

# Simple RTC-Based System Wake-up Controller Using MSP430™ MCUs

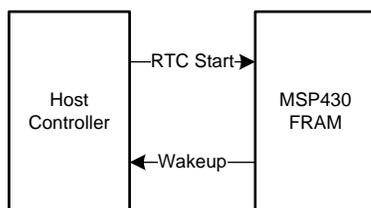


## Introduction

The simple system wake-up controller function of the [MSP430FR2000](#) microcontroller (MCU) offers a simple way to add an external, real-time, and low-power wake-up controller to an existing system. This type of system wake-up controller is useful to applications that need to stay in low-power modes for regular extended periods of time. One example is battery-operated wireless sensing applications that need to check in with central servers periodically while otherwise staying in low-power modes. To get started, [download project files and a code example](#) demonstrating this functionality. For a similar application but with variable wake-up time, see [Programmable System Wake-up Controller Using MSP430™ MCUs](#).

## Implementation

A low-frequency 32.768-kHz crystal is required for this application. Alternatively, the internal trimmed low-frequency reference oscillator (REFO) can be used at the cost of extra current. See the [MSP430FR2000 MCU data sheet](#) for specifics. The wake-up time is decided at compile time for the MSP430FR2000 device and cannot be changed when in system. The interface for this function is two GPIO lines (see [Figure 1](#)). The host-to-MSP430 line is used to tell the MSP430FR2000 device to start its real-time clock (RTC) counting function. At this time, the host should go into a low-power or sleep mode. The MSP430-to-host line is used to communicate to the host to wake up from its low-power or sleep mode. This line should be connected to an interruptible or wake-up capable source pin on the host.



**Figure 1. Simple System Wake-up Controller Block Diagram**

The wake-up time is a function of the RTC Counter peripheral and software scaling factors. The RTC Counter module in this application is clocked by XT1 at approximately 32.768 kHz. The largest predivider for the module is 1024. By using this divider value, every

32 counts of the RTC Counter is 1 second. The RTCMOD register holds a count value that gives an interrupt when the RTC Counter counts to it. The RTCMOD register of the RTC Counter is 16 bits wide, so the maximum time the RTC Counter can count before overflow is approximately 34 minutes. The example code uses a timing of 1 second and provides an alternate value of 0xE0FF, which gives a period of 30 minutes. In addition to the RTC Counter registers, the code uses a software overflow counter to scale the RTC Counter time to longer periods. The example code defines the software overflow counter to be 1, and thus the 1-second (alternate: 30-minute) wake-up time is extended to 2 seconds (alternate: 1 hour). The user can change the #define INCREMENT to increase the software overflow counter interval. [Equation 1](#) and [Equation 2](#) can be used to calculate wake-up time in seconds in both a general case and for the parameters described above.

$$\frac{\text{RTCMOD}}{\left(\frac{\text{ClockSource}}{\text{ClockPredivider}}\right)} \times (\text{increment}) = \text{WakeUpTime}_{\text{Seconds}} \quad (1)$$

$$\frac{\text{RTCMOD}}{32} \times (\text{increment}) = \text{WakeUpTime}_{\text{Seconds}} \quad (2)$$

[Figure 2](#) shows the code flow for the application. The simple wake-up controller is design to stay in low-power mode 3 (LPM3) to conserve power. When the host controller sends a low-to-high transition pulse to the MSP430FR2000 MCU, the RTC starts counting to the time value programmed into the device. The RTC interrupt manages the total wake-up time and sends a low-to-high pulse to the host controller after the time value has been reached. When the host sends the RTC start signal to the MSP430FR2000 device, this GPIO interrupt is disabled until the programmed time value has elapsed. The host cannot start a new count or restart the current count until the previous one has ended. To start a new count, the host must send another low-to-high transition to the MSP430FR2000 MCU.

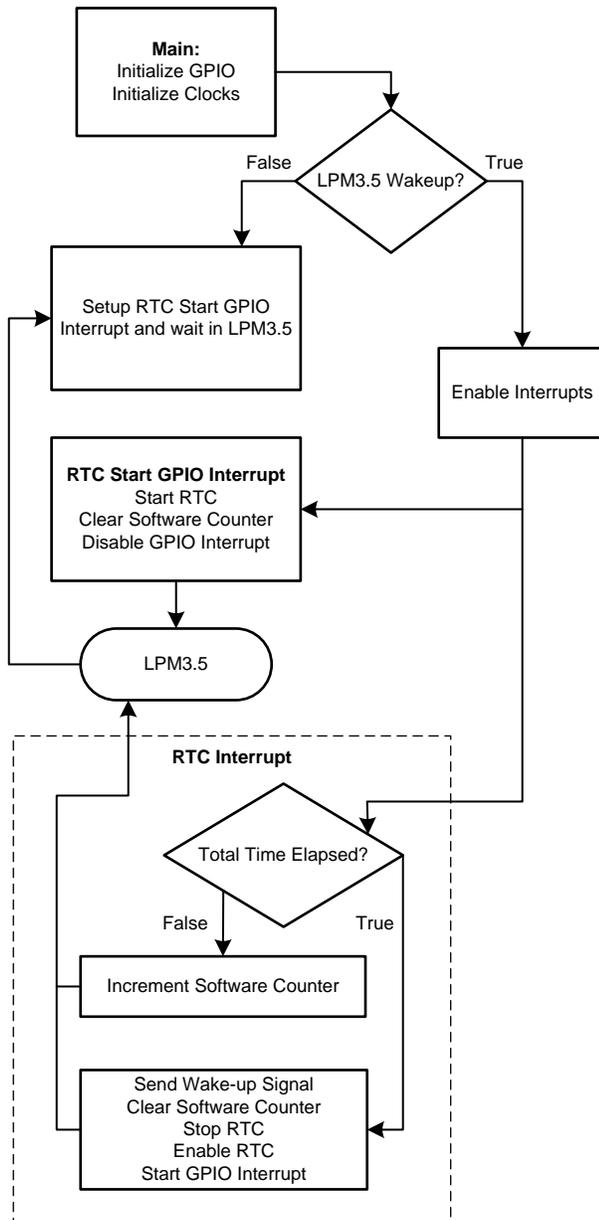
## Performance

Example code size is less than 200 bytes. [Table 1](#) lists the power consumption of the simple system wake-up controller. The average current of the application is dominated by the LPM3 current of the device and approaches this level as the the wake-up time period is extended. [Table 1](#) lists measured values for 1- and 10-second wake-up intervals and calculated values for longer time periods.

**Table 1. Average Power Consumption**

Wake-up Time:	1 s	10 s	1 m*	1 h*	24 h*
Average Current:	1.5 $\mu$ A	1.06 $\mu$ A	1.00 $\mu$ A	<1.00 $\mu$ A	<1.00 $\mu$ A

\* Estimated


**Figure 2. Code Flow Diagram**
**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 2](#) with minimal code changes. For more information on the entire Value Line Sensing MCU portfolio, visit [www.ti.com/MSP430ValueLine](http://www.ti.com/MSP430ValueLine).

**Table 2. 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 RAM, 10-bit ADC, eComp
MSP430FR2111	3.75KB FRAM, 1KB RAM, 10-bit ADC, eComp

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