Parking Space Monitoring System

Team 39: Nauman Qureshi, Alex Kapustka, Elias Velez

ECE 445 Design Document – Fall 2017

TA: Zhen Qin

1 Introduction

1.1 Objective

Finding an open parking space in a crowded parking lot is often a long and frustrating endeavor. This irritation frequently stems from being unable to know where the open spots are, forcing drivers to wander aimlessly aisle by aisle, floor by floor, until finding a vacant spot. An IBM survey conducted in 2011 found that over "30 percent of city traffic is caused by drivers searching for a parking spot" [1]. Furthermore, the survey found that 29 percent of drivers in New York City spent 20 minutes on average searching for a parking spot, while 10 percent spent over 40 minutes. INRIX, a leader in transportation analytics, issued a report stating that "motorists spend an average of 17 hours a year searching for [parking] spots...estimated $345 per driver in wasted time, fuel, and emissions" [2]. The extra time spent searching for a parking spot also contributes to the discharge of more vehicle carbon emissions [3], which exacerbates a growing pollution problem. Clearly, the problem of finding an open parking space extends far beyond just the time wasted by the driver. Our goal is to find a solution for this dilemma. This will not only lead to happier customers since they can identify a spot faster, but may also lead to reduced accidents in the parking lot. A driver will spend less time circling the lot and will not need to be as visually distracted.

The objective of our project is to design a system, which reduces the time spent by the driver searching for an open parking space. By monitoring the status (occupied or vacant) of each and every spot in the lot, we can collect the necessary data to alert the driver to vacant parking spaces faster. Parking spots will be monitored for vacancy/occupancy using a proximity sensor, which transmits data to a central hub via an RF signal, where the data will be aggregated and presented to incoming drivers through an LCD display. Additionally, LED light bulbs at parking spots will visually indicate its occupancy status by color, providing another alert system for the driver.

1.2 Background

As stated earlier, a driver in the US spends on average 17 hours a year looking for a parking spot [2]. And in the country's largest cities, such as New York City (one of the best known cities for traffic and parking difficulty), that number can rise to over 100 hours annually. Typical parking lots do not present incoming drivers with any data or visual markers regarding the vacancy/occupancy of spots. In large and crowded parking lots, it is often very difficult to easily identify where the open spots are because other vehicles block them. This system would provide drivers with useful data to make finding a spot much easier.

While attempts have been made to put parking lot systems in place to perform the function of identifying vacant spots [4][5][6], most notably outside the U.S.A, similar systems have yet to fully integrate themselves into American life. The marketability of such a system has yet to develop fully, so it is important that our solution be somewhat cost-effective in order to incentivize the installation of such systems in parking lots. The time wasted and potential pollution concerns associated with driving around searching for spots must be addressed and our goal for this project is to design and implement a system which helps reduce the magnitude of the problem.

1.3 High-Level Requirements

- IR proximity sensor must be able detect the presence of a vehicle and toggle connected LED light bulbs between RED (occupied) and GREEN (vacant)
- Proximity sensors must be able to send their data via RF transmission to a central data hub to be processed
- The processed data aggregated from all the proximity sensors must be displayed in visual format to the user (driver) via LCD display.

