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

TEXAS INSTRUMENTS

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

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.

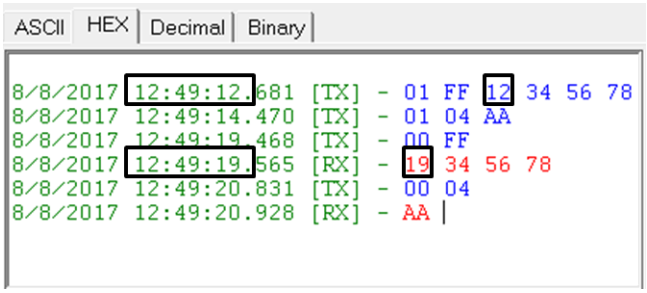

Figure 1. RTC and Backup Memory Example

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

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ('TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products http://www.ti.com/sc/docs/stdterms.htm), evaluation modules, and samples (http://www.ti.com/sc/docs/sampterms.htm).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265