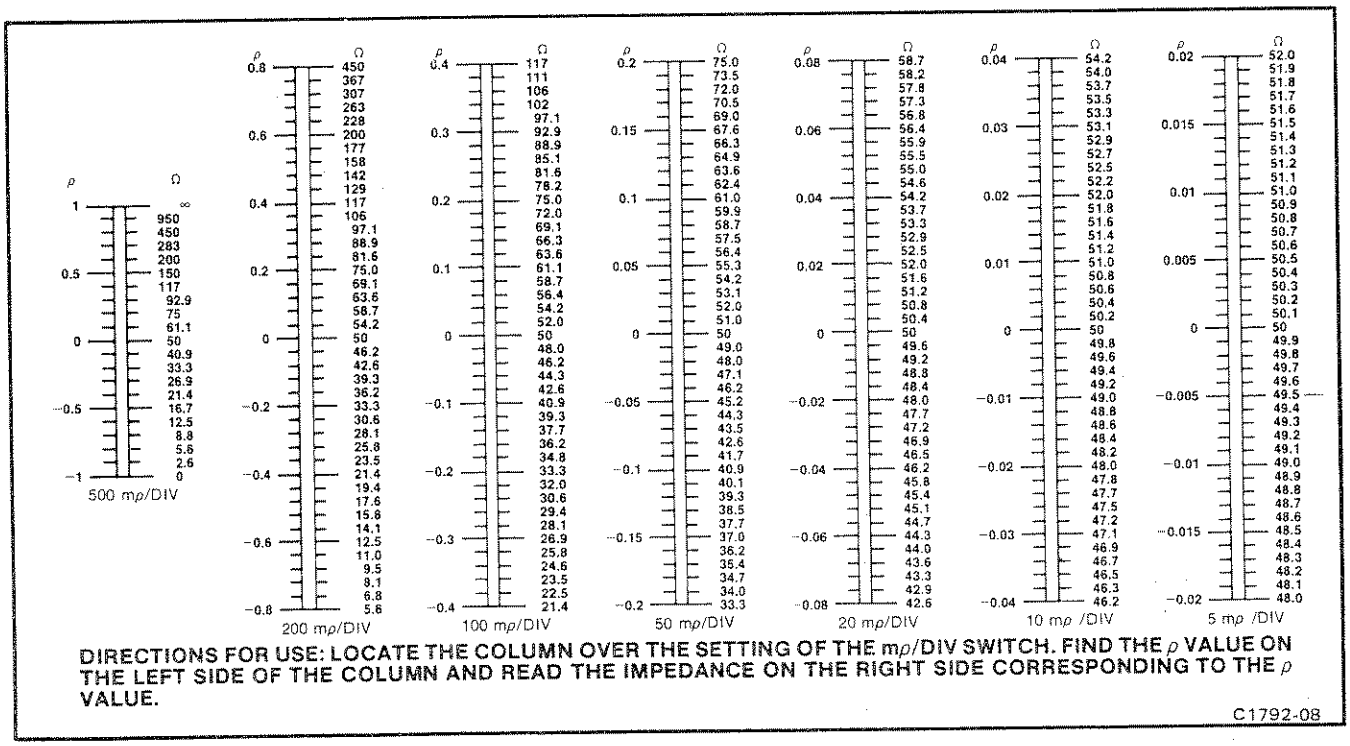
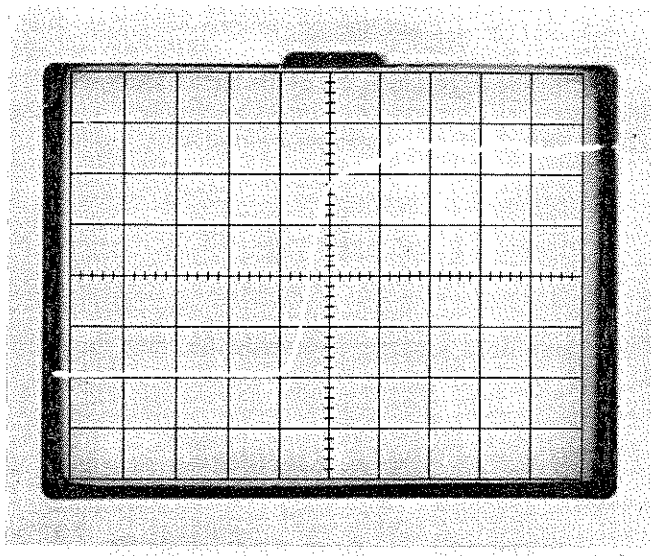
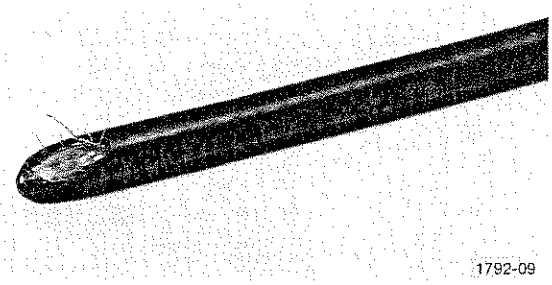