2 Design

2.1 Block Diagram

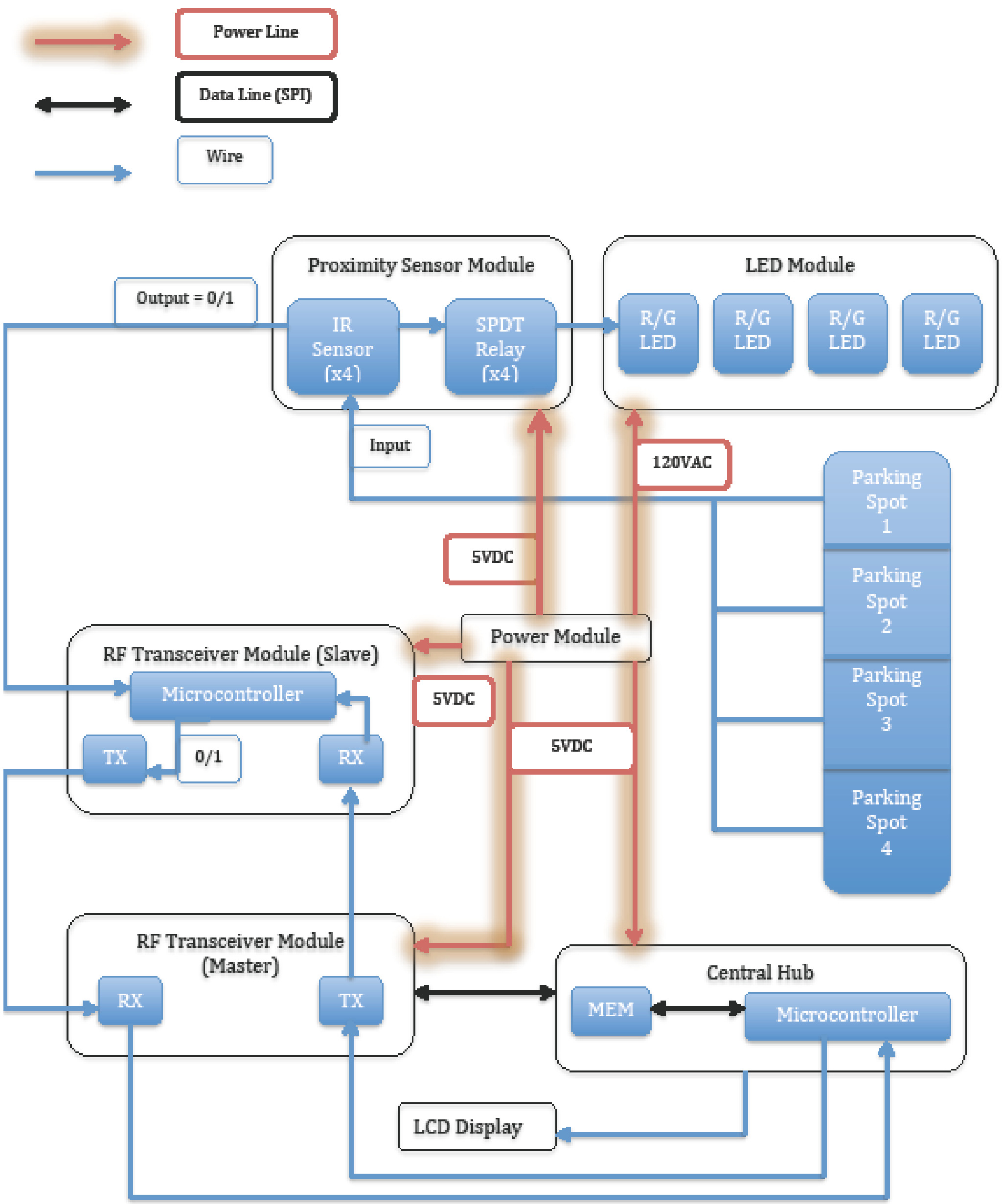

Figure 1: Overall System Block Diagram

2.2 Power Supply

This module is responsible for supplying power to all the components required in the design.

A voltage output of 5VDC will be used to power multiple modules in our system. 5V will be provided as a power supply to the microcontrollers in the slave transceiver module and the central data collection module. This voltage will also be drawn by the RF transceiver chips in those modules (master and slaves). A voltage level of 5V will be also used to power the LCD Display module and the proximity sensor module. The LED modules in our system will be powered directly from the 120VAC wall line voltage.

We plan to utilize the voltage that is normally output from the wall (120VAC) to power our system. Our power supply module will consist of a 120VAC to 5VDC converter that will provide us the necessary 5VDC output to our sub-systems from the 120VAC line voltage.

Requirements	Verification
1. Must provide between 4.5-5.5 V to the slave and master RF transceiver modules and the central data collection modules	1. a. Measure open-circuit voltage output to central data collection module with a multimeter, ensuring that it is below 5.50 V b. Measure open-circuit voltage output to central data collection module with a multimeter, ensuring that it is above 4.50 V c. Add resistive load at output of power supply to central data collection module such that the voltage supplied to the microcontroller falls in range 4.50-5.50 V. d. Repeat steps a-c for the slave RF transceiver module and the master RF transceiver module
2. Must provide voltage of between 4.5-5.5V to the IR sensors in the proximity sensor modules	2. a. Measure open-circuit voltage output to proximity sensor module with a multimeter, ensuring that it is below 5.50 V

