EEE3088 Breadboard Assignment 2024
Sensing Subsystem

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Chapter 1

Introduction

1.0.1 Design Problem Statement

For this assignment, I was required to design and build a sensing subsystem that uses Infrared rays to detect whether a wall is present in the sense direction.

1.0.2 Specifications and Requirements

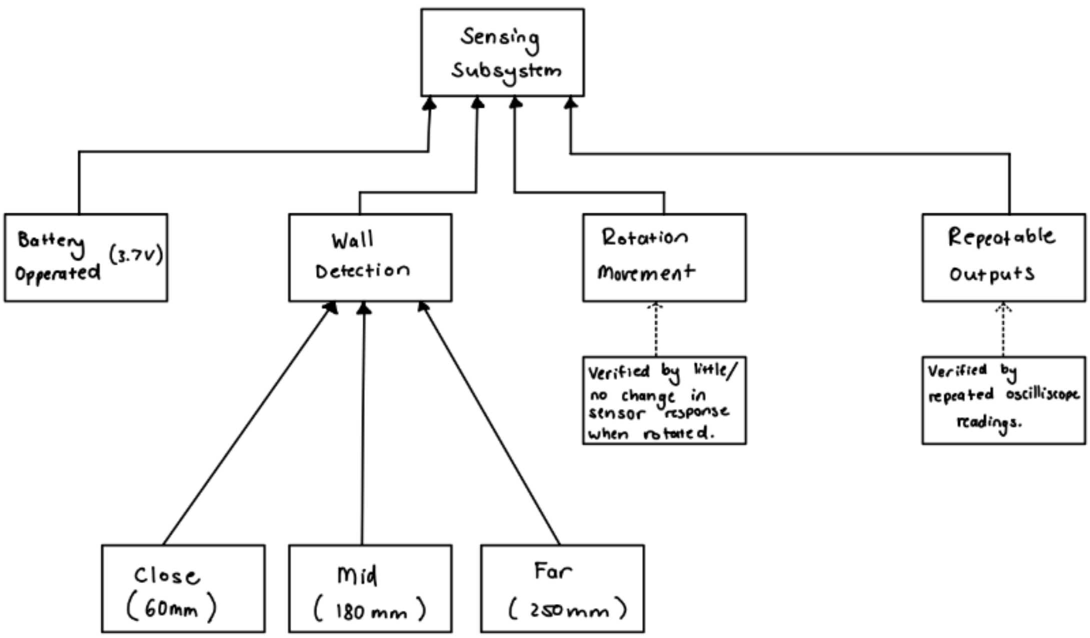

Figure 1.1: High Level Requirements Diagram

Assessment	Requirement
Power 1	System operates at 3.7V
Sense 1a - Close (60mm)	Sensor detects wall and system produces large output.
Sense 1b - Mid (180mm)	Sensor detects wall and system produces a lesser output.
Sense 1c - Far (250mm)	Sensor does not detect wall and system produces no output.
Sense 2	Sensor does not respond to small changes in angle or jiggling of the system.
Sense 3	Outputs are repeatable.

Table 1.1: Sensing Subsystem Assessments and Requirements

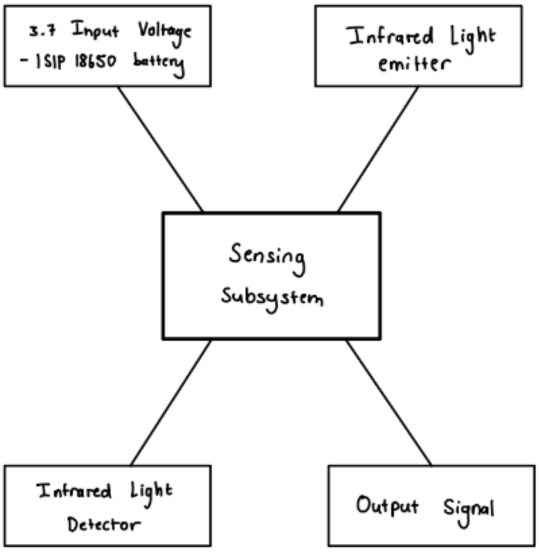

Figure 1.2: Context Diagram

My system must be able to repeatably detect the presence of an external reflector (a wall) from different physical locations on the testing rig. The system should be able to take infrared (IR) light as in input and produce a signal-based output that will be read via an oscilloscope. This subsystem will be powered by a 1S1P18650 battery which supplies 3.7 V.

