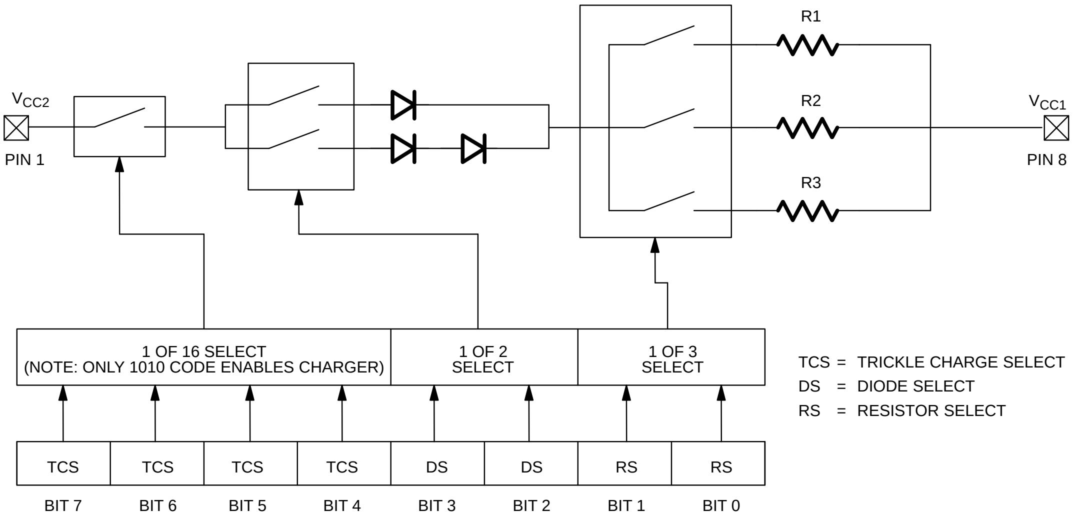
DALLAS SEMICONDUCTOR

Application Note 82
Using the Dallas Trickle Charge Timekeeper

DESCRIPTION
The Dallas Semiconductor DS1302 Trickle Charge Timekeeping Chip is a programmable 3–wire serial interface clock with a trickle charge circuit for using both rechargeable and non–rechargeable backup supplies. The real time clock/calendar provides seconds, minutes, hours, day, date, month, year information. The end of the month date is automatically adjusted for months with less than 31 days, including corrections for leap year. The clock operates in either the 24–hour or 12–hour format with an AM/PM indicator. The DS1302 also provides 31 bytes of nonvolatile SRAM for data storage. Interfacing the DS1302 with a microprocessor is simplified by using a synchronous serial communication. Only three wires are required to communicate with the clock/RAM: (1) $\overline{RST}$ (Reset), (2) I/O (Data Line), and (3) SCLK (Serial Clock). Data can be transferred to and from the clock/RAM one byte at a time or in a burst of up to 31 bytes. The DS1302 is designed to operate on very low power and retain data and clock information on less than 1 microwatt. The DS1302 is designed to be completely compatible with designs that are currently using the DS1202. This compatibility allows the DS1302 to be dropped directly into a DS1202 socket. Then the optional trickle charge circuit on the DS1302 can be used to backup the system time and data with a super cap or a rechargeable battery.

DS1302 PROGRAMMABLE TRICKLE CHARGER Figure 1



TRICKLE CHARGER

The trickle charge circuit is shown in Figure 1 along with the trickle charge register. To enable the trickle charger the desired path through the circuit must be selected and the appropriate pattern written to the trickle charge register. The trickle charge select (TCS) bits (bits 4 – 7) control the selection of the trickle charger. In order to prevent accidental enabling, only a pattern of 1010 will enable the trickle charger. All other patterns will disable the trickle charger. The DS1302 powers up with the trickle charger disabled. The diode select (DS) bits (bits 2 – 3) select whether one diode or two diodes are connected between V_{CC2} and V_{CC1}. If DS is 01, one diode is selected or if DS is 10, two diodes are selected. If DS is 00 or 11 the trickle charger is disabled independent of TCS. The RS bits (bits 0 – 1) select the resistor that is connected between V_{CC2} and V_{CC1}. The resistor selected by the resistor select (RS) bits is as follows:

RS BITS	RESISTOR	TYPICAL VALUE
00	None	None
01	R1	2KΩ
10	R2	4KΩ
11	R3	8KΩ

If RS is 00 the trickle charger is disabled independent of TCS.

Diode and resistor selection is determined by the user according to the maximum current desired for battery or super cap charging. The maximum charging current can be calculated as illustrated in the following example. Assume that a system power supply of 5V is applied to V_{CC2} and a super cap is connected to V_{CC1}. Also, assume that the trickle charger has been enabled with 1 diode and resistor R1 between V_{CC2} and V_{CC1}. The maximum current I_{MAX} would therefore be calculated as follows:

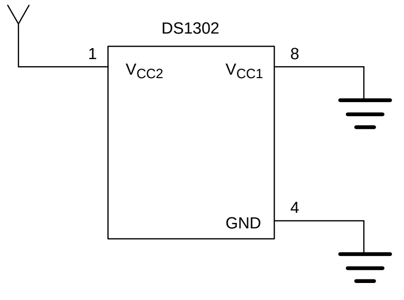
$$I_{MAX} = (5.0V - \text{diode drop})/R1$$
$$\sim(5.0V - 0.7V)/ 2K\Omega$$
$$\sim 2.2 \text{ mA}$$

Obviously, as the super cap charges, the voltage drop between V_{CC2} and V_{CC1} will decrease and therefore the charge current will decrease (please see curves in Trickle Charge Characteristics section).

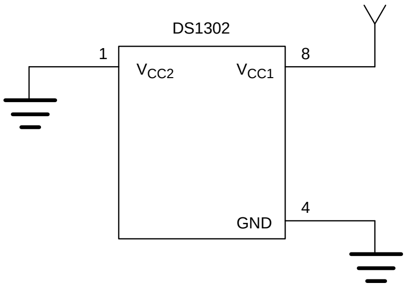
POWER CONTROL

The DS1302 can be powered in several different ways. The first method, shown in Figure 2, illustrates the DS1302 being supplied by only one power supply. In Figure 2a the power supply is connected to V_{CC2} (pin 1) and in Figure 2b the power supply is connected to V_{CC1} (pin 8). In each case the unused power pin, V_{CC1} or V_{CC2}, is grounded. The second method, Figure 3, illustrates the DS1302 being backed up using a non–rechargeable battery connected to V_{CC1}. In these two cases the trickle charge circuit has been disabled. In the final case, Figure 4, the DS1302 is being backed up by connecting a super cap, Figure 4a, or a rechargeable battery, Figure 4b, to V_{CC1}. In this case the trickle charge circuit has been enabled.

SINGLE POWER SUPPLY OPTION Figure 2

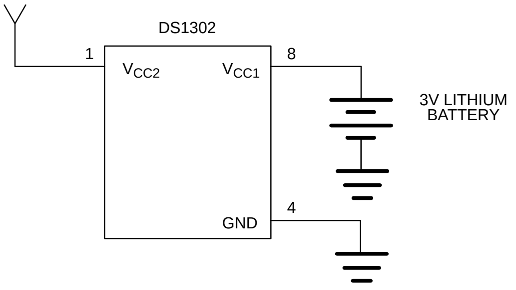


2a

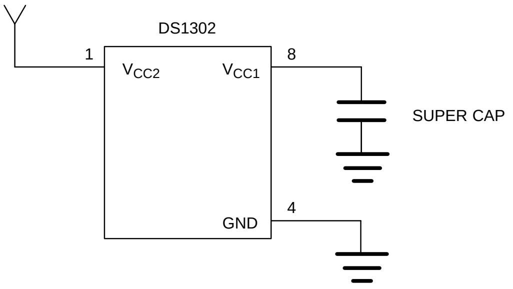


2b

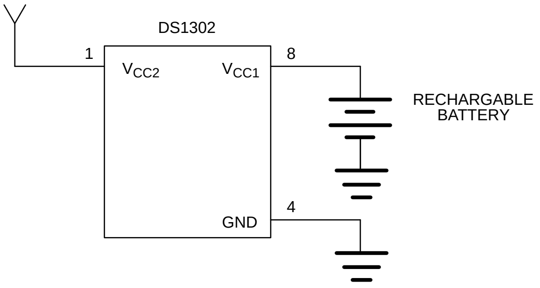
NON–RECHARGEABLE BATTERY BACKUP Figure 3



