



## AN015 Integrating Kionix Tri-Axis Accelerometer Evaluation Board with Microcontroller Development Boards

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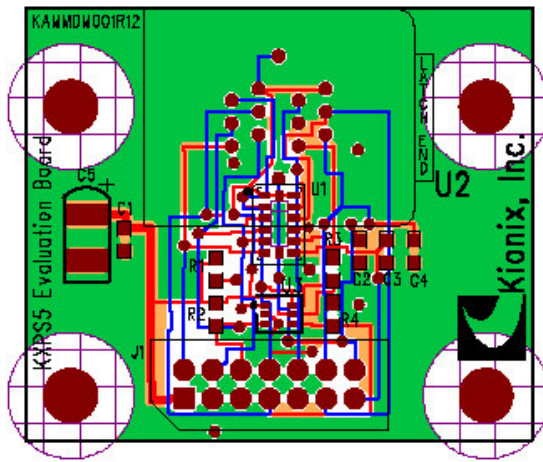
### Introduction

Frequently, customers ask how their microcontroller can interface with a Kionix tri-axis accelerometer. Sometimes they request custom development boards to be made with a particular microcontroller and a Kionix accelerometer paired on the board. Using this custom development board, they are able to develop motion based applications. Given the nearly infinite number of microcontroller products available, however, it is impossible to create custom development boards for each one. Therefore, Kionix provides an evaluation board for each of its products. These evaluation boards give the customers easy access to all of the accelerometer's input and output pins. Through some simple connections, the boards can be connected to any microcontroller's development board.

In this application note, a description of the Kionix evaluation board is given. Then, through schematics and photographs, the hardware connections between some example microcontroller development boards and Kionix evaluation boards are shown. Finally, some example firmware is given to demonstrate communication between the microcontroller and the Kionix accelerometer.

### The Kionix Evaluation Board

The Kionix evaluation board is a small printed circuit board with a Kionix accelerometer (or a socket for a Kionix accelerometer) soldered to it. An example of an accelerometer evaluation board is shown in Figure 1 for the KXPS5. The connector provides access to each of the pins of the accelerometer. Several other components like capacitors and resistors may be on the board as well. These components are typically decoupling capacitors, low pass filter capacitors, or pull-up or pull-down resistors for the proper termination of digital communication lines. Either there is a single accelerometer soldered to the board as shown in Figure 1, or a socket is soldered to the board to allow for the testing of multiple parts – usually with different factory programmed settings – without the needed for multiple evaluation boards. In this way, accelerometers with different g-ranges, for example, can be tested. Screw holes are located in each of the corners. These holes can be used to mount the evaluation board to an object or a surface or to attach stand-offs to the board.



J1 Connector Pin Description	
pin 1	VDD
pin 2	Enable
pin 3	GND
pin 4	SCL/SCLK
pin 5	GND
pin 6	SDA/SDO
pin 7	ADDR/SDI
pin 8	CS
pin 9	GND
pin 10	MOT EN
pin 11	FF/MOT
pin 12	Out Z
pin 13	Out Y
pin 14	Out X

Outer Dimensions: 3.0cm x 3.5cm

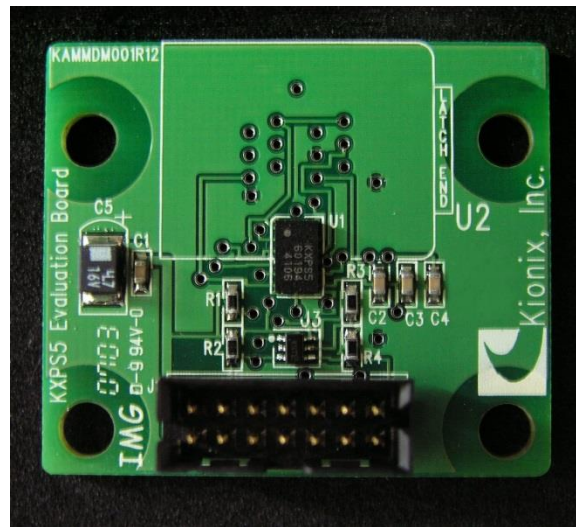


Figure 1: The KXPS5 evaluation board with connector pin descriptions.