The subsystem will be placed into a testing rig with multiple predetermined testing points at varying distances from the wall. The system will also be rotated through an angle between $\pm 15^{o}$ at each testing point. The analogue output produced by the sensing system at each testing point will be recoded via an oscilloscope.

I expect the system to produce a high voltage at the ‘close’ testing point, followed by a lesser voltage at the ‘mid’ and at the final ‘far’ testing point I expect there to be little to no output voltage produced.

Chapter 2

Subsystem Design

2.0.1 Calculations and Schematic

· Calculations:

· 1S1P 18650 ⇒ 3.7 V

· QRD1114 ⇒ · 5V – V_{ECO} (linear)

· 30V – V_{CEO} (saturation / breakdown)

For sensor:

V_F = 1.7 V (max)

I_F = 20mA

I_R = 100 μA

V_R = 5V

R_1 is a pull-up R

∴ let R_1 = 10kΩ

For Diodes:

I_C = 1mA

∴ R_2 = 100Ω

∴ I_E = 0.1mA

Figure 2.1: Circuit Calculations

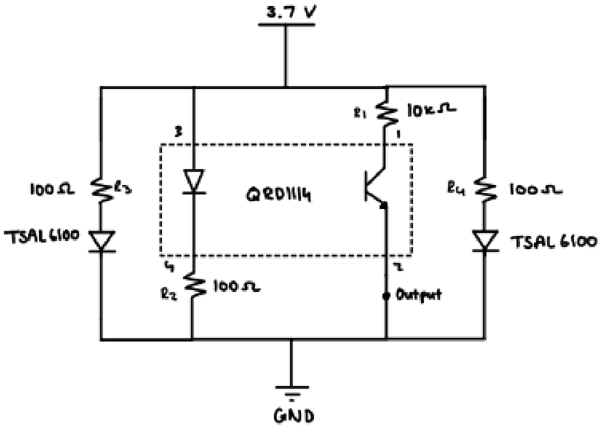

Figure 2.2: Circuit Schematic

2.0.2 My Solution

When it came to creating a solution to the task at hand one of my main goals, apart from ensuring my circuit is effective and consistent in its results, was to insure that was simple design. With that in mind I decided to use the QRD1114, a reflective object sensor, as the main component of my design. The QRD1114 was the obvious choice as it produces a Phototransistor output. It also has contactless surface sensing and a daylight filter on the sensor as some of its main features. It is also compact in stature.

After much debugging and testing, I decided to make use of two TSAL6100's as well, which are high power infrared emitting diodes. These diodes, along with emitter in the QRD1114 ensure that the sensor in the QRD1114 receives substantial feedback in the form of reflected infrared light rays.

The two TSAL6100's are each connected to the supply voltage of 3.7V from the 1S1P18650 battery through 100Ω resistors. They are strategically positioned on either side of the QRD1114 to ensure concentrated emission of IR rays in the direction of the sensor, so that it can receive sufficient reflection rays from the wall or a detectable object at varying distances. The collector of the sensor is connected to the supply voltage through a 10kΩ resistor.

The sensor output is measured from the emitter (pin 2) of the QRD1114 with an oscilloscope which is grounded.

Chapter 3

System Integrated Design

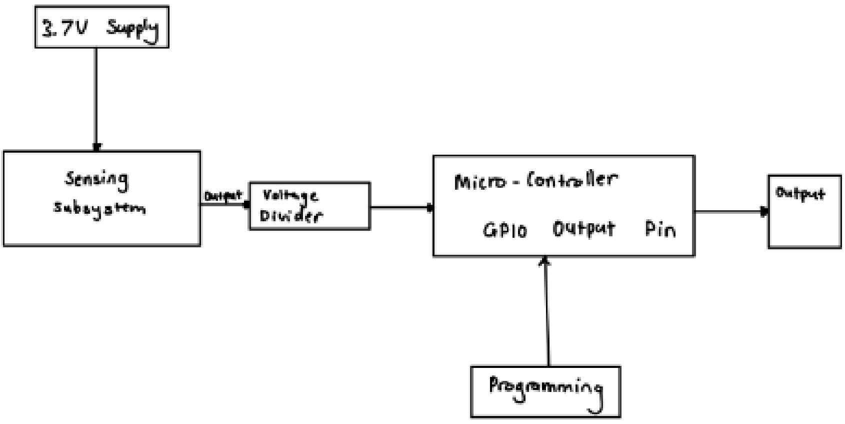

Figure 3.1: System Interfacing Diagram

In order to be able to integrate my subsystem with a microcontroller (ie. STM32F0) my circuit will have to undergo some minor modifications to ensure that it is compatible with a microcontroller.

