TI TechNotes

Hysteresis Comparator With UART Using Low-Memory MSP430™ FRAM MCUs

TEXAS INSTRUMENTS

Introduction

Comparators are used to differentiate between two different signal levels, like between overtemperature and normal temperature conditions. Because signal variation at the comparison threshold can cause multiple transitions, hysteresis upper and lower limits are applied to minimize the effects of noise. Hysteresis comparators can be crucial in applications that require window detectors or relaxed oscillators, including analog sensors, switching power supplies, level detectors, and function generators. This application uses the internal comparator of a microcontroller (MCU) to implement a hysteresis comparator with a UART interface. By using the UART, the host can set different hysteresis values and interrogate the MSP430™ MCU over the UART to provide the current hysteresis values in the same format. The MSP430FR2000 MCU can be used as a low-cost solution for this example. To get started, download project files and a code example demonstrating this functionality.

Implementation

For this application, the MSP430FR2000 MCU in the MSP-TS430PW20 target development board was used. The demonstration code requires an external 32768-Hz crystal with appropriate loading capacitors 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). 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). If system communication is not required for the end application, the external crystal and UART connections can be removed. See Figure 1 for a simple block diagram.

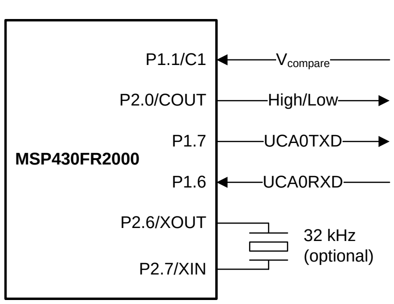

Figure 1. Hysteresis Comparator Block Diagram

The firmware implements the following communications protocol over UART:

READ/WRITE	D0	D1

Where READ = 00h, WRITE = 01h, and D0 and D1 are the data bytes to be written or requested as a response from the MSP430 MCU on the appropriate commands. D0 and D1 correspond to the CPDACBUF2 and CPDACBUF1 bits of the CPDACDATA register. Only the least significant six bits (0 to 63) of each byte are considered, and the two most significant bits are ignored.

01h	CPDACDATA_H	CPDACDATA_L

WRITE Hysteresis Command

00h	CPDACDATA_H	CPDACDATA_L

READ Hysteresis Command

For setting the hysteresis comparator, first select P1.1 (C1) as the input for the V+ terminal and the built-in 6-bit DAC as the input for the V– terminal. Then enable these pins accordingly in the CPCTL0 register.

The DAC is configured by setting CPDACCTL and CPDACDATA. Enable DAC output, choose VDD as the DAC reference voltage, and use the eCOMP output as the DAC buffer control source. This configuration realizes the hysteresis function, because the built-in DAC has a dual buffer. The buffer is controlled by the comparator output (P2.0) in this application. When the output is high, the input signal is compared to CPDACBUF2. When the output turns to low, the input signal is then compared to CPDACBUF1.

Figure 2 shows how CPDACBUF1 and CPDACBUF2 influence the comparator result.

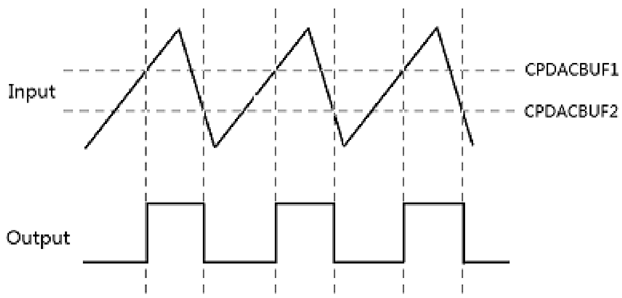

Figure 2. How CPDACBUF1 and CPDACBUF2 Influence the Result

The UART can be used to set different CPDACDATA values to change the hysteresis of the comparator.

After setting the built-in DAC, enable the comparator (CPCTL1) and set the MCU to low-power mode 3 (LPM3). CPCTL1 can also configure the output low-pass filter function if required.

There is another way to set up a hysteresis comparator with the MSP430 MCU. That is by setting the CPHSEL bits of CPCTL1. Three optional hysteresis settings are available for designers to choose among: 10 mV, 20 mV, and 30 mV. If these hysteresis settings can meet your requirements, this method is easier than setting the CPDACDATA.

For more hysteresis comparator information or references, see the Comparator With Hysteresis Reference Design.

Performance

The current consumption of this hysteresis comparatoris is approximately 7 µA, because of ultra-low-power performance of MSP430 MCU.

Figure 3 and Figure 4 show the results of different hysteresis values, where the yellow square wave is the input to P1.1/C1 and the blue square wave is the output generated by P2.0/COUT.

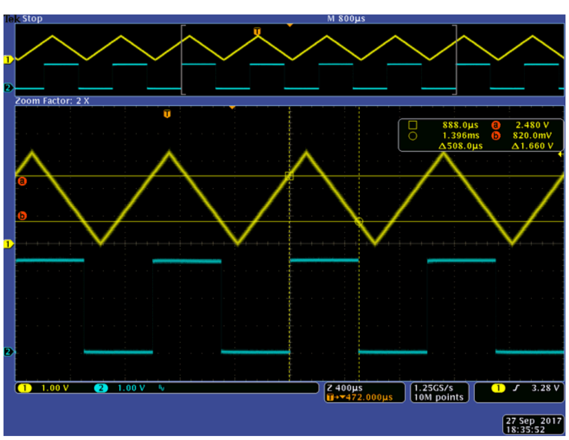

Figure 3. Scope of Input and Hysteresis Comparator Output (CADACDATA = 0x1030)

In Figure 3, CPDACBUF1 (0x30) is configured as ¾ DVCC and CPDACBUF2 (0x10) is configured as ¼ DVCC. Use Equation 1 to calculate the hysteresis voltage.

$$\text{Hysteresis voltage} = \text{Reference voltage} \times \text{CPDACBUFx} / 64 \quad (1)$$

In this application, the reference voltage is 3.3 V, CPDACBUF1 is 48 (0x30), and CPDACBUF2 is 16 (0x10). This results in two hysteresis voltages of 2.475 V and 0.825 V. These data are consistent with the measured results.

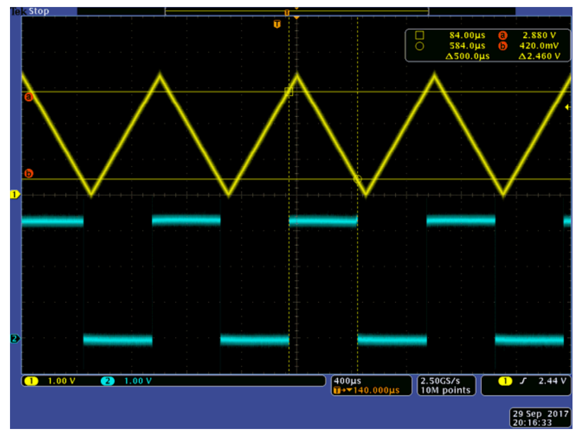

Figure 4. Scope of Input and Hysteresis Comparator Output (CADACDATA = 0x0838)

Using the MSP430FR2000 MCU is the best choice for this kind of application, because 0.5KB of memory is enough for the code needs, and the MCU has a functional built-in comparator.

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

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