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Using a Super Cap to Back-up the M41T56, M41T00,  
M41T11, M41T81, M41T94, and M41ST84 (16-pin)

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### INTRODUCTION

The M41T56, M41T00, M41T11, M41T81, M41T94, and M41ST84 (16-pin) TIMEKEEPER® devices from STMicroelectronics are used by applications designers who need a single chip device that offers fast SRAM storage and an integrated Real Time Clock (the M41T00 and M41T81 provide the Real Time Clock only). Many of their designs switch in a battery to maintain the data and keep the clock running when the external power supply falls below specification (or is completely absent). When the battery is depleted, though, the designer or user can be faced with the issues of replacement and disposal (see the Application Note AN1011, "Battery Technology Used in NVRAM Products from ST").

This document describes a more maintenance-free way to sustain the data and clock in systems that only experience short breaks in the power supply (on the order of days). A Super Cap can be used as a type of secondary cell (a rechargeable battery) and can therefore provide an alternative solution to using a primary cell. Figure 1, page 2 (for the M41T56) and Figure 2, page 4 (for the M41T00, M41T11, M41T81, and M41T94 as well as for the 16-pin M41ST84) show two typical circuit arrangements. Since the Super Cap is limited to a certain maximum charging current, a series-limiting resistor may also be required (please consult the data sheet for the Super Cap.)

In this document, the reliability, leakage current, and charging cycle limitations of the Super Cap have not been taken into account. Please consult the data sheet of the Super Cap for details.

### Calculating the Values of the Circuit Components for the M41T56

The minimum battery voltage for this device is 2.5V, while the maximum battery supply voltage is 3.5V. This gives the maximum delta voltage swing across the capacitor (1.0V).

**Note:** Charging the capacitor above 3.5V will result in a higher Power-fail Deselect Voltage ( $V_{PFD}$ ) trip point, and may cause inadvertent deselection of the device at nominal  $V_{CC}$  values.

$$V_{PFD} = 1.25 \times V_{BAT(typ)}$$

The voltage divider provides a bias on the transistor; the resistor divider is calculated according to the ratio of  $V_{CC}$  to  $V_{BASE}$ . Limit the maximum voltage charge on the capacitor using the formula,

$$V_{BAT} = V_{BASE} - V_{BE}$$

Derive the maximum voltage as follows:

$$V_{BASE} = \text{MaximumSupplyVoltage} + V_{BE}$$

Maximum Supply Voltage is 3.5V;  $V_{BE}$  is typically 0.6V, so the typical value of  $V_{BASE}$  is 4.1V.

## AN922 - APPLICATION NOTE

Recommended starting values for R1 and R2 are R1=22KΩ and R2=100KΩ (with V<sub>CC</sub> = 5V). Since the battery current, "I<sub>BAT</sub>," is limited to a maximum value of 550nA, the capacitance and the duration of "power-out time" can be calculated using the formula:

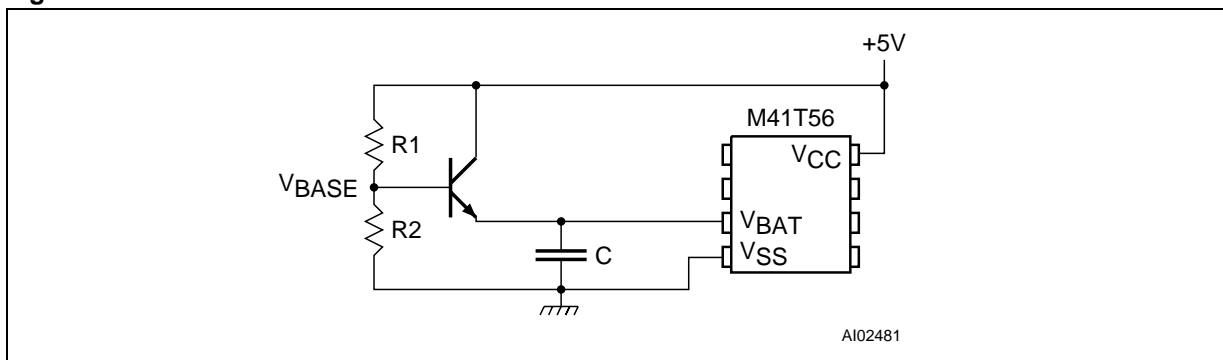
$$I = C \times \Delta V / \Delta t$$

where I = 550nA, ΔV = 1.0V, C = capacitance is in "Farads," and Δt = "power out time" is in "seconds." Using a 100,000 μF capacitor, for example, the equation would be:

$$550\text{nA} = 0.1\text{F} \times 1.0\text{V} / \Delta t$$

Solving for Δt, the maximum power down time is about 181,818 seconds. This is just over two days.

