

Rotary and Linear Motion Detection Using the MSP430™ Scan Interface and Optical Sensors

MSP430 Applications

ABSTRACT

The MSP430FW42x Scan Interface module provides an innovative way of detecting rotation and movement without the need for CPU intervention. While the interface was designed with LC and GMR sensors in mind, it is also possible to use the Scan Interface with optical sensors. The peripheral module performs the complete measurement sequence and the processing of the measurement results with no CPU intervention.

The source code described in this document can be downloaded from www.ti.com/lit/zip/slaa289.

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1 Theory of Operation

A common method to measure rotary or linear motion is to use a light barrier. An emitter and a detector coupled with a code-wheel translates rotary motion into a two-channel digital signal. Similarly, coupling the emitter and detector with a code-strip translates linear motion into a two-channel digital signal. [Figure 1](#) shows these systems.

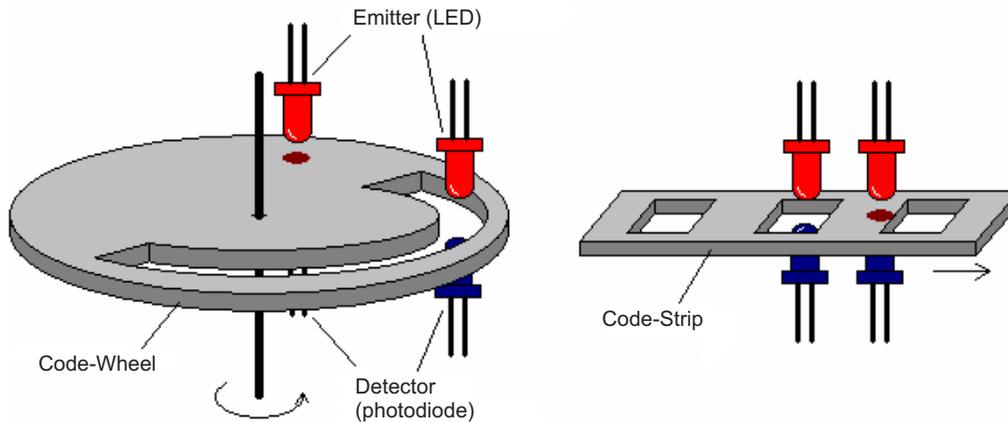


Figure 1. Emitter and Detector Coupled With a Code-Wheel and a Code-Strip

[Figure 2](#) shows the principle schematic. The system uses LEDs as its emitters. Opposite the emitters are the detector circuits (the photodiodes). Two comparators process the detector outputs and generate the output signals S1 and S2. The thresholds of the comparators are defined by the two reference voltages V_{ref1} and V_{ref2} .

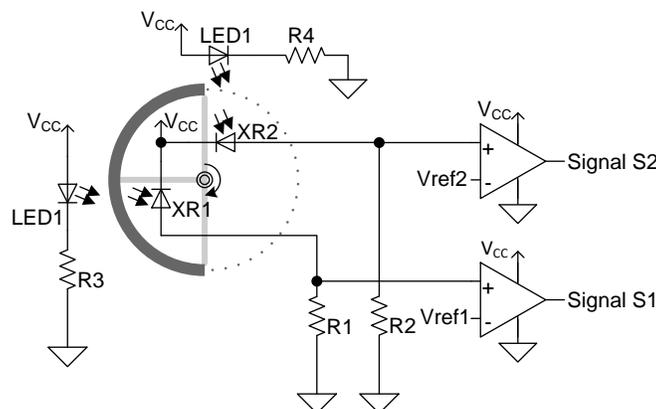


Figure 2. Example Schematic for Rotation Detection

The code-wheel or code-strip moves in the gap between the emitter and detector. The pattern of spaces and bars on the code-wheel or code-strip causes an interruption of the light beam. The light barriers that detect these interruptions are arranged in a pattern that corresponds to the radius and count density of the code-wheel or code-strip.

[Figure 3](#) shows the comparator output signals S1 and S2 for a system using a code-wheel (see [Figure 1](#)). Either the digital level of signal S1 or the digital level of signal S2 changes depending on the direction of the rotation. If the old state and the new state are known, it is possible to also detect the direction of rotation. The processing of these signals can easily be realized by using a state machine. The state machine stores the old state and, depending on the new measurements, the next state will be defined. For example, if state A is reached and the prior state was state D, a counter can be incremented to count the rotations. If the prior state was state B, the rotation direction was different, and the rotation counter can be decremented.

