

RTC Oscillator Guide

For FM31xx, FM3808, and FM30C256



Overview

The FM31xx, FM3808, and FM30C256 are Integrated Processor Companion devices that feature nonvolatile FRAM memory and a real-time clock or RTC. The RTC operates on V_{DD} power and switches to a backup supply when V_{DD} power is removed. Under backup power, the RTC draws very little current thereby allowing a long operating time. This application note focuses on the RTC oscillator and precautions the system designer should make when using these devices.

Oscillator and Crystals

The heart of any RTC is the crystal oscillator. It provides an accurate, low power timebase for the divide-by counters that generate seconds, minutes, hours, etc. The oscillator must work properly and go undisturbed in order for the clock to be accurate over long periods of time.

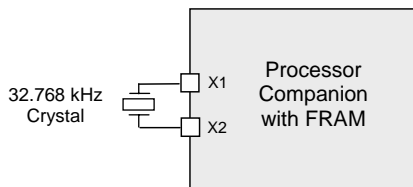


Figure 1. Crystal Hookup to RTC

Aside from the crystal, all necessary oscillator components are integrated within the companion device. If additional components, such as capacitors or resistors, are connected to the X1 or X2 pins, the oscillator will not operate properly. The DC operating point will be shifted and the oscillator frequency will also be shifted. It is possible the oscillator will not even start at power up. Passive 10X oscilloscope probes with 10pF and 10M Ω impedance will upset the oscillator as well.

All 32.768kHz crystals have a capacitive rating. There are two common 32kHz crystals on the market, a “6pF” type and a “12.5pF” type. This rating is the recommended capacitive load that the crystal must see when operating. That is, the X1/X2 pins must present a 6pF load to the crystal. The rating is not the capacitance of the crystal (shunt capacitance), which tends to be about 1 pF. All FRAM companion devices have been designed to use the 6pF type, not the 12.5pF type.

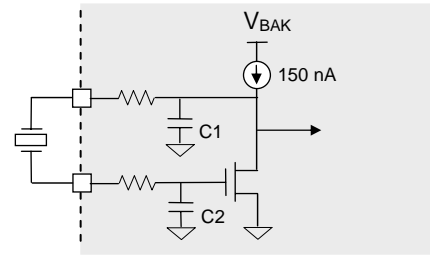


Figure 2. Simplified Oscillator Circuit

A look at the simplified schematic of the oscillator shows a Pierce oscillator with C1 and C2 loading capacitors inside the chip. The value of these capacitors is 12 pF each. The capacitors operate in series with the crystal, so the C_{LOAD} is $C1 \cdot C2 / (C1 + C2)$, or 6 pF. The two resistors are 1K Ω each and provide phase shift to improve oscillator stability.

All Ramtron companions with RTC have been optimized for the 6pF crystal in order to achieve the lowest operating current under backup power. A 12pF crystal oscillator will draw almost twice as much current. Notice the 150 nA current source in the oscillator, which provides the circuit’s very low DC bias current. It can be upset by noise or extra loading on the X1/X2 pins.

Oscillator Frequency Measurement

The oscillator’s 32.768kHz frequency cannot be monitored directly. Do not add capacitors to the X1 or X2 pins. Do not attach a scope probe either. The recommended way to check the frequency is shown here:

1. Power-up and set OSCEN bit to 0.
2. In the RTC/Control register (Flags/Control in the FM30C256 and FM3808), set CAL bit to 1. This turns the CAL pin (INT on the FM3808) into a 512Hz monitor. This is the crystal frequency divided by 64.
3. Use a frequency counter or other accurate frequency measurement technique (use digital scope with cursors and look at 10 or more cycles, not one cycle). You should expect to read 512.000 Hz. However, if you measure between 511.975 to 512.025 Hz, then the oscillator is most likely working fine and the CAL(4:0) register bits will be able to reduce RTC errors to < 2 ppm. Note that 0.025Hz deviation from 512Hz is about 50 ppm error.

While 50 ppm frequency error is far from being very accurate, this is well within the capabilities of the calibration settings to correct for this frequency shift. To further test the oscillator, the system microcontroller should be enabled (run code) and disabled (no activity). Continue to monitor the 512Hz output for frequency accuracy. If the frequency changes significantly, then your micro is introducing noise into the oscillator. If you follow the layout recommendations, the RTC oscillator performance will greatly improve.

Important Note: The calibration settings CAL(4:0) do not affect the 512Hz output. You will not see a change in the 512Hz frequency on the CAL (INT) pin when the CAL(4:0) bits are changed. The RTC correction is done digitally after the divide-by-64 counter. It is not done by bending the crystal frequency either.

Layout Recommendations

The X1 and X2 crystal pins are high impedance pins that must be treated with care.

- Ensure crystal lead length to X1 and X2 pins is short, less than 5 mm
- Ensure that the V_{DD} pin has good decoupling (0.1uF with return to ground plane)
- Do not route other signals close to the X1/X2 pins, even if the signal is routed on an inner board layer

- Use a guard ring (ground) around the crystal pins
- Use a ground plane on an inner or backside board layer

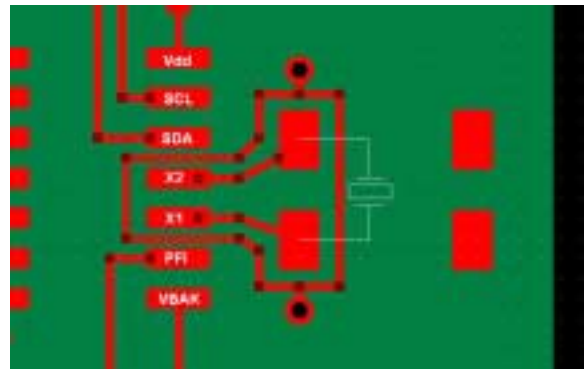


Figure 3. Guard Ring Around X1/X2 Pins

There are many crystals available today in the surface mount package. An FM31xx device and SMD crystal are shown in the example layout. Notice the plated through holes that tie the guard ring down to the ground plane. Abracon, Citizen, Epson, Raltron, and Saronix make a “6pF” surface mount 32kHz crystal. The recommended 6pF crystal will oscillate exactly at 32,768 Hz when loaded with 6pF.