

RTC Backup & UL Compliance

For Processor Companions w/ RTC



Overview

The FM31xx family and FM4005 devices are Integrated Processor Companion devices that feature a real-time clock (RTC). The RTC provides the date/time information for the system and operates on either V_{DD} or V_{BAK} power. A battery or a capacitor is attached to the V_{BAK} backup power supply pin. This application note discusses the backup power sources, the internal charging circuit, and associated issues.

RTC Backup

The FM31xx and FM4005 RTCs are designed to operate over long periods of time without the main V_{DD} power supply. A backup power source can be provided by a battery (lithium coin cell) or a large value super capacitor. Depending on the size/capacity, a lithium coin cell can provide continuous RTC operation for many years. When V_{DD} is powered up, the RTC and other backup circuits operate from the V_{DD} power source. There is essentially no current drawn from the backup source. If V_{DD} is powered down, the RTC is automatically switched over to the V_{BAK} power source.

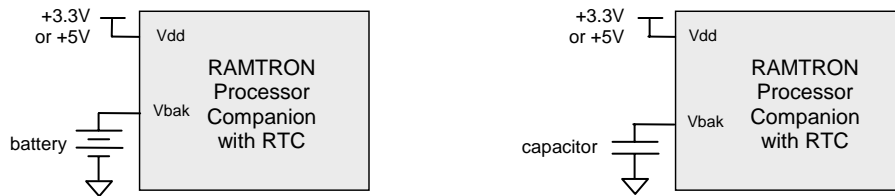


Figure 1. Two RTC Backup Options

The RTC operates under very low current ($<1\mu\text{A}$). A 3V coin cell is typically used. The expected life in hours of a lithium cell is approximately:

$$1000 \times \text{Rated Battery Capacity (mAh)} / \text{Load Current } (\mu\text{A})$$

For example, a BR1225 rated at 48mAh with a continuous load current of $1\mu\text{A}$ (system powered down) will last 48,000 hours, or nearly 5 ½ years. If V_{DD} is powered up some portion of the time, then the battery will last longer since there is no backup current when V_{DD} is applied. During this time, the battery's self-discharge characteristic dominates the battery life.

In applications for which a battery cannot be used (impractical, environmental, cost), a capacitor may be used as a backup power source. A large value capacitor, such as a super capacitor, is generally used. The FRAM companion devices have an integrated charging circuit that is used with a super capacitor. This provides the user cost savings, reduced board space, and convenience. The internal circuit allows a super cap to be charged up when V_{DD} is applied. No external diodes or resistors are needed. The circuit provides a constant current to deliver charge to the capacitor. When V_{DD} is powered down, the RTC and other backed-up circuits are powered from the super capacitor. See Figure 2.

The calculation for the length of time in hours that the RTC will run from the super capacitor follows:

$$\text{Capacity of supercap (F)} \times (V_{\text{INITIAL}} - 2.0\text{V}) / (0.0036 \times \text{Load Current } (\mu\text{A}))$$

where V_{INITIAL} is the capacitor voltage that the V_{BAK} pin is charged to when V_{DD} is powered down and 2.0V is the minimum operating RTC voltage as specified in the datasheet. The factor 0.0036 converts seconds to hours and amps to microamps.

A 0.1F capacitor provides approximately two days of backup and a 1F super cap, twenty days. The VBC bit in the Companion Control register (0Bh, bit 2) must be set high in order to activate the charging circuit.

The trickle charger voltage is limited by an internally regulated voltage V_{REG} , 3.75V. This is the highest expected initial V_{BAK} voltage. If the super capacitor has not been fully charged, the V_{BAK} voltage starts at a lower initial voltage and therefore the RTC runs for fewer hours. Typically systems are run from either 3.3V or 5V. In the case of a 5V system, the highest V_{BAK} voltage is 3.75V, the internally regulated voltage. In the case of a 3.3V system, the internal regulator will be limited to the V_{DD} voltage since there are no internal charge pumps or other boost circuits.