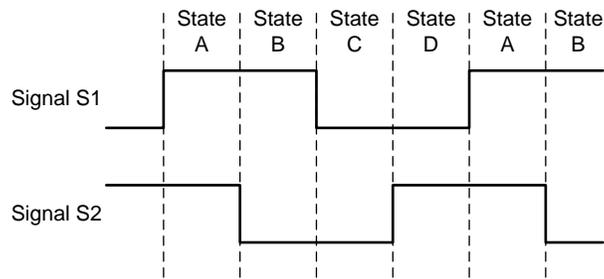


Figure 3. Digital Representation During Rotation

2 MSP430FW42x Solution

The Scan Interface module in the MSP430FW42x microcontroller can be used to automatically measure linear or rotational motion with the lowest possible power consumption. The reduction of power consumption is realized by switching off parts of the peripheral module and performing measurements only with a defined sample rate. Instead of two comparators, only one comparator is used, and the analog input signals are sequentially measured through a multiplexer. After each measurement sequence, the results are processed.

Figure 4 shows the schematic of an example rotation detection implementation using optical sensors.

Bill of Materials

R1	100 kΩ
R2	100 kΩ
R3	47 kΩ
C1	100 nF
Q1	32768 Hz
LED1	LD274
LED2	LD274
XR1	SFH203
XR2	SFH203

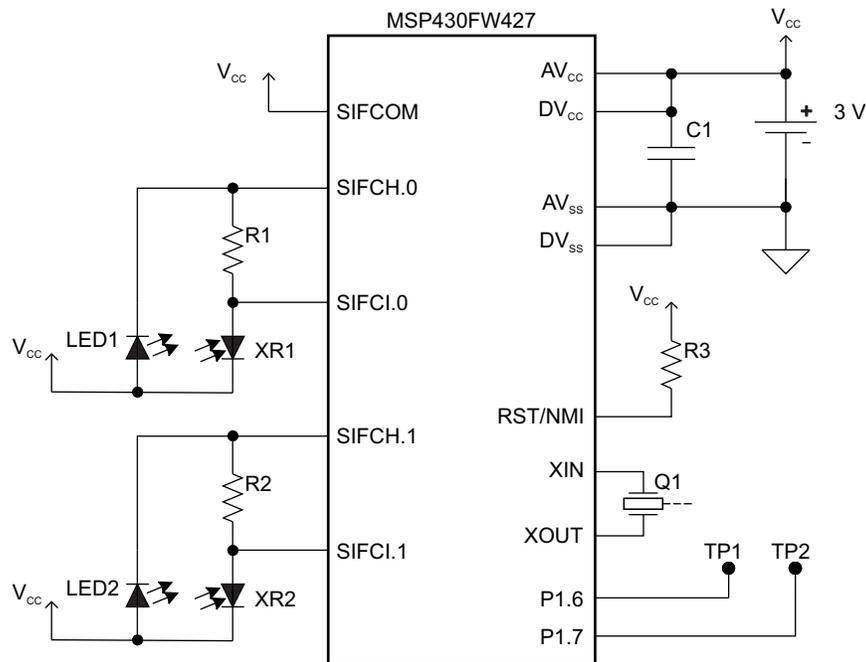


Figure 4. Example Schematic for Rotational or Linear Motion Detection Using Optical Sensors

Figure 4 needs a 32-kHz crystal. The Scan Interface uses the 32-kHz clock signal to define the sample rate. The Scan Interface can also be used to measure and calculate the rotation speed.

3 Software Implementation

The Scan Interface timing state machine (TSM) defines the measurement sequence. First, the DAC and comparator are switched on. Both modules have a maximum settling time of 2 μ s.[1] The next step is to select the SIFCH.0 and SIFCI.0 channels for the next measurement and excite (switch on) the first optical sensor. After a short sensor settle time, the measurement is performed. The next step is to select SIFCH.1 and SIFCI.1 channels. After a short sensor settle time for the second optical sensor, the measurement is performed. Finally the DAC, comparator, and all optical sensors are switched off to reduce the current consumption.

When a measurement sequence is finished, the Scan Interface processing state machine (PSM) is triggered. The measurement results of the previous sequence are processed.

A detailed description of the PSM state diagram can be found in the application report [Rotation Detection With the MSP430 Scan Interface](#) in the section about advanced two-sensor PSM. The optical-sensor demonstration uses the same state diagram as the LC-sensor demonstration.

4 Analysis

An optical sensor solution has some advantages compared with an LC-sensor solution. The measurement of two optical sensors takes approximately 6 μ s. The LC-sensor solution using two sensors takes approximately 60 μ s – ten times longer than the optical sensor solution. One benefit of this is that the optical sensor solution can be used to detect higher rotation speeds. However, the current consumption of the optical-sensor system is usually higher than the current consumption of an LC-sensor system.

Another advantage of the optical sensor is that the comparator threshold is more stable than in the LC-sensor system. The adjustment of the SIFDAC registers, which define the comparator thresholds for the different LC sensors, is not needed in the optical-sensor system.

5 References

1. [MSP430FW42x Mixed-Signal Microcontrollers](#)
2. [MSP430x4xx Family User's Guide](#)
3. [Rotation Detection With the MSP430 Scan Interface](#)
4. [MSP430FW42x Scan Interface SIFCLK Adjustment](#)

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from January 5, 2007 to July 19, 2018

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- Editorial changes throughout document..... 1
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