ELECTRICAL AND ELECTRONICS
ENGINEERING DEPARTMENT

EE447 LABORATORY PROJECT
TEMPERATURE-INITIATED OBJECT DETECTION

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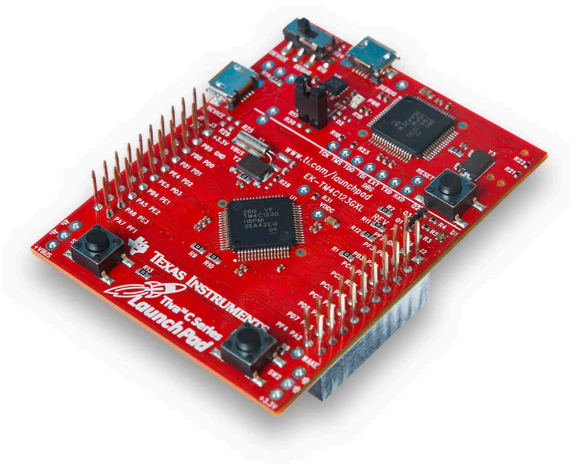

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1.Introduction

The report presents the implementation of Temperature-Initiated Object Detection, the project of the course EE447 Introduction to Microprocessors. The system comprises heat sensing, object detection, and a user interface. In the project, we utilize the TM4C123G microcontroller as the core. The first objective of the project is to build a multi-functional system that detects temperature increases and the closest object. For this objective, there are heat sensing, step motor, and distance measurement units. The second objective of the project is to display measurements to the user. Displaying unit of the projects takes a role in this objective. In addition to those objectives, there are also deep sleep and analog comparator units for saving energy and necessary

2. Components

1. NOKIA 5110 LCD Screen
2. Step Motor
3. HC-SR04 Ultrasonic Distance Sensor
4. LM35 Analog Temperature Sensor
5. BMP280 Pressure and Temperature Sensor
6. Speaker
7. Trimpot
8. 4x4 Keypad

9. Transistors
10. 1W Power LED

3. Project Units

3.1. Deep Sleep Unit

The deep sleep unit has critical importance in the power consumption of the system. When the system is idle, it enters the deep-sleep mode and the essential components remain active. In the deep-sleep mode, the analog comparator unit is active to wake up the system again. The interrupt of the analog comparator unit wakes up the system.

3.2. Analog Comparator Unit

In the analog comparator unit, there are 2 hardware components. LM35 measures the ambient temperature and the adjustable trimpot puts a threshold value for the comparator unit. With proper GPIOC(6-7) and COMP initializations, comparing unit gives an interrupt when the ambient temperature is higher than the threshold value.

3.3. Temperature Measurement Unit

The BMP280 is a high-precision barometric pressure sensor developed by Bosch Sensortec. This versatile sensor integrates temperature measurement capabilities alongside barometric pressure readings. Inside of BMP, there are couple of registers and some of those registers contains the temperature data and some of them contains pressure data. In our project, no pressure sensing were needed therefore we were only interested in temperature registers.

Also, BMP280 supports both communication protocols I2C and SPI. In our project we used I2C communication protocol in order to take the data from BMP280 and send it to our Tiva Board. We used GPIOC0 and GPIOC1 as Serial I/O pins.

I2C uses a master-slave relationship between devices, and can only send 1-byte(8 bit). Therefore, we had to search the data sheet of BMP280 to find its slave address and the register addresses which the temperature data is being held. After all the necessary data is found, we start communication by simply sending a start signal and afterwards, slave address, register addresses, read or write commands are as follows. Lastly an end signal is being sent to the sensor and the communication is finished.

After we take raw temperature from BMP280, we are calibrating it by using the algorithm that has been shared at BMP280s datasheet. By doing this procedure continuously, we have achieved the ability to update the temperature data whenever we want.

3.4. Step Motor Unit

Step motor unit is the unit that is responsible for scanning 180 degrees, turning the distance sensor. In order to turn the distance sensor, we mount the distance sensor on top of our step motor.

In the code, we are simply checking the value of the digital threshold and the temperature data continuously and if the temperature increases above the threshold, we are initializing the Systick timer module.

Then we are driving the motor by giving full steps, until it scans an area of angle of 180 degrees. After the first scanning is done, the shaft goes back to its initial position so that it gets ready for further scanning. In Figure 1, representations of full step driving of a step motor is given. GPIO pins PE1-PE2-PE3-PE4 are used to give these outputs to the step motor.

Step No.	Out_0	Out_1	Out_2	Out_3
Full Step 1	1	0	0	0
Full Step 2	0	1	0	0
Full Step 3	0	0	1	0
Full Step 4	0	0	0	1

Figure 1

3.5. Distance Measurement Unit

For distance measurement, we used HC-SR04 Ultrasonic Distance Sensor. It works by sending an input signal and listening to the signal. A timer, calculates the time it passes to listen to the sent input signal and by doing some calculations, we can measure the distance of the sensor from an object. In Figure X, you can see the trigger and echo pulse of this distance sensor.

In our code, we are sending the trigger and listening signals inside of the systick handler by closing the systick, measuring the distance, saving the measured distance to an array and then opening the systick again.

Our code does this process around 33 times, so that it can scan almost every angle without disturbing the step motor.

After the scanning is finished, our code iterates over the distance array and finds the smallest distance that is being stored. Also by using the index of that smallest distance value, it calculates the angle. If the smallest distance value is larger than 1 meter, it writes to our LCD screen "No Object". If there is an object within 1 meter, it writes its distance and angle.

