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) 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

PIN 1 PIN 8
VCC2 VCC1
TCS TCS TCS TCS TCS TCS DS DS RS RS
R1 R2 R3
1 OF 16 SELECT 1 OF 2 SELECT 1 OF 3 SELECT
(Note: Only 1010 Code Enables Charger)

TCS = TRICKLE CHARGE SELECT
DS = DIODE SELECT
RS = RESISTOR SELECT

R1
R2
R3
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 charge disabled. The diode select (DS) bits (bits 2 – 3) select whether one diode or two diodes are connected between VCC2 and VCC1. 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 VCC2 and VCC1. The resistor selected by the resistor select (RS) bits is as follows:

<table>
<thead>
<tr>
<th>RS BITS</th>
<th>RESISTOR</th>
<th>TYPICAL VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>01</td>
<td>R1</td>
<td>2KΩ</td>
</tr>
<tr>
<td>10</td>
<td>R2</td>
<td>4KΩ</td>
</tr>
<tr>
<td>11</td>
<td>R3</td>
<td>8KΩ</td>
</tr>
</tbody>
</table>

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 VCC2 and a super cap is connected to VCC1. Also, assume that the trickle charger has been enabled with 1 diode and resistor R1 between VCC2 and VCC1. The maximum current I_{MAX} would therefore be calculated as follows:

\[ I_{MAX} = \frac{(5.0V - diode\ drop)}{R1} \]
\[ \sim \frac{(5.0V - 0.7V)}{2KΩ} \]
\[ \sim 2.2\ mA \]

Obviously, as the super cap charges, the voltage drop between VCC2 and VCC1 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 VCC2 (pin 1) and in Figure 2b the power supply is connected to VCC1 (pin 8). In each case the unused power pin, VCC1 or VCC2, is grounded. The second method, Figure 3, illustrates the DS1302 being backed up using a non-rechargeable battery connected to VCC1. 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 VCC1. In this case the trickle charge circuit has been enabled.

SINGLE POWER SUPPLY OPTION Figure 2
NON–RECHARGEABLE BATTERY BACKUP

Figure 3

SUPER CAP OR RECHARGEABLE BATTERY BACKUP

Figure 4

TRICKLE CHARGE CHARACTERISTICS

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

$$I_{\text{MAX}} = \frac{(V_{\text{CC2}} - \text{diode drop})}{R}$$

Table 1 contains the values of $I_{\text{MAX}}$ for $V_{\text{CC2}}$ values of 4.5V, 5.0V and 5.5V; 1 diode drop and 2 diode drops; resistor values of 200Ω, 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

$$V(t) = V_{\text{MAX}} \left[1 - e^{-t/(RC)}\right]$$

where

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

$$R = \text{Internal Trickle Charge Resistor}$$

$$C = \text{Super Cap Capacitance}$$

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

$$I(t) = \frac{V_{\text{MAX}}}{R} \cdot e^{-t/(RC)}$$

where

$$I(t) = \text{Charging Current}$$

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

$$R = \text{Internal Trickle Charge Resistor}$$

$$C = \text{Super Cap Capacitance}$$
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 $\mu$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.

### Table 1: Calculated Values of $I_{MAX}$

<table>
<thead>
<tr>
<th>$V_{CC2}$</th>
<th>2000$\Omega$</th>
<th>4000$\Omega$</th>
<th>8000$\Omega$</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 diode</td>
<td>2 diodes</td>
<td>1 diode</td>
<td>2 diodes</td>
</tr>
<tr>
<td>4.5V</td>
<td>1.90</td>
<td>1.55</td>
<td>0.95</td>
<td>0.78</td>
</tr>
<tr>
<td>5.0V</td>
<td>2.15</td>
<td>1.80</td>
<td>1.08</td>
<td>0.90</td>
</tr>
<tr>
<td>5.5V</td>
<td>2.40</td>
<td>2.05</td>
<td>1.20</td>
<td>1.03</td>
</tr>
</tbody>
</table>

### Table 2: Charging Time for Super Cap to 95% of $V_{MAX}$

<table>
<thead>
<tr>
<th>Super Cap</th>
<th>2000$\Omega$</th>
<th>4000$\Omega$</th>
<th>8000$\Omega$</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.047 F</td>
<td>4.7</td>
<td>9.4</td>
<td>18.8</td>
<td>minutes</td>
</tr>
<tr>
<td>0.47 F</td>
<td>46.9</td>
<td>93.9</td>
<td>187.7</td>
<td>minutes</td>
</tr>
<tr>
<td>1.5 F</td>
<td>149.8</td>
<td>299.6</td>
<td>599.2</td>
<td>minutes</td>
</tr>
</tbody>
</table>

### Table 3: Super Cap Discharge Time to 2V

<table>
<thead>
<tr>
<th>$V_{CC2}$</th>
<th>0.047F</th>
<th>0.47F</th>
<th>1.5F</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 diode</td>
<td>2 diodes</td>
<td>1 diode</td>
<td>2 diodes</td>
</tr>
<tr>
<td>4.5V</td>
<td>69.8</td>
<td>47.7</td>
<td>698.3</td>
<td>476.8</td>
</tr>
<tr>
<td>5.0V</td>
<td>83.3</td>
<td>63.9</td>
<td>832.8</td>
<td>639.5</td>
</tr>
<tr>
<td>5.5V</td>
<td>95.2</td>
<td>78.1</td>
<td>952.5</td>
<td>780.9</td>
</tr>
</tbody>
</table>
SUPER CAP CHARGING CHARACTERISTICS Figure 5

SUPER CAP CHARGE TIME – 0.47F

Charge Voltage (V)

Charge Time (minutes)

Charge Current (mA)

Charge Time (minutes)

SUPER CAP CHARGE CURRENT – 0.47F
SUPER CAP DISCHARGING CHARACTERISTICS

Figure 6

SUPER CAP DISCHARGE TIME

$V_{\text{MAX}} = 4.3V$

Super Cap Voltage (V) vs. Discharge Time (hours)

SUPER CAP DISCHARGE TIME

$V_{\text{MAX}} = 3.6V$

Super Cap Voltage (V) vs. Discharge Time (hours)