

ESET 369 LAB 5 REPORT

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INTRODUCTION

The purpose of this experiment is to configure the MSP430FR5944 Launchpad board to interface with a 2-axis analog joystick and a QTR-3A reflectance sensor, displaying real-time voltage readings on a 16x2 LCD screen. Additionally, the system expands upon previous implementations by integrating LED indicators to visually represent specific sensor conditions. By utilizing analog-to-digital conversion (ADC) in a 12-bit mode, the system captures voltage variations corresponding to joystick movements and surface reflectance levels. The experiment aims to reinforce an understanding of microcontroller-based data acquisition, LCD interfacing, and LED control while ensuring accurate and efficient data processing.

SYSTEM A

The purpose of System A is to correctly configure the MSP430FR5944 Launchpad board to display the X and Y position voltage readings of a 2-axis joystick and display the voltage reading of a reflectance sensor on the BH board 16x2 LCD screen using a C/C++ code sequence. The reflectance sensor being used is a “QTR-3A Reflectance Sensor Array” from Pololu and the 2-axis joystick being used is an “Analog 2-axis Thumb Joystick with Select Button + Breakout Board” from Adafruit. They can be seen in Figure 1 and Figure 2 respectively.

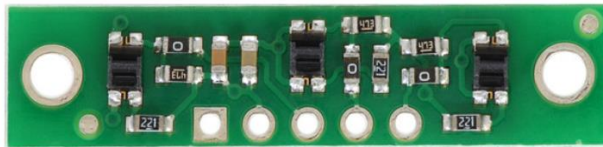


Figure 1: QTR-3A Reflectance Sensor Array



Figure 2: Analog 2-axis Thumb Joystick with Select Button + Breakout Board

The joystick will be tested for four different conditions. These conditions are when it is pushed right (positive x), left (negative x), up (positive y), and down (negative y). The voltage reading for each condition will be recorded. The reflectance sensor will be tested for two different conditions using a black and white piece of paper. The first condition is with the color white and the second condition is with the color black, each being within 0.5 inches or less of the sensor. The voltage reading for each condition will be recorded. To obtain these voltages the LCD screen will be used to display them. This involves creating a program to display the corresponding multiple converted voltages from three given ADC channels for the analog joystick and reflectance sensor. These three converted voltage values are measuring the readings from the X-axis output of the analog joystick, Y-axis output of the analog joystick, and the output of the reflectance sensor. The X-axis and Y-axis output readings from the analog joystick must be displayed with 2 decimal places on the first line of the LCD using "X:0.00" and "Y:0.00" while the reflectance sensor output must be displayed with two decimal places on the second line using "R:0.00". The ADC should work in a 12-bit mode and the values should be updated on the LCD reasonably fast.

The first step in addressing this problem is making the physical board connections between the BH board and the MSP430FR5994 microcontroller. This can be done by connecting eighteen specific pins together using male-to-female/female-to-female jumper wires, checking that all the DIP switches on the BH board are in the correct configuration, and ensuring the microcontroller itself is properly seated on the BH board. For the 16x2 LCD screen pin P8.3 connects to RS, P8.2 connects to R/W, P8.1 connects to E, P3.0 connects to DB0, P3.1 connects to DB1, P3.2 connects to DB2, P3.3 connects to DB3, P3.4 connects to DB4, P3.5 connects to DB5, P3.6 connects to DB6, and P3.7 connects to DB7. For the Reflectance Sensor the G port of the sensor connects to the GND port, V port of the sensor connects to 3.3V port, and 2 port of the sensor connects to pin P4.3. For the 2 Axis Analog Joystick the GND port of the joystick connects to the GND port, VCC port of the joystick connects to 3.3V port, Xout port of the joystick connects to P4.1, and Yout port of the joystick connects to P4.2.

Using the code sequences created for previous labs that were based on code sequences found in: *Learning Embedded Systems with MSP430 FRAM microcontrollers* by B. Hur, as references the code sequence used for this system was created. One part of the system was coded and tested at a time to ensure that there were no issues with the code or the hardware. The code is designed to interface an MSP430FR5944 microcontroller with a 16x2 LCD display, a 2-axis analog joystick, and a QTR-3A reflectance sensor. It begins by disabling the watchdog timer and unlocking GPIO to ensure proper operation. The ADC is configured to read from three channels corresponding to the joystick's X and Y axes and the reflectance sensor, using a 12-bit resolution. The LCD display and LEDs are initialized, with specific GPIO pins assigned for communication and output control. Inside the infinite loop, an ADC conversion sequence is initiated, and the program waits for all three readings to complete before storing them in an array. These raw ADC values are converted into voltage readings based on the reference voltage of 3.3V and the 12-bit ADC range of 0-4095. The joystick's voltage values are used to determine movement directions, and LEDs are turned on or off accordingly using an active-low logic. Similarly, the reflectance sensor voltage determines whether the surface is black or white, toggling an LED in response. The calculated voltage values

are then formatted and displayed on the LCD with two decimal places. The LCD operates in 8-bit mode, and commands are sent to control cursor positioning and character output. A delay is introduced to regulate update speed and prevent excessive flickering on the display. The resulting voltage values for all conditions that were tested with this code sequence can be seen in Table 1.