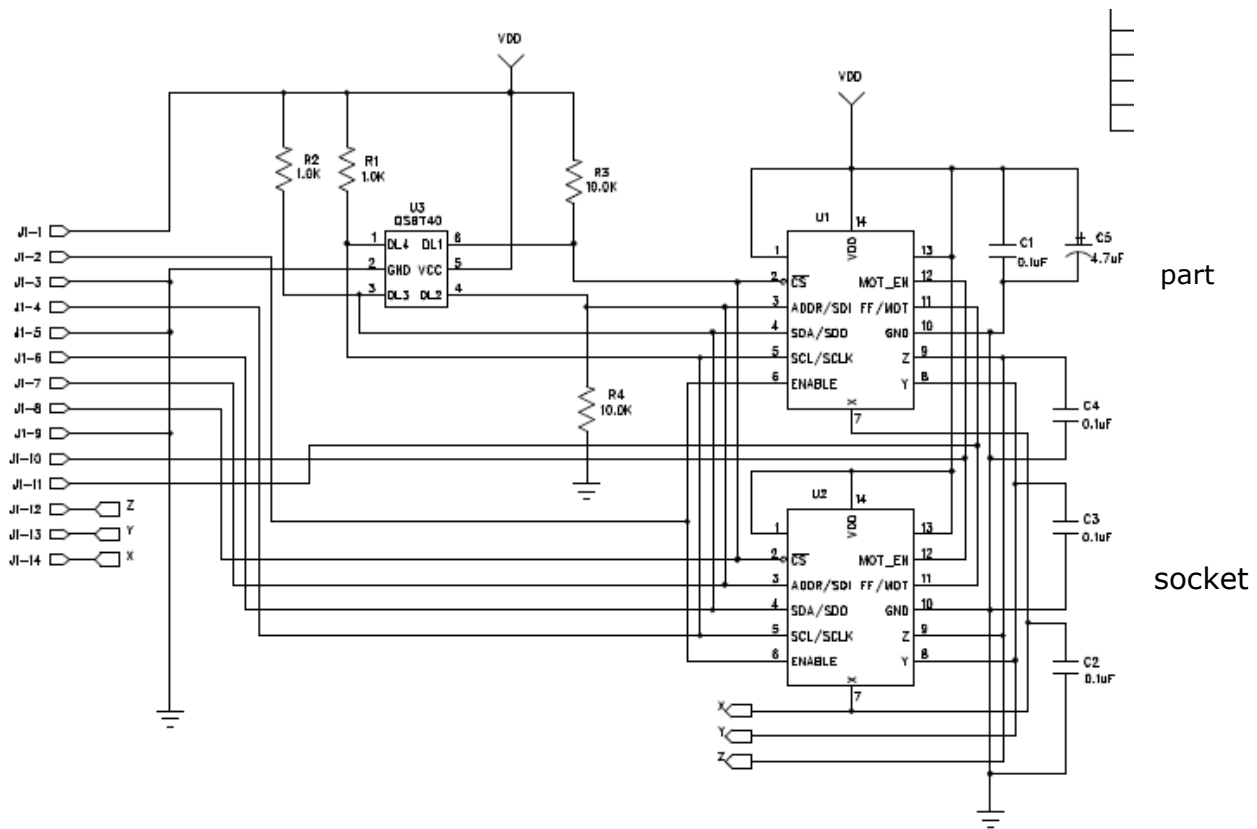


Figure 2: The schematic for the KXPS5 evaluation board

Information about all of the Kionix accelerometer evaluation boards can be found at <http://www.kionix.com/developer-tools>