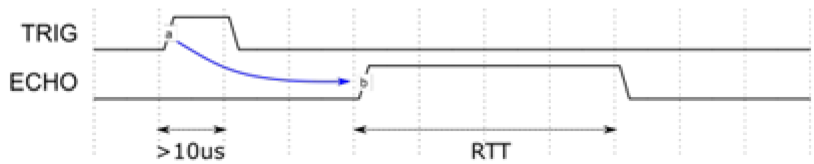

Figure 2

3.6. Displaying Unit

The displaying unit consists of multiple elements. The first element of the unit is the power LED. The power LED turns on when the system is awake and turns off when the system enters deep sleep mode. To make a proper unit, we used a N-mos MOSFET. We are giving voltage to GPIOE5 which is connected to the gate of the MOSFET. The MOSFET acts as a switch between the power source and LED.

The second displaying element is the speaker. The speaker works when the system wakes up from deep sleep mode. The speaker unit consists of the same logic as the power LED unit. The only difference is the GPIO pin. We use GPIOD2 to give sufficient voltage to MOSFET.

The third displaying element is the LCD screen. In the LCD screen, we write out digital threshold value, measured temperature value, measured distance, and angle values. In the deep sleep mode, there is only the digital threshold value on the LED screen. Writing operations are being done by using Professor Valvano's functions for the Nokia5510 LCD Screen.

4. Pin Configuration and Visualization

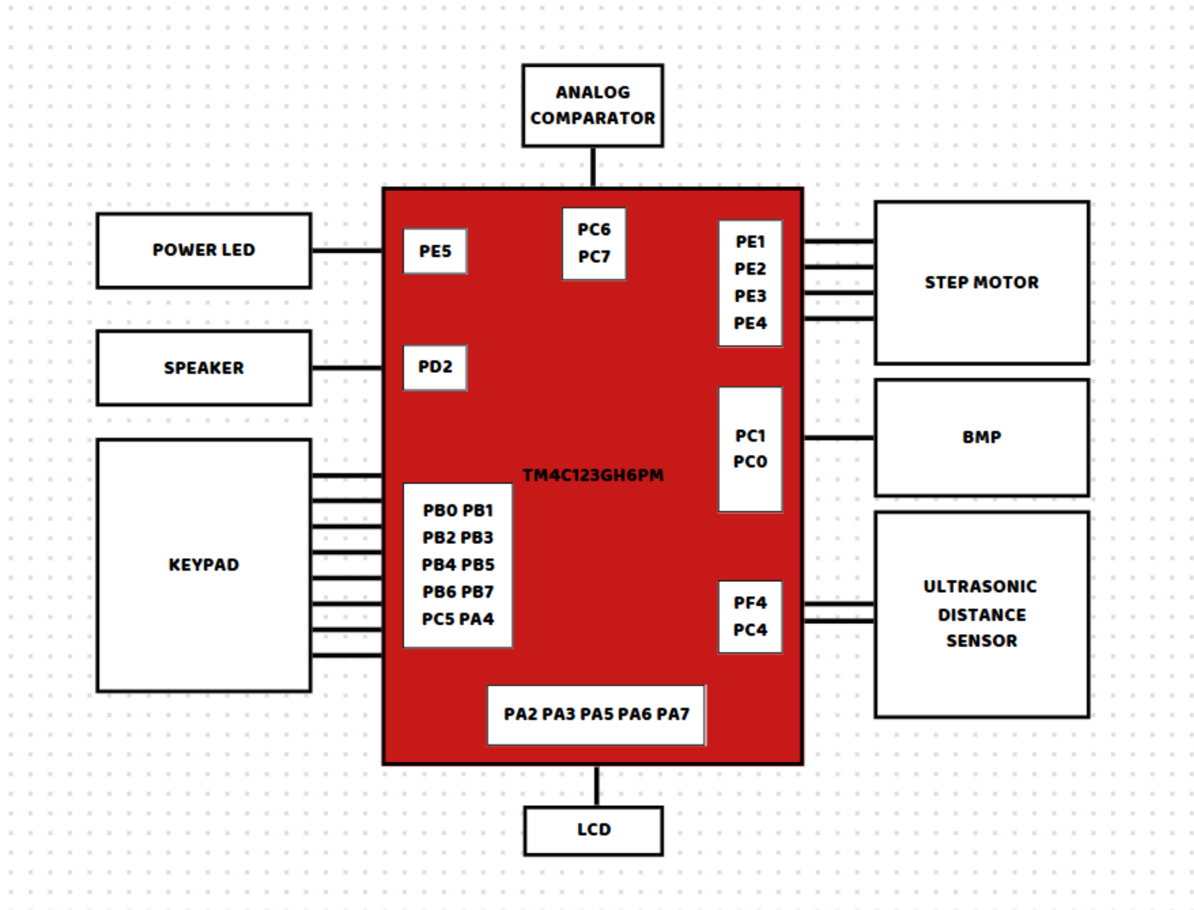

Figure 3: Pin configuration

5. Summary

By integrating multiple sensors, a motor, and user interfaces, the project exemplifies the importance of hardware-software co-design and modular programming. It demands detailed information on the sensors LM35 and BMP280. For proper operation, the project demands GPIO, timer, interrupt, and I2C knowledge. In conclusion, this project emphasizes the applications of embedded systems in condition monitoring. The system's successful completion indicates the capacity to combine theoretical knowledge with practical skills.

6. Appendix

General workflow of our code: