



## 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	2K $\Omega$
10	R2	4K $\Omega$
11	R3	8K $\Omega$

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:

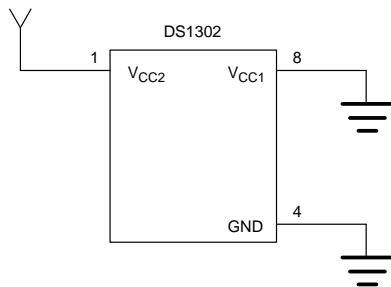
$$I_{MAX} = (5.0V - \text{diode drop})/R1 \\ \sim (5.0V - 0.7V)/2K\Omega \\ \sim 2.2 \text{ mA}$$

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 Charger Characteristics section).

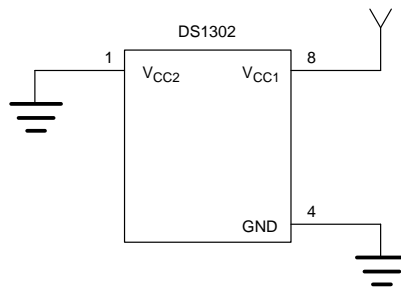
## POWER CONTROL

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.

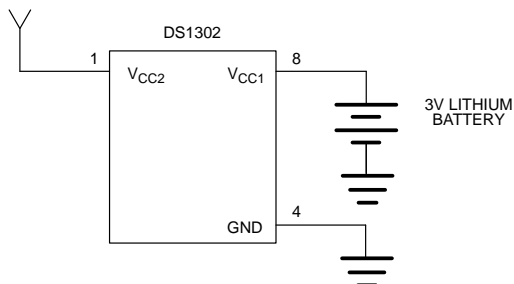
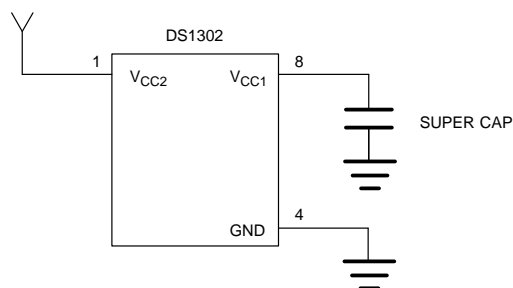
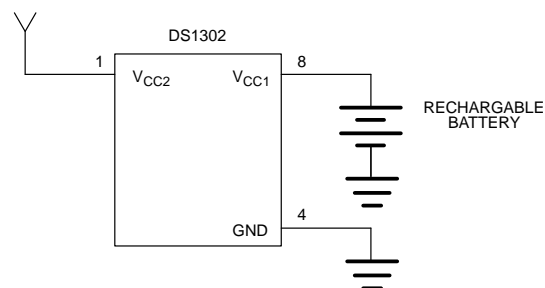
### SINGLE POWER SUPPLY OPTION Figure 2



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

$V_{MAX} = (V_{CC2} - n \text{ Diode Drops}), n=1,2$

$R$  – 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

$V_{MAX} = (V_{CC2} - n \text{ Diode Drops}), n=1,2$

$R$  – 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  $I_{CC1T}$ , Time Keeping 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  $0.3 \mu A$  at  $2.5 V_{CC1}$  gives a value for  $R_L$  of  $8.3M\Omega$ . 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

$V_{MAX} = (V_{CC2} - n \text{ Diode Drops}), n=1,2$

$R_L$  – 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

$V_{CC2}$	2000 $\Omega$		4000 $\Omega$		8000 $\Omega$		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

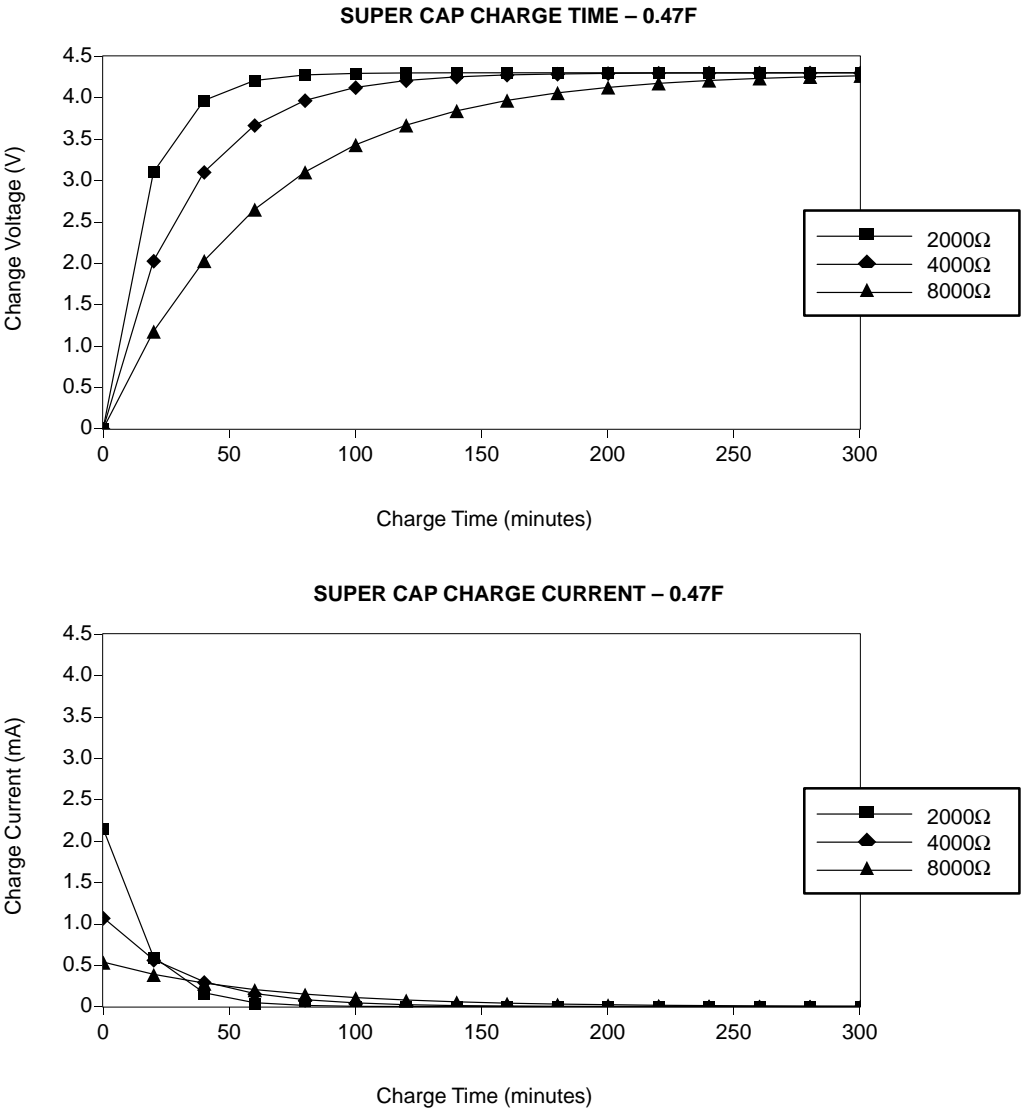
**CHARGING TIME FOR SUPER CAP TO 95% OF  $V_{MAX}$**  Table 2

	2000 $\Omega$	4000 $\Omega$	8000 $\Omega$	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