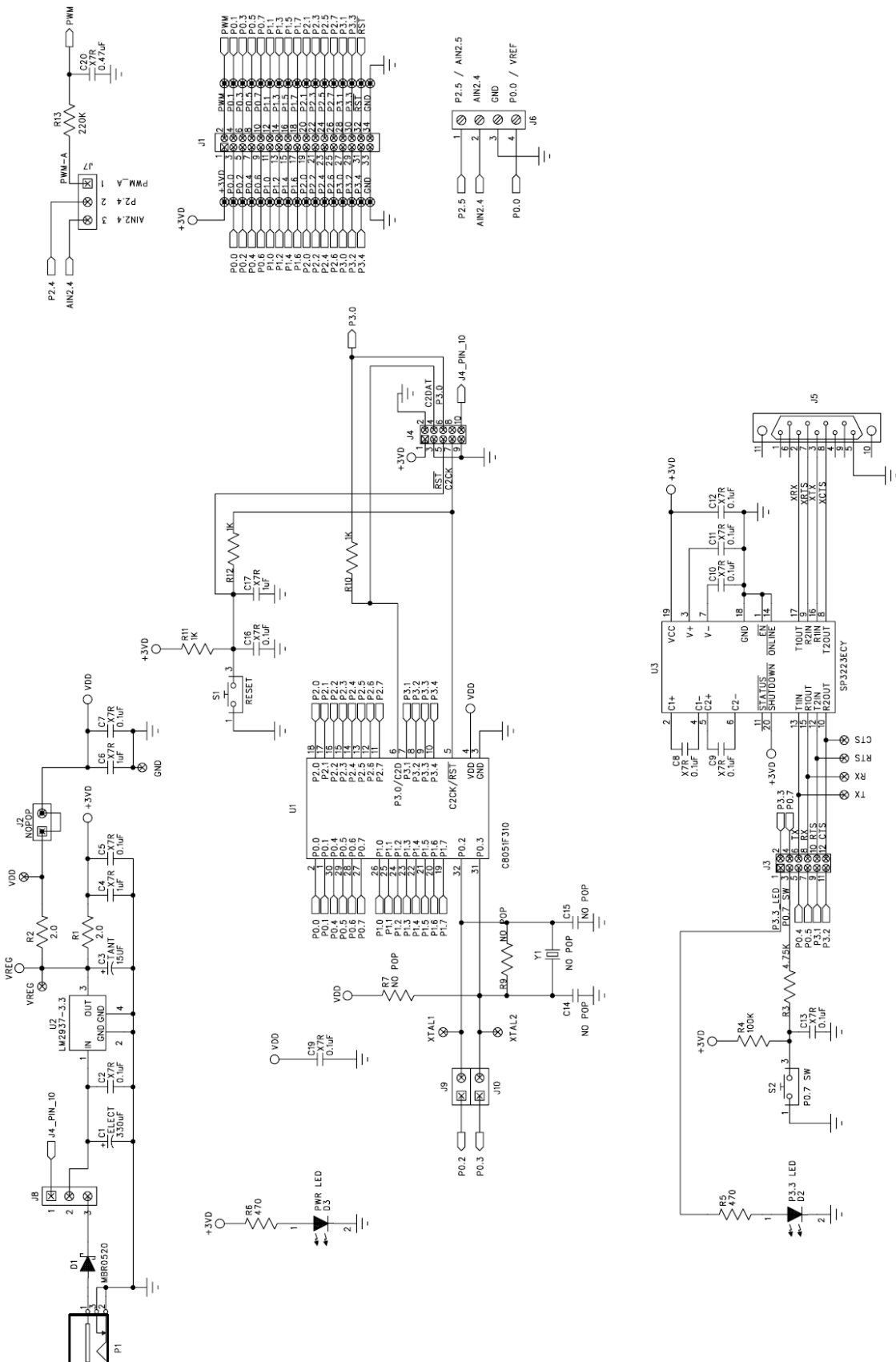
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## Hardware Implementation