**Figure 1. External Connections to the M41T56**



**Calculating the Values of the Circuit Components for the M41T00, M41T11, and M41T81**

The minimum operating voltage for these devices is 2.0V, with a typical  $V_{BAT}$  voltage of  $V_{CC} - V_F$  (diode). Therefore, the typical delta voltage swing across the capacitor is:

$$\Delta V = V_{CC} - V_F - V_{CCmin}$$

where  $V_F$  is approximately 0.5V. Therefore:

$$\Delta V = 5.0V - 0.5V - 2.0V$$

$$\Delta V = 2.5V$$

Since the battery current ( $I_{BAT}$ ) is limited to maximum value of 1.0 $\mu$ A, the capacitance and the duration of "power-out time" can be calculated using the formula:

$$I = C\Delta V/\Delta t$$

where  $I=1.0\mu$ A,  $\Delta V=2.5V$ ,  $C$  = capacitance in Farads, and  $\Delta t$  = "power-out time" in seconds.

Using a 100,000  $\mu$ F capacitor, for example, the equation would be:

$$1.0\mu A = 0.1F \times 2.5V/\Delta t$$

Solving for  $\Delta t$ , the maximum power down time is about 250,000 seconds. This is 69.4 hours, or 2.9 days.

**Calculating the Values of the Circuit Components for the M41ST84 and M41T94**

The minimum operating voltage for these devices is 2.5V, with a typical  $V_{BAT}$  voltage of  $V_{CC} - V_F$  (diode). Therefore, the typical delta voltage swing across the capacitor is:

$$\Delta V = V_{CC} - V_F - V_{CCmin}$$

where  $V_F$  is approximately 0.5V. Therefore:

$$\Delta V = 5.0V - 0.5V - 2.5V$$

$$\Delta V = 2.0V$$

## AN922 - APPLICATION NOTE

Since the battery current ( $I_{BAT}$ ) is limited to maximum value of 500nA, the capacitance and the duration of “power-out time” can be calculated using the formula:

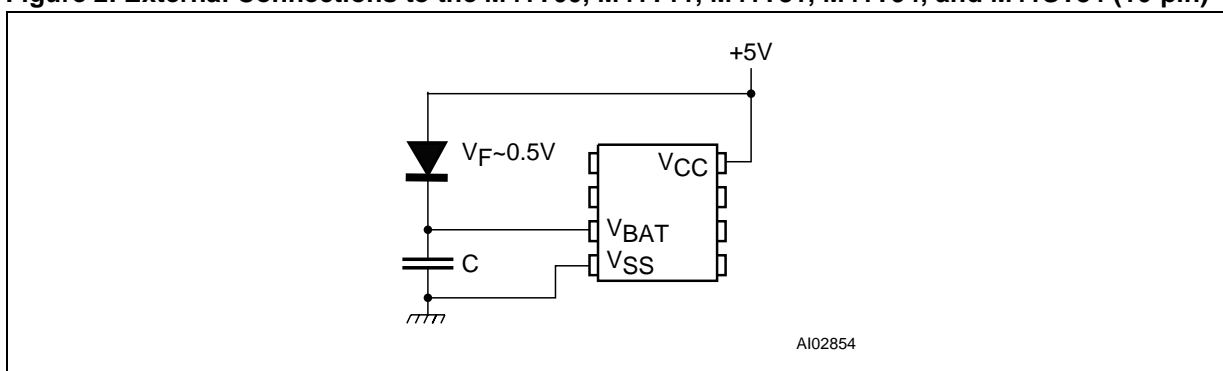
$$I = C\Delta V/\Delta t$$

where  $I=500\text{nA}$ ,  $\Delta V=2.0\text{V}$ ,  $C$  = capacitance in Farads, and  $\Delta t$  = “power-out time” in seconds.  
Using a 100,000  $\mu\text{F}$  capacitor, for example, the equation would be:

$$500\text{nA} = 0.1\text{F} \times 2.0\text{V}/\Delta t$$

Solving for  $\Delta t$ , the maximum power down time is about 400,000 seconds. This is 111.1 hours, or 4.63 days.

**Figure 2. External Connections to the M41T00, M41T11, M41T81, M41T94, and M41ST84 (16-pin)**



Note: The same configuration is possible using the M41ST84 (16-pin)

**CONTACT INFORMATION**

If you have any questions or suggestions concerning the matters raised in this document, please send them to the following electronic mail addresses:

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Please remember to include your name, company, location, telephone number, and fax number.

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