Table 1: System A Measurement Values

	Voltage Value (Volts) (V)
Voltage (X-axis) (Right/Center/Left)	3.29/1.65/0
Voltage (Y-axis) (Up/Center/Down)	3.29/1.65/0
Voltage (Case A – Black, Reflectance sensor)	2.70
Voltage (Case B – White, Reflectance sensor)	0.19

SYSTEM B

The purpose of System B is to correctly configure the MSP430FR5944 Launchpad board to not only display the X and Y position voltage readings of a 2-axis joystick and display the voltage reading of a reflectance sensor on the BH board 16x2 LCD screen, but also trigger an LED on the BH board LED bar based on certain conditions using a C/C++ code sequence. The joystick will be tested for four different conditions. These conditions are when it is pushed right (positive x), left (negative x), up (positive y), and down (negative y). For the up position the first LED, on the LED bar, from the right side, should turn on. For the right position the second LED, on the LED bar, from the right side, should turn on. For the down position the third LED, on the LED bar, from the right side, should turn on. For the left position the fourth LED, on the LED bar, from the right side, should turn on. The reflectance sensor will be tested for two different conditions using a black and white piece of paper. The first condition is with the color white and the second condition is with the color black, each being within 0.5 inches or less of the sensor. For the black color the first LED, on the LED bar, from the left side, should be off. For the white color the first LED, on the LED bar, from the left side, should be on.

The first step in addressing this problem is making the physical board connections between the BH board and the MSP430FR5944 microcontroller. This can be done by connecting twenty three specific pins together using male-to-female/female-to-female jumper wires, checking that all the DIP switches on the BH board are in the correct configuration, and ensuring the microcontroller itself is properly seated on the BH board. For the 16x2 LCD screen pin P8.3 connects to RS, P8.2 connects to R/W, P8.1 connects to E, P3.0 connects to DB0, P3.1 connects to DB1, P3.2 connects to DB2, P3.3 connects to DB3, P3.4 connects to DB4, P3.5 connects to DB5, P3.6 connects to DB6, and P3.7 connects to DB7. For the Reflectance Sensor the G port of the sensor connects to the GND port, V port of the sensor connects to 3.3V port, and 2 port of the sensor connects to pin P4.3. For the 2 Axis Analog Joystick the GND port of the joystick connects to the GND port, VCC port of the joystick connects to 3.3V port, Xout port of the joystick connects to P4.1, and Yout port of the joystick connects to P4.2. For the LED bar, pin P6.0 connects to LED1, P6.1 connects to LED2, P7.0 connects to LED3, P7.1 connects to LED4, and P6.2 connects to LED5.

Using the code sequences created for previous labs that were based on code sequences found in: *Learning Embedded Systems with MSP430 FRAM microcontrollers* by B. Hur, as references the

code sequence used for this system was created. One part of the system was coded and tested at a time to ensure that there were no issues with the code or the hardware. The code configures the MSP430 microcontroller to read analog voltage values from a two-axis joystick and a reflectance sensor, process the data, and display the results on a 16x2 LCD screen. It also controls an LED bar based on specific conditions. The watchdog timer is disabled, and GPIO functionality is enabled. The ADC is set up to read values from three input channels corresponding to the X and Y positions of the joystick and the reflectance sensor. After initiating an ADC conversion, the raw data from each channel is stored in an array, converted to voltage using a scaling factor of $3.3\text{V}/4095$, and then split into integer and decimal parts. The LCD is initialized and used to display the voltage values in a formatted manner. The LED bar is controlled based on predefined conditions: different LEDs turn on when the joystick is pushed in a certain direction, and the first LED on the left side is controlled by the reflectance sensor's reading of a black or white surface. The hardware connections involve linking the LCD, joystick, reflectance sensor, and LED bar to specific GPIO pins on the microcontroller. The program continuously reads sensor data, updates the LCD display, and adjusts the LED bar state accordingly, ensuring that all components function correctly in real-time.

CONCLUSION

The experiment successfully demonstrated the ability to interface an MSP430FR5944 microcontroller with an LCD display, joystick, and reflectance sensor while incorporating LED indicators for condition-based feedback. The recorded voltage values accurately reflected joystick movements and surface reflectance, validating the functionality of the ADC conversion and display mechanisms. Additionally, the LED bar responded correctly to predefined conditions, further reinforcing the effectiveness of the system. The results confirm a solid understanding of embedded systems programming, sensor integration, and real-time data visualization.

REFERENCES

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