	b. Measure open-circuit voltage output to proximity sensor module with a multimeter, ensuring it is above 4.5 V c. Add resistive load at output to proximity sensor module such that the voltage supplied to the sensors falls in range 4.50-5.50 V.
3. Must provide voltage of 120VAC (+/-5V) to the LED module	3. Measure open-circuit voltage output to the LED module with a multimeter, ensuring that it is 120VAC
4. Must provide between 4.5-5.5 V to the LCD display module	4. a. Measure open-circuit voltage output to central data collection module with a multimeter,, ensuring that it is below 5.50 V b. Measure open-circuit voltage output to central data collection module with a multimeter, ensuring that it is above 4.50 V c. Add resistive load at output of power supply to central data collection module such that the voltage supplied to the microcontroller falls in range 4.50-5.50 V.

2.3 Proximity Sensor Module (s)

This module will have IR sensors and SPDT relays. This module is responsible for the transmission of data into the RF Transceiver module (Slave) and for controlling the LED module (switching between Red and Green LED lighting up).

2.3.1 IR sensors

We will use one IR-based proximity sensor for each parking space. The supply voltage for the IR sensor comes from the power supply module. The output of these IR sensors will be an analog signal (0 when the sensor does not detect a vehicle in range, greater than a threshold voltage [0.25 V] when the sensor does detect a vehicle within range). This sensor will be mounted at bumper height of the vehicle so when a vehicle approaches the sensor, the sensor will be able to detect the vehicle. The range of the IR sensor will be up to 80 cm, so that vehicles outside this distance will not be detected. The analog voltage output of the sensors is then passed onto the microcontroller in the slave RF transceiver module, which converts the analog output to a digital signal for controlling the relays (for toggling connected LEDs) and for populating a data message to the central RF transceiver.

Requirements	Verification
1. Must provide analog voltage output of >0.25V when vehicle is in detection radius of 80 cm.	1. a. Move vehicle into detection radius (within 80 cm) b. Verify that the voltage output of the IR sensor is greater than 0.25 V using a voltmeter.
2. Must provide analog output of <0.25V when vehicle is not within detection radius of 80 cm.	2. a. Move vehicle outside of detection radius (>80 cm) b. Verify that the voltage output of the IR sensor is less than 0.25 V using a voltmeter.

2.3.2 4-Channel Relay Module

We will use a 4 Channel Relay Module. This module takes in 4 digital inputs from the microcontroller in the RF transceiver module (converted from the proximity sensor voltage output) and is powered by 5V. This will serve as our mechanism to turn on the red or green LEDs depending on whether the coil is energized or not. The input of digital 1 is drawn from the converted IR sensor output (via ADC on MCU) so whenever the sensor detects a vehicle, it generates an analog voltage output that corresponds to a digital 1 and it is supplied to the onboard relay, which will turn on a green LED, otherwise it will turn on a red LED.

Requirements	Verification
1. Input must be a digital 1 to energize the coil and switch to the normally open position. 2. Input must be a digital 0 to de-energize the coil and switch to normally closed position. 3. Relay will be supplied with 50 - 60 mA of input current to sufficiently energize the coil.	1. Apply digital 1 to relay input and use multimeter to verify continuity between N0 and COM relay terminals. 2. Apply digital 0 to relay input and use multimeter to verify continuity between NC and COM relay terminals. 3. Apply digital 1 to relay input and use multimeter to verify 50 - 60 mA of input current.

2.4 LED Module (s)

This module has 4 pairs of green and red LED bulbs. A single pair of LEDs will be mounted above its associated parking spot (and proximity sensor). The LEDs will be powered by 120VAC from the power supply module, but this voltage is controlled by the 4 channel relay module in the proximity sensor module. Only one LED of a given pair will be powered on at a given time (RED for occupied, GREEN for vacant) because the source voltage for the LEDs is controlled by the relay sub-module present in the proximity sensor module. The sole purpose of this module is to visually display the status of each parking spot.