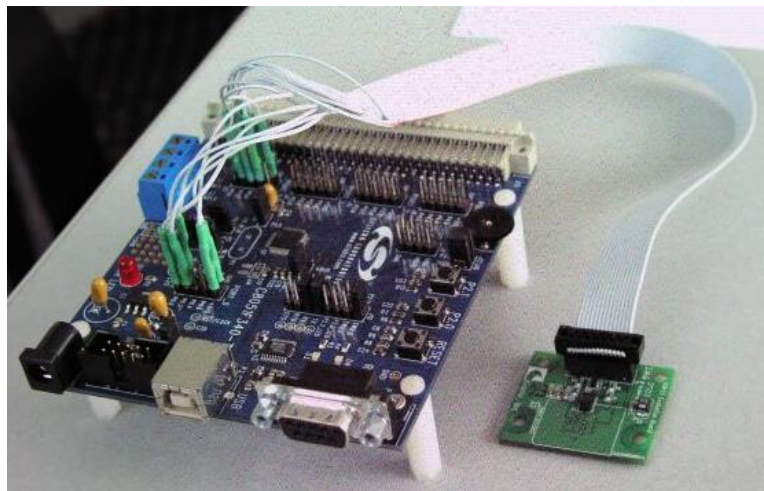
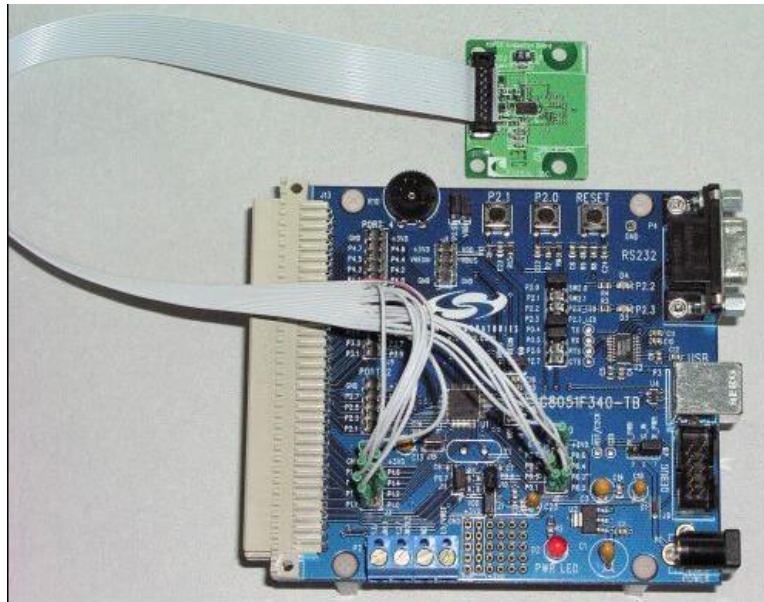
To assist with firmware and product development with their microcontrollers, most companies that provide microcontrollers also provide a development board or kit. These kits give developers a platform from which they can develop their firmware on the same part or a part from the same family that they will be using in their application. These development kits also provide an excellent platform for developing motion based applications when paired with one of Kionix's evaluation boards. As an example, we will show how to connect one of Kionix's evaluation boards to a Silicon Laboratories C8051F340 development board. Information about the C8051F340 development kit can be found at:

[http://www.silabs.com/tqwWebApp/public/web\\_content/products/Microcontrollers/USB/en/C8051F340DK.htm](http://www.silabs.com/tqwWebApp/public/web_content/products/Microcontrollers/USB/en/C8051F340DK.htm)

The schematic for the development board is shown on the following page.



As is typical for these development boards, the board has connectors or headers for connecting to all of the input/output pins of the microcontroller as well as the supply voltage and ground.



