

External RTC With Backup Memory Using a Low Memory MSP430™ MCU



Introduction

In a number of applications such as metering, building automation, and remote sensing, it is important to be able to keep track of the real time for monitoring or coordination purposes. Often additional information about system state also needs to be stored through a power loss to the main system. The [MSP430FR2000](#) microcontroller (MCU) can be used as a low cost solution for this problem by making use of the internal real time clock (RTC) counter module and internal ferroelectric random access memory (FRAM) as backup memory. By using the UART, the host can set the initial time in POSIX format, and it can interrogate the MSP430™ MCU over the UART to provide the current time in the same format. Additionally, the host can write to and read from 16 bytes of backup memory, within the MSP430FR2000 device. This allows for data retrieval even after a total system power loss. To get started, [download project files and a code example](#) demonstrating this functionality.

Implementation

For this application the MSP430FR2000 MCU and the [MSP-TS430PW20](#) target development board was used. It requires an external 32768-Hz crystal with appropriate loading capacitors to be populated, and UART connections to P1.6 and P1.7 (the [MSP-FET](#) or eZ-FET backchannel UART can be used to connect to a PC terminal program at 9600 baud for testing). Note that the MSP-TS430PW20 target board already includes the correct connections for the UART TXD and RXD on the MSP-FET connector as long as JP14 and JP15 are populated (leave JP13 unconnected).

The firmware implements the following communications protocol over UART:

READ/WRITE	ADDR	D0	D1	D2	D3

Where:

- READ = 00h
- WRITE = 01h
- ADDRESS = FFh for timestamp, 00h to 0Fh for backup memory
- D0 to D3 = The data bytes to be written or the requested data as a response from the MSP430 MCU on appropriate commands.

01h	FFh	D0	D1	D2	D3
-----	-----	----	----	----	----

WRITE TIME Command

00h	FFh	D0	D1	D2	D3
-----	-----	----	----	----	----

READ TIME Command

01h	00h to 0Fh	D0
-----	------------	----

WRITE MEM Command

00h	00h to 0Fh	D0
-----	------------	----

READ MEM Command

	Response
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The timestamp is sent LSB first, so that the timestamp should be interpreted as D3D2D1D0h.

The RTC Counter module sourced from the 32768-Hz crystal is configured to generate an interrupt once per second. The interrupt service routine updates the timestamp value stored in FRAM. The host must set the initial timestamp the very first time after programming using the WRITE TIME command. From then on, the MSP430 device will keep updating the timestamp value. The current timestamp value will be retained through a reset or power loss.

Performance

Both timestamp and the backup memory are stored in FRAM and are nonvolatile, so they will be retained even through a total power loss.

The RTC Counter module in the device updates the stored timestamp once a second. The host can request the current timestamp at any time using the read time command. An example showing the setting of RTC timestamp and backup memory, and then read back is shown below.

Observe that the WRITE TIME command was sent at 12:49:12 and set to 78563412h. 7 seconds later, at 12:49:19, the READ TIME command was sent and the reply shows the current value of timestamp is 78563419h. Therefore the timestamp also has incremented 7 seconds.

```

ASCII  HEX  Decimal  Binary
8/8/2017 12:49:12.681 [TX] - 01 FF 12 34 56 78
8/8/2017 12:49:14.470 [TX] - 01 04 AA
8/8/2017 12:49:19.468 [TX] - 00 FF
8/8/2017 12:49:19.565 [RX] - 19 34 56 78
8/8/2017 12:49:20.831 [TX] - 00 04
8/8/2017 12:49:20.928 [RX] - AA |
  
```

Figure 1. RTC and Backup Memory Example

Limitations of this implementation include that no temperature compensation or calibration to adjust for small ppm errors of the 32768-Hz crystal is implemented. This means that the RTC could drift slightly over time, so it would be recommended for the host to periodically re-sync the RTC by sending the WRITE TIME command (for example, once per day).

This solution provides external RTC with backup memory with only an external 32768-Hz crystal, and optimized software that fits in code-limited devices down to 0.5KB.

Device Recommendations

The device used in this example is part of the MSP430 Value Line Sensing portfolio of low-cost MCUs, designed for sensing and measurement applications. This example can be used with the devices shown in [Table 1](#) with minimal code changes. For more information on the entire Value Line Sensing MCU portfolio, visit www.ti.com/MSP430ValueLine.

Table 1. Device Recommendations

Part Number	Key Features
MSP430FR2000	0.5KB FRAM, 0.5KB RAM, eComp
MSP430FR2100	1KB FRAM, 0.5KB RAM, 10-bit ADC, eComp
MSP430FR2110	2KB FRAM, 1KB of RAM, 10-bit ADC, eComp
MSP430FR2111	3.75KB FRAM, 1KB RAM, 10-bit ADC, eComp

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