SUPER CAP OR RECHARGEABLE BATTERY BACKUP Figure 4



4a



4b

TRICKLE CHARGE CHARACTERISTICS

Charging the Super Cap – As was discussed earlier the maximum current, I_{MAX}, required by the trickle charge circuit can be calculated by inserting the correct values selected in the trickle charge register into the following equation:

$$I_{MAX} = (V_{CC2} – \text{diode drop})/R$$

Table 1 contains the values of I_{MAX} for V_{CC2} values of 4.5V, 5.0V and 5.5V; 1 diode drop and 2 diode drops; resistor values of 2000Ω, 4000Ω and 8000Ω.

Also, the charging current can be modeled as a function of charge time. Both the super cap voltage and charging current as a function of time are represented in Figure 5. The equation to model the super cap voltage as a function of time is

$$V(t) = V_{MAX} [1–e^{(–t/RC)}]$$

where

V(t)	=	Super Cap Voltage
V_{MAX}	=	(V_{CC2} – n Diode Drops), n=1,2
R	=	Internal Trickle Charge Resistor
C	=	Super Cap Capacitance

The time needed to charge the super cap to 95% of V_{MAX} is given in Table 2. Note that the time required to charge the super cap to 95% of the value of V_{MAX} is independent of the value of V_{MAX}. The equation which models the charging current as a function of time is given as

$$I(t) = V_{MAX}/R * e^{(–t/RC)}$$

where

I(t)	=	Charging Current
V_{MAX}	=	(V_{CC2} – n Diode Drops), n=1,2
R	=	Internal Trickle Charge Resistor
C	=	Super Cap Capacitance

Discharging the Super Cap – When modeling the DS1302 for the time to discharge the super cap the DS1302 characterization data was used to observe that the I_{CC1T}, Timekeeping Current through V_{CC1}, was linear. This implies that it is proper to represent the DS1302 as a resistive load, R_L, through which the super cap will be discharged. Using the data sheet spec of I_{CC1T} max of 0.3 µA at 2.5 V_{CC1} gives a value for R_L of 8.3MΩ. Then the equation modeling the discharging of the super cap is given by

$$V(t) = V_{MAX} * e^{(-t/R_L C)}$$

where

$V(t)$	=	Super Cap Voltage
V_{MAX}	=	(V_{CC2} – n Diode Drops), n=1,2
R_L	=	DS1302 Load Resistance
C	=	Super Cap Capacitance

The calculated values for the time required to discharge the super cap to 2V are given in Table 3 and a sample of the super cap voltage as a function of discharge time is given in Figure 6.

CALCULATED VALUES OF I_{MAX} Table 1

V_{CC2}	2000Ω		4000Ω		8000Ω		UNITS
	1 diode	**2 diodes**	**1 diode**	**2 diodes**	**1 diode**	**2 diodes**	
4.5V	1.90	1.55	0.95	0.78	0.48	0.39	mA
5.0V	2.15	1.80	1.08	0.90	0.54	0.45	mA
5.5V	2.40	2.05	1.20	1.03	0.60	0.51	mA

