	ECGR 4101/5101 LAB 6 Report	10/26/2023
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Lab Objective:

The objective of this lab was to enhance the complexity of the previous lab by incorporating UART along with an Ultra Sonic Sensor. The goal was to program an application to measure the distance of an object in the range of 0 to 400 cm using an Ultrasonic Sensor and transmit the value to display it on the quad-digit display. This was expected to be achieved with an efficient and concise code, keeping the number of executable lines minimal, thus ensuring optimized application.

Lab Figures/Tables:

Table 1: Board 1 PIN Mappings

PIN # on PORT 1	Purpose
PIN 0	Connected to GND for Board Identification
PIN 2	UART Connection with Board 2
PIN 3	TRIGGER (For Ultrasonic Sensor)
PIN 4	ECHO (For Ultrasonic Sensor)

PIN 0 was connected to GND to identify which board the program should be sent, and in this case Board 1. PIN 2 was connected to Board 2 for UART Communication between the two boards. To connect the Ultrasonic Sensor to the board, 4 connections were made including the GND and VCC to 3.3 V. PIN 3 and PIN 4 were connected to the Trigger and Echo to trigger a wave and calculate the echo length. Table 1 shows the connections for Port 1 of the 1st Board.

Table 2: Board 2, PORT 1 PIN Mappings

PIN # on PORT 1	Purpose
PIN 0	Connected to 3.3V for Board Identification
PIN 1	UART Connection with Board 1
PIN 4	Power to Digit 1
PIN 5	Power to Digit 2
PIN 6	Power to Digit 3
PIN 7	Power to Digit 4

On the 2nd Board, PINS 4 through 7 were connected to the Quad-Digit display powering the 4 digits of the display. PIN 1 of this board was connected to the 1st board for UART communication. This board was the Receiver in this communication setup and PIN 0 was thus connected to 3.3V. Table 2 provides an overview of the same.

Table 3: Board 2, PORT 2 PIN Mappings to Segments on the Quad 7-Segment LED Digits

PIN # on PORT 2	Segment
PIN 0	a
PIN 1	b
PIN 2	c
PIN 3	d
PIN 4	e
PIN 5	f
PIN 6	g
PIN 7	dp

PINS 0 through 7 on PORT 2 of Board two were connected to each of the 7 segments on the digits of the Quad-Display and the 7^{th} pin was connected to the decimal point. Table 3 provides an overview of the same.

Table 4: Hex Digit's Binary and Hexadecimal Values Used

Hex Digit	Binary Combination	Hexadecimal Combination
0	1100 0000	0xC0
1	1111 1001	0xF9
2	1010 0100	0xA4
3	1011 0000	0xB0
4	1001 1001	0x99
5	1001 0010	0x92
6	1000 1001	0x82
7	1111 1000	0xF8
8	1000 0000	0x80
9	1001 0000	0x90

By using an array of 10 elements that stored the hexadecimal combinations of the 10 unique digits (0-9), the code was efficiently optimized and reduced. The connections were made assuming an Anode. i.e., 0 represented OFF and 1 represented ON. To display the digits, a predefined combination from one of the 10 values was used and turned ON. Table 4 shows a list of the hex digits, its binary, and hexadecimal representation.

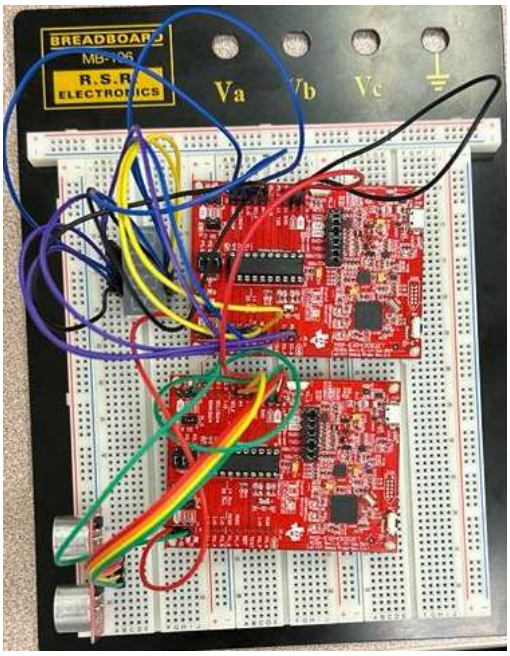

Figure 1: Connections made between the two MSP430 Boards, Breadboard, Quad-Digit Display, and the Ultrasonic Sensor

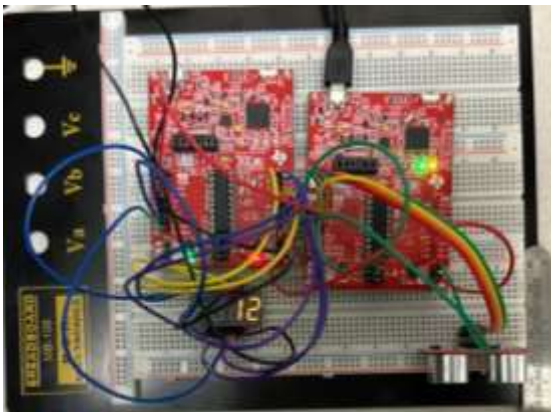

Figure 2: Ultrasonic Sensor Readings

Figure 2 above shows an image with the reading of 12 on the Quad-Digit Display. To check for the accuracy, a ruler was used for measuring the distance from the sensor to the wall. The ruler's starting point in at 120 mm, which is in fact 12 cm. Thus, it can be concluded that the sensor's readings are accurate.

Commentary and Conclusion:

In lab 6, two MSP430g2553 boards were interconnected and UART was used for communication. Similar to previous labs, requirements for this lab were addressed incrementally. Initially, the code from the previous lab was used as a starting point, which was

then edited, and refined as necessary. The code from the previous included UART communication, Quad-Digit display and some Timers and Interrupts. With this part of the code working, the Ultrasonic Sensor was tested separately using a single board. Simple if statements were added to see if any distance was being measured. If any distance was recorded, LED was toggled. Finally, everything was connected together and then tested for any issues with the hardware as well as the software.

During the lab, a few major challenges were encountered. Some were solved and implemented correctly, while an issue of sending two bytes of data by breaking was not solved, hence taken out and not implemented as it was disrupting the regular working of the code. One of the problems was the flickering of digits on the quad display. This problem was solved when the code from lab 7 (Stopwatch) was used. Also, the timers and interrupts were successfully used for the display as well as for the ECHO and TRIGGER for the Ultrasonic Sensor. Only, in one place, which was sending the TRIG wave for 10 microseconds, the Timer was not implemented. For this, an unsuccessful attempt of using Timer A1 was made. Like other instances, using a single timer for all the situations proved difficult due to scaling TACCR0 Register issues.

One of the problems that was left unresolved was the sending of two bytes of data across the UART. For this, the idea was to split the data into two bytes and send each individual byte and join it together on the Rx side by shifting the lower byte by 8 places to the right and Oring it with upper byte to get back the full value. Several methods with minor changes were tried, but this caused Quad-Digit to display a lot of random garbage values. As a result, the code for this mechanism was taken out of the entire, working code.