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Charging Methods for the F-RAM RTC Backup Capacitor

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Associated Part Family: FM31256, FM3164, FM31278, FM31276, FM31L278, FM31L276, FM33256B

Related Application Notes: [click here](#)

AN401 describes the charging methods for the F-RAM RTC (FM31xxx/FM33xxx Processor Companion family) backup capacitor. A backup capacitor is used for backing up the real-time clock and event counters.

1 Introduction

The F-RAM real-time clock (RTC), which includes the FM31xxx/FM33xxx Processor Companion family devices, provide an option to backup RTC and event counters in the absence of system power through a backup power source (V_{BAK}). V_{BAK} can be either a battery or a capacitor. However, often a capacitor is preferred.

When a capacitor backup source is used, the capacitor must be initially charged and then constantly recharged to keep it ready to supply the RTC during periods when the system is powered down. The highest charged voltage yields the longest backup time period after power fails. In a 3-V part, V_{BAK} can go up to V_{DD} , while in the 5-V part, the maximum allowed voltage on the V_{BAK} pin is 3.75 V. The capacitor can be charged through the following methods.

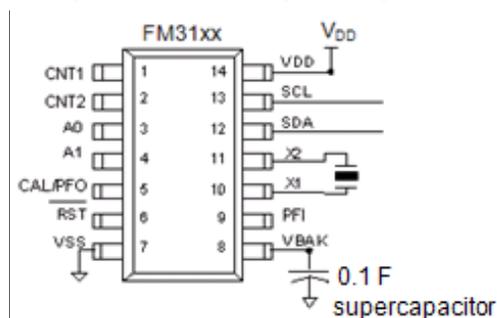
- Built-in trickle charger for both 3-V and 5-V systems
- External charger for a 3-V system
- External charger for a 5-V system

This application note describes these charging methods in detail.

2 Trickle Charger

The FM31xxx/FM33xxx Processor Companion family includes a built-in trickle charger designed to charge a backup capacitor that is connected to the V_{BAK} pin when V_{DD} is applied. It is available in both 3-V and 5-V devices. The trickle charger is enabled by setting the VBC bit (V_{BAK} Charger Control) in the Companion Control Register. It requires no external components except for the backup capacitor itself as shown in Figure 1. When enabled, the trickle charger sources approximately 15 μ A for the FM31256/FM3164 devices (80 μ A for FM31278/FM31276/FM31L278/FM31L276/FM33256B devices) until the V_{BAK} pin reaches V_{DD} or the maximum allowed voltage of 3.75 V.

Figure 1. Trickle Charger Configuration



This trickle current can charge a 0.1-F supercapacitor to the required voltage in a few hours. Trickle charging is the simplest method to maximize the V_{BAK} voltage in a 3-V system and helps to comply with the $V_{BAK(max)}$ specification of 3.75 V in a 5-V system.

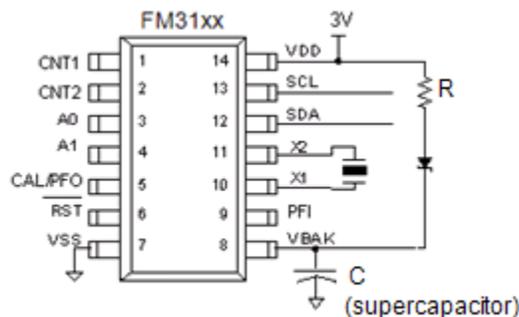
Note: The FM31278/FM31276/FM31L278/FM31L276/FM33256B devices define a Fast Charge mode (FC bit – register 0Bh, bit 5), which is capable of sourcing approximately 1 mA.

3 External Charger in a 3-V System

In systems that operate from a 3-V supply, you can charge the V_{BAK} capacitor using a Schottky diode and a current-limiting resistor. This solution requires additional external components when compared to trickle charger, but offers a faster charge time. In this case, you can select virtually any charging time by selecting an appropriate current-limiting resistor. The charge time is approximately $5 * RC$.