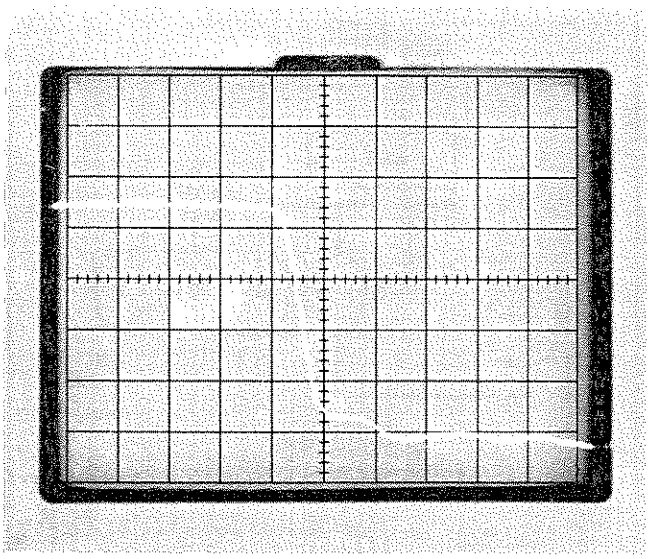
Fig. 2-7. Impedance Nomograph.

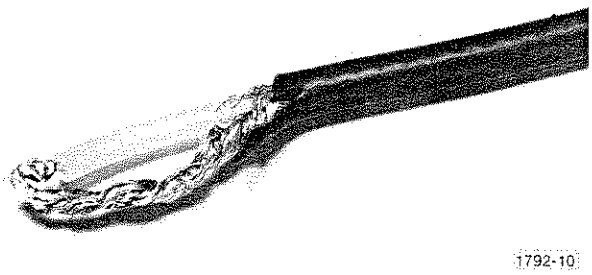




1792-09

Fig. 2-8. Open Cable.





1792-10

Fig. 2-9. Shorted Cable.

CHECKING CABLES WITH IMPEDANCE OTHER THAN 50 Ω

Cables with a characteristic impedance other than 50 Ω can be evaluated by adjusting the GAIN control (screwdriver adjust) to correct the reflected pulse for +1 ρ at the open end of a cable. When the GAIN is changed, the incident pulse will no longer be 1 ρ.

To reset the GAIN for an impedance other than 50 Ω, either connect an impedance-matching adapter (50 to 75 Ω, 50 to 93 Ω, 50 to 125 Ω, etc) to the CABLE connector and connect a short length of cable (with impedance the same as the adapter, i.e., 75 Ω, 93 Ω, 125 Ω, etc.) to the adapter or connect the cable to be tested to the CABLE connector. With the mρ/DIV control set at 500, position the trace on the graticule so that the display of the cable appears in the display. Now adjust the GAIN control so that the open end display (reflected pulse) is set 2 divisions above the cable display (horizontal centerline). This sets the reflected pulse to +1ρ from the characteristic impedance.

NOTE

If an impedance adapter is not used, secondary reflections will re-appear as discontinuities beyond the open end of the cable.

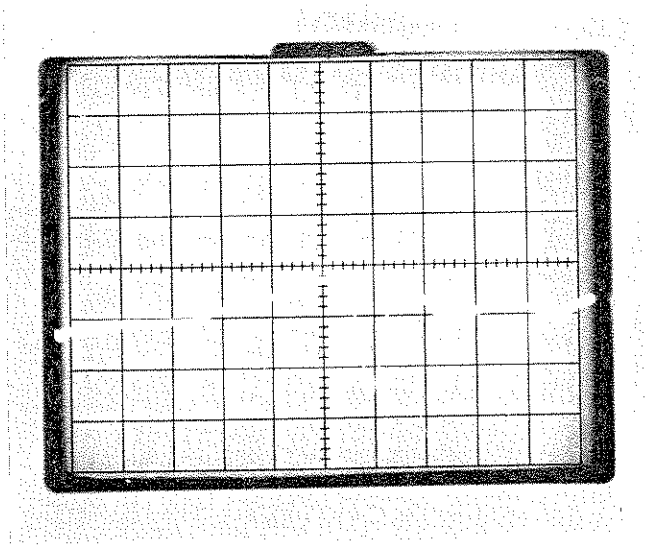
1502 ACCESSORIES

Plug-Ins

The 1502 plug-in compartment will accept the X-Y OUTPUT MODULE (provided as a standard accessory) or the TEKTRONIX Y-T Chart Recorder (part number 016-0506-03).