The following table shows the connections made between the KXPS5 evaluation board and the C8051F340 development board.

KXPS5	F340
Vdd	Vdd
nCS	P0.3
MOT_Enabl e	P2.5
Enable	P0.5
SCLK/SCL	P0.4
SDO/SDA	P0.1

KXPS5	F340
Gnd	Gnd
SDI/Addr	P0.2
FF/MOT	P0.6
Out X	P2.1
Out Y	P2.2
Out Z	P2.3

This is only one of many possible ways to connect the evaluation board to this development board. Of course, the connections will vary based on the particular microcontroller being used and the additional components connected to that microcontroller for the given application.

## Firmware Implementation

With the KXPS5 evaluation board connected to the C8051F340 development board, firmware can be written to communicate between the two parts. The following is an example of firmware to configure and communicate over the SPI digital communication bus.

```
// SPI_Transfer() - sends and receives a byte on the SPI bus
unsigned char SPI_Transfer(unsigned char txbyte)
{
    SPIF = 0; // clear SPI complete flag
    SPI0DAT = txbyte; // transmit a byte by loading it into transmit buffer
    while (!SPIF); // wait until end of transmission
    return SPI0DAT; // retrieve data from the slave
}

// wait() - uses timer2 to wait for a certain amount of time
void wait(int counts)
{
    TF2H = 0; // clear interrupt flag
    TMR2CN = 0x00;
    TMR2 = -counts; // timer will overflow in counts timer clock cycles (SYSCLK/12)
    TR2 = 1; // turn on timer
    while(!TF2H); // wait until timer interrupts
    TMR2CN = 0x00; // clear interrupt flag, turn timer off
}

sbit CS = P0^3; // Chip Select is controlled manually

// read_accel() - reads acceleration from the accelerometer
unsigned int read_accel(unsigned char axis)
{
    unsigned int output = 0;
    CS = 0; //CS low
    SPI_Transfer(axis); // command to convert axis
    // wait at least 200 microseconds for Analog to Digital conversion
    wait(200);
    output = SPI_Transfer(0x00); // read first 8 bits
    output = output<<8; // shift the first 8 bits to the left
    output |= SPI_Transfer(0x00); // read the second 8 bits
    output = output>>4; // right shift by 4 bits to go from 16 to 12 bits
    CS = 1; // CS high
}
```

```
    return output;
}

int main(void)
{
    // Add a section to initialize oscillator, watchdog timer, port I/O, SPI clock speed

    CS = 0; // Lower Chip Select to start SPI communication
    SPI_Transfer(0x06); // send command to write to Reset_write register
    SPI_Transfer(0xCA); // send key to load offset, sensitivity, and temperature correction values into RAM
    CS = 1; // raise Chip Select

    while(1)
    {
        int Xaccel = read_accel(0x00);
        int Yaccel = read_accel(0x02);
        int Zaccel = read_accel(0x04);
    }
}
```

## The Kionix Advantage

Kionix technology provides for X, Y, and Z-axis sensing on a single, silicon chip. One accelerometer can be used to enable a variety of simultaneous features including, but not limited to:

- Hard Disk Drive protection
- Vibration analysis
- Tilt screen navigation
- Sports modeling
- Theft, man-down, accident alarm
- Image stability, screen orientation & scrolling
- Computer pointer
- Navigation, mapping
- Game playing
- Automatic sleep mode

## Theory of Operation

Kionix MEMS linear tri-axis accelerometers function on the principle of differential capacitance. Acceleration causes displacement of a silicon structure resulting in a change in capacitance. A signal-conditioning CMOS technology ASIC detects and transforms changes in capacitance into an analog output voltage, which is proportional to acceleration. These outputs can then be sent to a micro-controller for integration into various applications. For product summaries, specifications, and schematics, please refer to the Kionix MEMS accelerometer product sheets at <http://www.kionix.com/parametric/Accelerometers>.