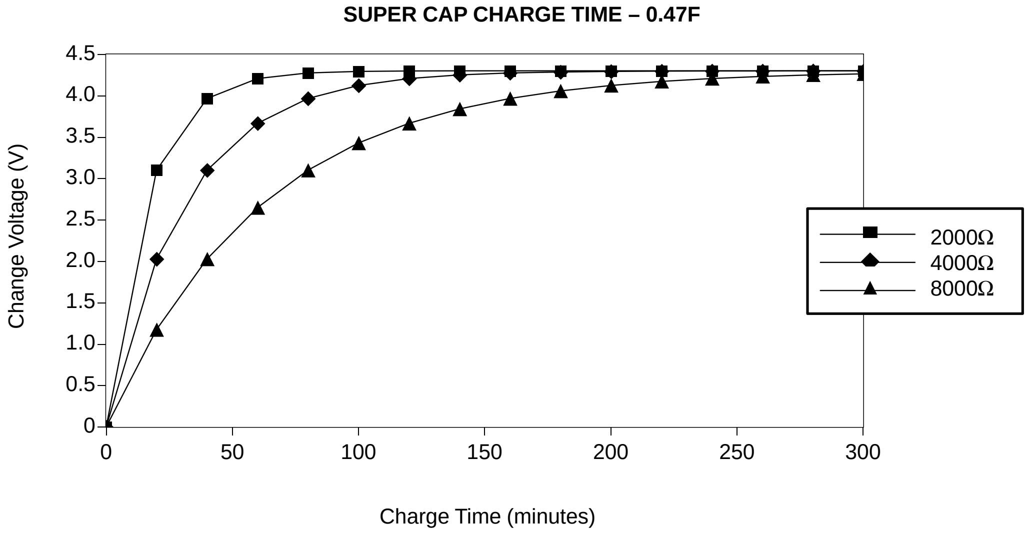
CHARGING TIME FOR SUPER CAP TO 95% OF V_{MAX} Table 2

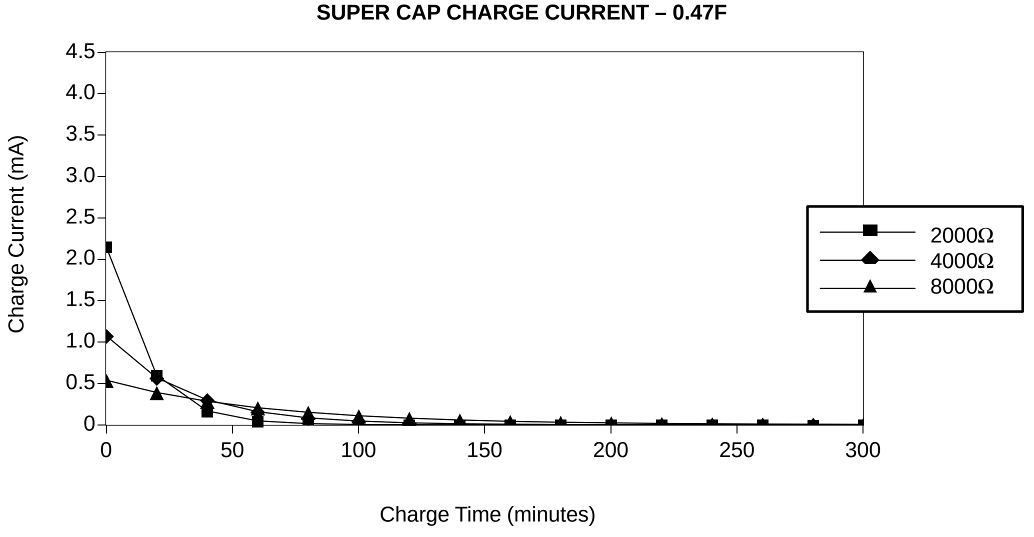
	2000Ω	**4000Ω**	**8000Ω**	**UNITS**
Super Cap=0.047 F	4.7	9.4	18.8	minutes
Super Cap=0.47 F	46.9	93.9	187.7	minutes
Super Cap=1.5 F	149.8	299.6	599.2	minutes

SUPER CAP DISCHARGE TIME TO 2V Table 3

V_{CC2}	0.047F		0.47F		1.5F		UNITS
	1 diode	**2 diodes**	**1 diode**	**2 diodes**	**1 diode**	**2 diodes**	
4.5V	69.8	47.7	698.3	476.8	2228.7	1521.7	hours
5.0V	83.3	63.9	832.8	639.5	2657.9	2040.9	hours
5.5V	95.2	78.1	952.5	780.9	3039.8	2492.5	hours

SUPER CAP CHARGING CHARACTERISTICS Figure 5





SUPER CAP DISCHARGING CHARACTERISTICS Figure 6