Figure 2 shows an example diode charger circuit. In Figure 2, the blocking diode prevents current from flowing out of the capacitor into the system when V_{DD} drops below the capacitor voltage on power-down. Using a Schottky diode minimizes the forward voltage drop to approximately 0.3 V. Since the capacitor only charges to $V_{DD} - 0.3$ V, this solution has a 0.3 V lower backup voltage than the trickle charger. For this application, it is suggested to enable the trickle charger so that V_{BAK} can continue to charge up to V_{DD} after the Schottky circuit reaches its maximum charge voltage.

Figure 2. Diode Charger Configuration



4 External Charger in a 5-V System

In 5-V systems, you cannot use the diode charger as an external charger because it will allow the maximum voltage on the V_{BAK} pin to exceed the V_{BAK} (max) specification of 3.75 V. To limit the voltage on the V_{BAK} pin, a variety of circuits are available. Figure 3 shows the most dependable circuit. This circuit limits the maximum voltage on the capacitor to the V_{BAK} (max) specification, regardless of the charging current. R1 and R2 should be selected such that the voltage across R2 is 4.45 V. With this, when the capacitor voltage crosses 3.75 V, the circuit is turned off and capacitor stops charging. The easiest way to select resistors is to choose one resistor and then solve for the other:

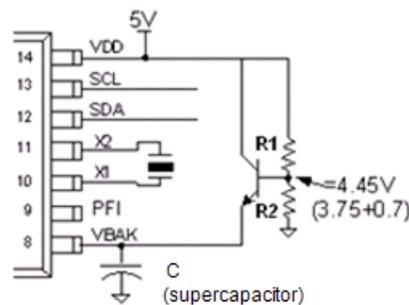
$$\text{We know, } 4.45 \text{ V} = 5.0 \text{ V} \times \frac{R2}{R1 + R2}$$

$$\text{and, } \frac{R1}{R2} + 1 = 1.124$$

$$\text{So, } R1 = 0.124 \times R2$$

$$\text{For } R2 = 4.7 \text{ k}\Omega, R1 = 580 \text{ }\Omega$$

Figure 3. Transistor Driven Charger



Note: In the above equation, VDD is assumed to be 5 V. For any other VDD value, R1 and R2 should be recalculated.

5 Summary

This application note explained different methods of charging a backup capacitor in the FM31xxx/FM33xxx devices. The backup capacitor is used to backup the RTC and event counters.

The trickle charger is a built-in option and needs no external components. It can source 15 μ A, 80 μ A, or 1 mA depending on the device and the mode selected. The application note also gave the external charging methods for faster charging of the backup capacitor.

6 Related Application Notes

You can refer to the following application notes for better understanding of the F-RAM Processor Companion devices.

- [AN407 - A Design Guide to I2C F-RAM Processor Companions – FM31278, FM31276, FM31L278, and FM31L276](#)
- [AN408 - A Design Guide to SPI F-RAM Processor Companion - FM33256B](#)
- [AN400 - Generating a Power-Fail Interrupt using the F-RAM Processor Companion](#)
- [AN402 - F-RAM RTC Oscillator Design Guide](#)
- [AN404 - F-RAM RTC Backup Supply \(\$V_{BAK}\$ pin\) and UL Compliance](#)

Document History

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	4039506	MEDU	06/25/2013	New Spec.
*A	4541202	MEDU	11/06/2014	Changed the title from “Charging Methods for F-RAM RTC Backup Capacitor” to “Charging Methods for the F-RAM RTC Backup Capacitor” Updated Abstract. Updated Introduction: Updated description. Updated Trickle Charger: Updated description. Updated External Charger in a 3-V System: Updated description. Updated External Charger in a 5-V System: Updated description. Updated Summary. Added Related Application Notes.
*B	5293268	MEDU	06/02/2016	Updated to new template.
*C	5847851	HARA	08/17/2017	Updated logo and copyright.

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