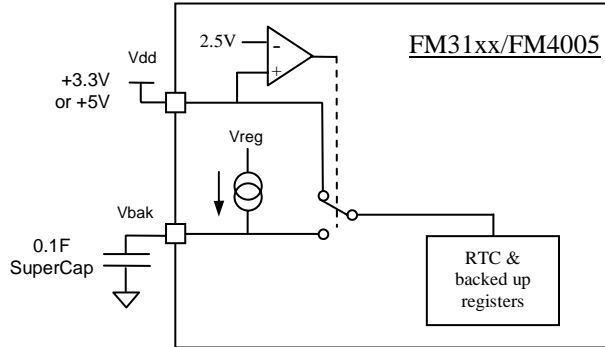


Figure 2. Simplified Diagram of Power Switch and V_{BAK} Trickle Charger

The time (in hours) to fully charge a discharged capacitor is approximately:

$$\text{Capacity of supercap (F)} \times (V_{\text{CHARGED}}) / (0.0036 \times \text{Charge Current } (\mu\text{A}))$$

For a 0.1F capacitor, $V_{DD} = 5V$, and a charge current of $15\mu\text{A}$, it takes almost 7 hours to fully charge the super cap. In the case of $V_{DD} = 3.3V$, it takes ~6 hours to fully charge the super cap. " V_{CHARGED} " is 3.75V ($V_{DD} = 5V$) and 3.3V ($V_{DD} = 3.3V$). The factor 0.0036 converts seconds to hours and amps to microamps.

UL Compliance

Users of primary batteries (non-rechargeable) need assurance that the charging circuit has low reverse current when off and that it also has a protective resistor in series with the battery. This limits the charge current in the event that a malfunction in the charging circuit that would cause excessive battery current. The circuit diagram below shows two 1.3K ohm resistors in series with the P-ch current source. There are no other elements in the path to the V_{BAK} pin.

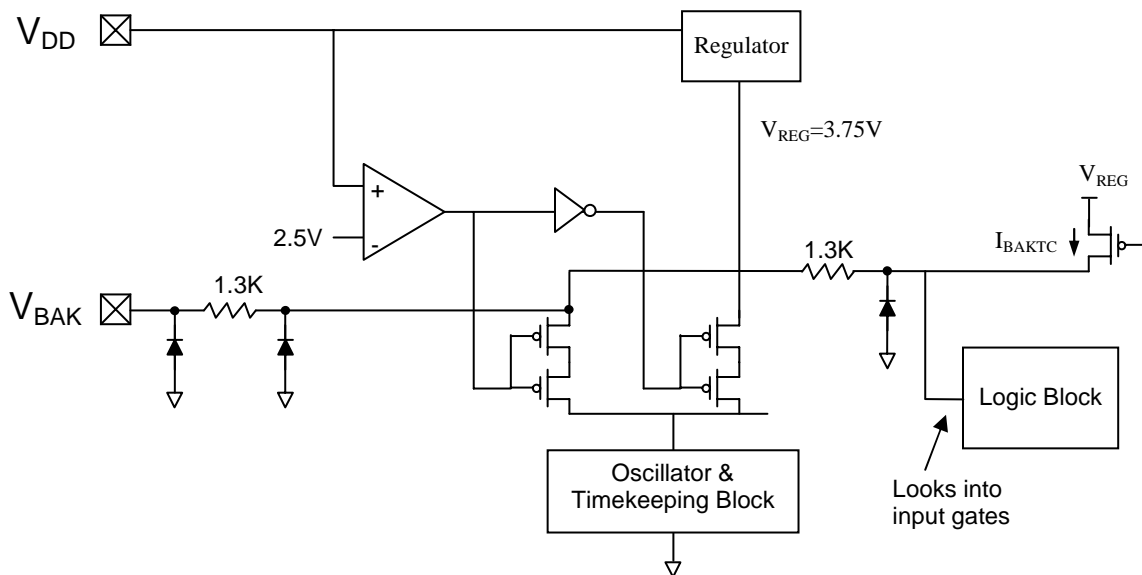


Figure 3. FM31xx/FM4005 Internal Circuits Relating to V_{DD} and V_{BAK}

The trickle charger current is provided by the P-ch shown as I_{BAKTC} current and is activated only when the VBC bit is set. The RTC comprises an oscillator block and timekeeping block, which holds time/day/date values. If V_{DD} drops below 2.5V, the RTC power is switched over to the V_{BAK} source. Under this condition, the oscillator and timekeeping block pulls no more than 1 μ A (I_{BAK} max. @ $V_{\text{BAK}}=3.0\text{V}$), which is 100% tested at worst case conditions.

When V_{DD} is within its normal operating range, there is no current into or out of the V_{BAK} pin, other than leakage current. Ramtron expects I_{BAK} to be $< 1\text{nA}$ under this condition.

NOTE: If a primary battery is used and the VBC bit is set (charger on), this is a condition that should be avoided. The battery life may be shortened. The charge current provided by the FM31xx/FM4005 is low enough that it poses no safety risk, such as excessive heat.