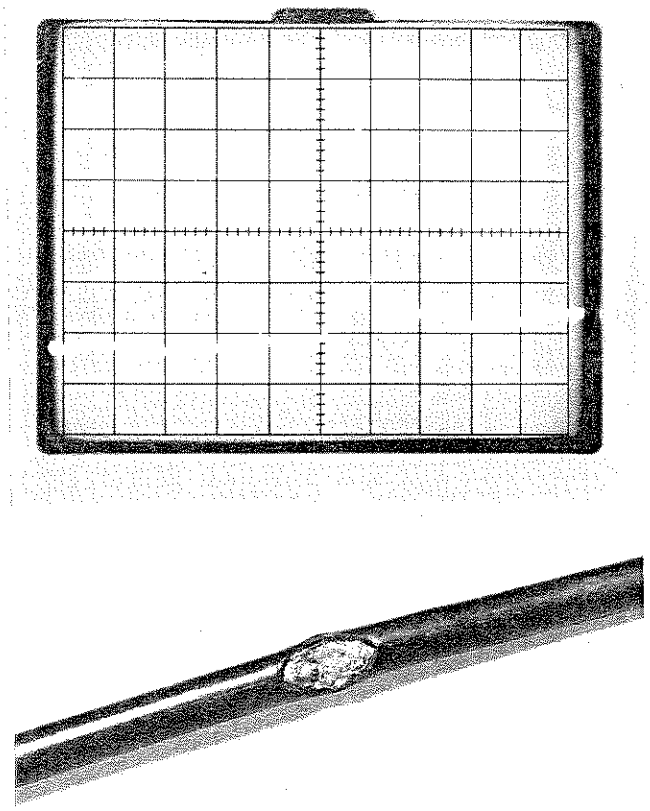
Using an X-Y Recorder

The X-Y OUTPUT MODULE is wired for either a positive or negative pen lift signal. Before using the X-Y OUTPUT MODULE, be sure that the pen lift circuit on the etched circuit board is properly connected. Fig. 2-12 shows the proper connection for either a positive or negative pen lift signal.



1792-11

Fig. 2-10. Crimped Cable.



1792-12

Fig. 2-11. Frayed Cable.

An X-Y recorder can be used with the 1502 by connecting it to the X-Y OUTPUT MODULE when this module is plugged into the 1502. Connect the X, Y, and PEN LIFT inputs of the recorder to the corresponding jacks of the X-Y OUTPUT MODULE. See the information or manual provided with the recorder for further information on its use.

Mesh Filter for the crt

A mesh filter is provided with the 1502, which makes viewing of the crt easier when the unit is being used in the sunlight. This filter is placed over the crt by sliding it onto the slots of the crt bezel.

Viewing Hood

The viewing hood provides shading for the crt and can be installed over the crt by sliding it down over the crt bezel sides. The mesh filter must be removed before the viewing hood will connect it to the crt bezel.

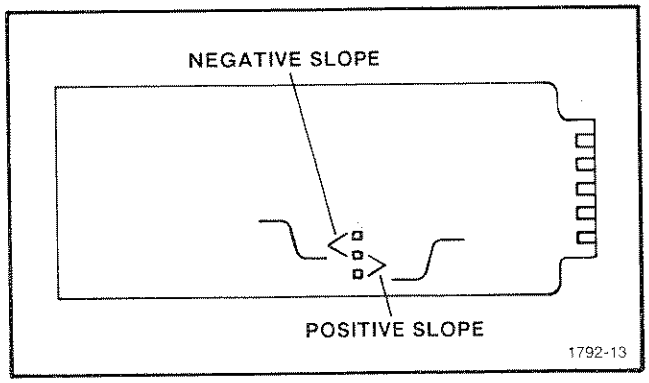


Fig. 2-12. X-Y Output Module Strap.

Using a Camera with the 1502

If a Camera Adapter (Tektronix Part Number 016-0327-01) is attached to the crt bezel of the 1502, A C-30B/31B camera can be used to take photographs of the crt display.

Nominal C-30B/31B camera settings are:

f/stop	5.6-11
time	1 sec
magnification	1.2 (fixed at 0.5 in C31B)
focus as necessary	

INSTRUMENT STORAGE

The 1502 has been made with a ruggedized case that will provide protection when stored in exposed areas. When the instrument is not being used, the accessories (including the Operators manual) should be packed in the instrument cover and the cover latched on the front of the instrument.

The 1502 can be stored in temperatures between −62° C and +85° C, but if the temperature is below −40° C or exceeds +55° C, the batteries must be removed and stored in a location where the temperature is between −40° C and +55° C.