External Programmable Watchdog Timer Using MSP430™ MCUs

Introduction

Watchdog timers (WDTs) are particularly useful because they detect if a microcontroller is in an invalid software state and initiate a reset if needed. These invalid software states can be caused by anything from a software bug to electromagnetic interference. In general, a WDT resets the system when it does not receive a regular pulsed signal from the host processor.

In critical systems, such as smoke detectors and other industrial applications, an invalid software state could be catastrophic. In these instances, an external WDT would be imperative. The external WDT has a separate clock source providing redundancy and making the system more robust.

This solution presents a configurable external watchdog timer that accepts watchdog time-out values ranging from 1 to 2 seconds, in increments of 200 ms. A shorter time-out interval could be achieved, if needed, by changing the values in the *timeout* array to match the application specifications. This example has been optimized for lowest code size, fitting in a low-cost 0.5KB MSP430FR2000 microcontroller (MCU). It also utilizes the MSP430™ ultra-low-power operating states by going into low-power mode 3 (LPM3) when not executing a WDT-specific operation. To get started, download project files and a code example demonstrating this functionality.

Implementation

This solution uses an MSP430FR2000 MCU and any external host processor with UART, reset, and GPIO capability. This allows the reset line of the host processor to be controlled by the low-cost MSP430FR2000 MCU with 0.5KB of memory.

The reset pulse duration, initialized to 1 ms, is user configurable inside of the source code by changing the *Reset_Cycles* value. The watchdog interrupt (WDI) input is a signal generated by the host processor to notify the external WDT that it is working properly. A high-to-low transition within every *n* seconds (specified by the *timeout* selection value) keeps the external WDT from resetting the host processor. As a typical default, the time-out value is initialized to 1.6 seconds.

The backchannel UART of the MSP-FET or eZ-FET on an MSP430 LaunchPad™ development kit is used for the UART communication with a terminal program on the PC to send the commands for selecting each time-out value. Figure 1 shows how the MSP430FR2000 MCU can be connected to an MCU to act as an external WDT.

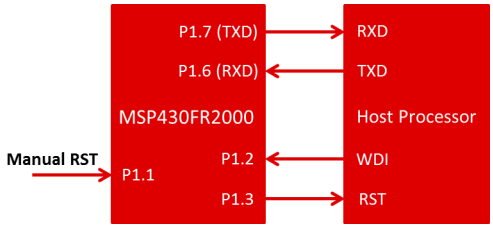

Figure 1. External Watchdog Timer Hardware Block Diagram

The external WDT uses interrupts to wake up from low-power mode to execute specific functions. Figure 2 shows how the software works with the hardware to reliably monitor a host processor.

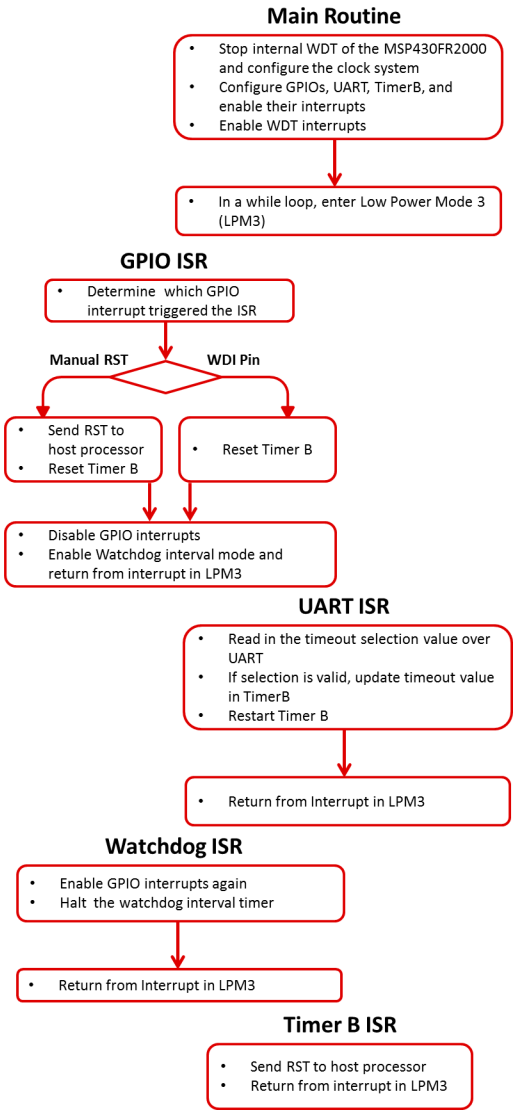

Figure 2. External Watchdog Timer Software Flow Chart

To run the demo on a PC, connect the LaunchPad kit or target development board to the PC, load the code into the device, allow the device to run, and end the debug session. The MSP-TS430PW20 target development 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).

At start-up, the code continues to send reset pulse signals from P1.3 unless it sees the watchdog being addressed by the WDI pin. Figure 3 shows the logic analyzer output from P1.3 when the WDT is and is not being addressed.

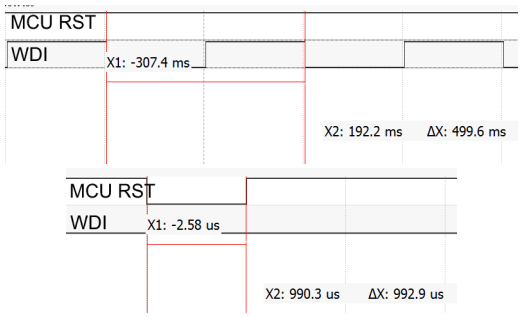

Figure 3. Logic Analyzer Output When Addressing and Not Addressing the WDT

In the top screenshot in Figure 3, the WDI input toggles every 500 ms, thus meeting the default time-out requirement and not causing the reset to be sent. In the bottom screenshot in Figure 3, the WDI input is held low, thus breaking the timing requirement and causing the reset line to pulse low for the default time of 1 ms.

To take advantage of the backchannel UART on the MSP-FET or the eZ-FET, use a terminal program on the PC set to 9600 baud, no parity, and 1 stop bit to select the time-out values. There are six acceptable values, selectable by sending hex values from 0 to 5. Table 1 lists the valid UART commands.

Table 1. Valid UART Watchdog Time-out Values

UART Command (Hex)	Time-out Value (Seconds)
0	1
1	1.2
2	1.4
3	1.6
4	1.8
5	2

An invalid UART command results in no change of the time-out value.

Performance

If a larger MSP430 microcontroller were used, then more features could be added to the solution. The current solution uses the internal reference oscillator running at 32768 Hz as the source for Timer_B, but an external crystal could be used to improve timing accuracy and decrease power consumption. More memory could allow a specific sequence or UART communication protocol to address the external WDT. Additional memory would also allow the user to program more time-out values into the external WDT, in addition to the six programmed in the provided example.

Using only the low-cost 0.5KB MSP430FR2000 MCU, this solution reliably monitors the state of a host processor and works to protect it from hanging up in an invalid loop.

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.

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 of RAM, 10-bit ADC, eComp
MSP430FR2111	3.75KB FRAM, 1KB RAM, 10-bit ADC, eComp

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