Requirements	Verification
1. LEDs must be visible from a distance of 1m when given a drive current of 10mA.	1. a. Adjust the current-limiting resistor connected to the LED in order to deliver 10mA over the LED

	b. Measure 1m distance from the LED c. Ensure that LED is clearly visible from viewer's position
2. Must display GREEN LED when connected 4 channel relay is in the normally closed position (digital 0 - analog 0V)	2. a. Force relay to the normally closed position b. Visually ensure that the GREEN LED is on
3. Must display RED LED when the connected 4 channel relay is in the normally open position (digital 1 - analog 5V)	3. a. Force relay to the normally open position b. Visually ensure that the RED LED is on
4. Must not have more than one LED in a pair visibly on at the same time	4. a. Toggle relay between the normally closed and normally open positions b. Visually ensure that both LEDs are not on together

2.5 Slave RF Transceiver Module(s)

This module is responsible for the data transmission using RF waves and it is termed as a slave unit because it waits for polling instructions from the master RF unit. The module will transmit the data associated with its attached IR sensors to be processed by the central data hub. Likewise, it communicates the sensor data to the relays above in a digital format.

2.5.1 Microcontroller

We will use a microcontroller to generate a RF signal to be transmitted to the master RF transceiver when the master transceiver polls the slave. The microcontroller is also responsible for converting the analog voltage output of the IR sensors to a digital signal to be communicated to the relay modules.

Requirements	Verification
1. Must create a message containing the data from proximity sensors formatted in a binary array for transmission	1. a. Program microcontroller to output a message containing a series of 0s and 1s. b. Measure voltage signal in time domain at the output of the microcontroller to the transceiver to view signal on oscilloscope. c. Ensure that this signal is identical to the programmed signal of the microcontroller.
2. Must transmit data message only when polled by the master RF unit (provided permission from RF to start transmitting)	2. a. Program microcontroller with an if-else conditional based on a set variable to emulate receiving permission from the master RF unit

	b. Verify that a voltage signal output from the microcontroller (using oscilloscope) is only generated when the variable is set to 1 (emulating that permission has been granted).
3. Must convert the analog voltage output of the IR sensors to a digital equivalent (<0.25 is equivalent to 0, >0.25 is equivalent to a digital 1)	3. a. Apply voltage of 0V to the ADC pins of the microcontroller b. Measure corresponding digital output signal of the microcontroller using a multimeter, ensuring that it corresponds to a digital 0 c. Apply voltage of 2V to the ADC pins of the microcontroller d. Measure corresponding digital output signal of the microcontroller using a multimeter, ensuring that it corresponds to a digital 1

2.5.2 RF Transceiver Chip

These channels are used for the transmission and receiving the information between slave and master units. TX will transmit the data to master and RX will receive the data from master. The data for transmission will be communicated from the micro-controller and the data received from the master RF transceiver is communicated to the microcontroller.

We have chosen NRF24L01 wireless transceiver chip due to its cost-effectiveness and large range of transmission. The minimum transmission speed on this chip is 250 kbps.

Requirements	Verification
1. Must be able to transmit messages at 2.4GHz at 250 kbps	1. a. Generate a test message in the microcontroller for transmission and transmit this message using the transceiver b. Measure the transmitted RF signal using an oscilloscope/spectrum analyzer listening on 2.4GHz frequency, ensuring that the transmission received is identical to the generated message. c. Verify that the speed is 250 kbps (+/-5%)
2. Must be able to receive messages sent at 2.4GHz at 250 kbps	2. a. Generate an RF signal at 2.4 GHz using an RF signal generator b. Measure the received RF signal at the transceiver using an oscilloscope, ensuring that the transmission received is identical to the generated message.

2.6 RF Transceiver Master Module

This is the master RF unit that polls the slave RF units to request the proximity sensor data. The polling is controlled by the central data collection microcontroller, so the master RF transceiver has its transmissions controlled by the microcontroller.

Requirements	Verification
1. Must be able to transmit messages at 2.4GHz at 250 kbps	1. a. Generate a test message in the microcontroller for transmission and transmit this message using the transceiver b. Measure the transmitted RF signal using an oscilloscope/spectrum analyzer listening on 2.4GHz frequency, ensuring that the transmission received is identical to the generated message. c. Verify that the speed is 250 kbps (+/-5%)
2. Must be able to receive messages sent at 2.4GHz at 250 kbps	2. a. Generate an RF signal at 2.4 GHz using an RF signal generator b. Measure the received RF signal at the transceiver using an oscilloscope, ensuring that the transmission received is identical to the generated message.