I can begin by adding a voltage divider to the output of the emitter of the QRD1114 as the microcontroller operates at a voltage less than the battery voltage that is used to supply my circuit. My circuit is supplied with a 3.7V input. This input voltage can be scaled down using a voltage divider circuit. I could let R1 and R2 be 12KΩ and 39KΩ resistors respectively to scale down the voltage to a maximum of 3V, which is within the ADC range of the STM32F0.

I would also need to make use of a decoupling capacitor (ie. 100nF) close to the power supply pins of the microcontroller, thus providing it with stable power.

The use of a pull-down resistor will ensure a voltage when the reflected IR rays are not incident to the sensor, thus preventing the ADC input from floating.

This integration with the microcontrollor are based of the reading recorded while testing the sensing subsystem, as seen below. All additions to the integrated circuit are constructed around these readings as they could be responsible for driving a larger system.

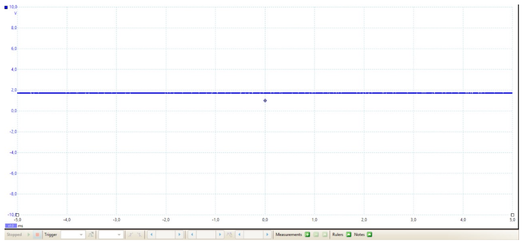

Figure 3.2: Close Reading - 1.9V

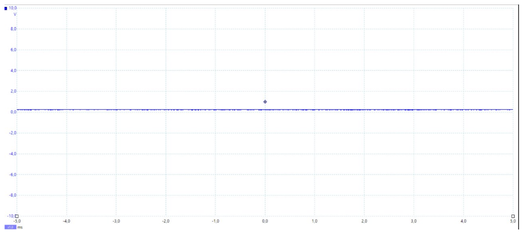

Figure 3.3: Mid Reading - 0.4V

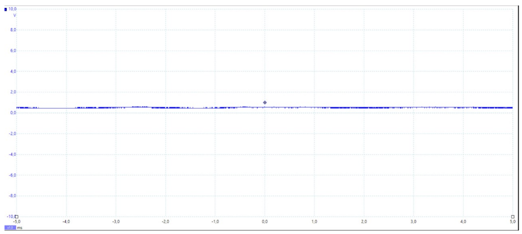

Figure 3.4: Far Reading - 0.2V

· Effective Resolution:

$$V_{ADC} = 3.7 \times \frac{100}{10k + 100}$$

$$= 0.0366\ V$$

∴ let the ADC have a 12bit res.

$$\therefore \text{Effective Resolution} = 12 \times \frac{0.0366}{VDD}$$

$$= 12 \times \frac{0.0366}{3V}$$

$$= 0.1464 \text{ bits}$$

Figure 3.5: Effective Resolution Calculation

Chapter 4

Conclusion

After rigorous testing, my subsystem ended up meeting all the requirements that were initially required. After much assessment of my design there are improvements that can be made, despite the subsystem meeting all the requirements. One major improvement I would make would be to create a better casing or funnel for the TSAL6100 so that the Ir rays it emits are more focused and directed to in the sense direction.

Assessment	**Requirement**	**Conclusion**
Power 1	System to operate at 3.7V	The subsystem operated at 3.7V
Sense 1a - Close (60mm)	Sensor detects wall and produces a large output.	The wall was detected and an output of 1.9V was recorded.
Sense 1b - Mid (180mm)	Sensor detects wall and produces a lesser output.	The wall was detected and an output of 0.4V was recorded.
Sense 1c - Far (250mm)	Sensor does not detect the wall and produces no output.	There was a significantly lesser voltage of 0.2V was recorded.
Sense 2	Sensor does not respond to small changes in the angle or jiggling of the system.	The sensor was unaffected and there was little to no change in outputs recorded via the oscilloscope.
Sense 3	Outputs are repeatable.	Outputs were repeatable as at the same places on the testing rig, the same outputs were produced by the subsystem on different occasions.

Table 4.1: Circuit Design Assessment and Conclusion