2.7 Central Data Collection Module

This is the central hub and control unit that controls the sequences of the data transmission and reception. This unit is passed data from the master RF transceiver after requesting data from a slave unit and stores that information into onboard memory. This aggregated data will be passed to LCD display module to provide a visual interface for drivers.

2.7.1 Microcontroller

We will use a microcontroller that will receive data from the master RF transceiver module and store it in the onboard memory. This microcontroller will be responsible for periodically polling the slave RF transceivers. The microcontroller will also transfer this information to the LCD display via SPI so that the status of vacant spots per floor is displayed to drivers.

Requirements	Verification
1. Must store aggregated data from master RF transceiver module in onboard memory.	1. a. Use function generator to emulate a data signal transmitted from master RF transceiver module to the microcontroller (binary array of 0s and 1s). b. View the stored data in memory to ensure that the data matches the generated signal data
2. Must generate a periodic polling sequence for the master RF transceiver to poll the slave units, switching between slave IDs every second.	2. a. Program microcontroller to generate periodic polling sequence b. View output signal of microcontroller to the master RF transceiver (via oscilloscope) and verify that the message contents are rotating periodically each second (with a timer) between different slave RF ids

3. Must continuously output parking space data stored in memory to the LCD display via SPI	3. a. Program microcontroller to output a set of data to the LCD display b. Verify on LCD display that the data is correctly output continuously

2.7.2 MEM

We plan to use onboard memory for this project since there is minimal data that needs to be stored at any given time.

Requirement	Verification
1. Must have at least 1KB of storage space for collecting data.	1. a. Fill 1KB of memory with verifiable, documented data b. Read data back and echo to UART terminal and ensure that data matches completely.

2.8 LCD Display Module

The LCD display module is used to visually display the status of open spots in a parking garage to an incoming driver. It will tell how many spots are open on a specific floor and also total number of spots. It will show something like “Floor 1: Open Spots = 36/60”. This is just an example as the exact nature of the visual display is subject to change.

Requirement	Verification
1. Must display the number of vacant spots on each level of the parking lot	1. a. Program microcontroller to output a set of data to the LCD display that indicates completely occupied b. Verify on LCD display that the data is correctly output as 0 vacant spots c. Program microcontroller to output a set of data to the LCD display that indicates completely vacant d. Verify on LCD display that the data is correctly output as all vacant spots e. Program microcontroller to output a set of data to the LCD display that indicates half vacant f. Verify on LCD display that the data is correctly output as half vacant spots

2.9 Risk Analysis

The RF communication modules pose the most difficulty to the completion of the project. Because the RF transceivers will be transmitting on the same frequency, it is vitally important that the polling protocol works as intended. Otherwise, if multiple transmissions are attempted simultaneously, data will be dropped at the master RF receiving unit. Additionally, our team background is not exceptionally strong in RF, so this is the aspect of the project that will likely take the longest to completely master and implement.

It should be noted that our project has two main parts to its high-level requirements. One of the parts of the project is ensuring that the communication of the proximity sensors to the LEDs is correct. This controls the visual indicators at the parking spot to turn either red or green. This part of the project is independent of the part of the project which deals with RF transmission. The RF transmission aspect of the project is connected to the LCD display of the parking lot information since it is necessary to aggregate the data at a central location. So therefore, though the RF transmission modules are the modules which pose the most risk to the successful completion of the project, there is still an independent part of the project that can be completed successfully and fulfill the basic motivation behind the project, which is to visually indicate the status of parking spots to the incoming drivers.

2.10 Tolerance Analysis

A critical feature in our design is the voltage output of the IR sensors, which are converted to a digital signal which indicates whether or not a vehicle is detected by the sensor.

There are two main requirements for the IR sensors: 1) Must provide analog voltage output of >0.25V when vehicle is in detection radius of 80 cm. 2) Must provide analog output of <0.25V when vehicle is not within detection radius of 80 cm.

In order to achieve these requirements, we have selected an IR sensor which is capable of detecting up to a distance of 80 cm. However, the voltage output varies between 10 and 80 cm (from ~3.0 V at 10 cm to ~0.4 V at 80 cm). The plot below illustrates the relationship between the voltage output and the distance between the sensor and detected object.

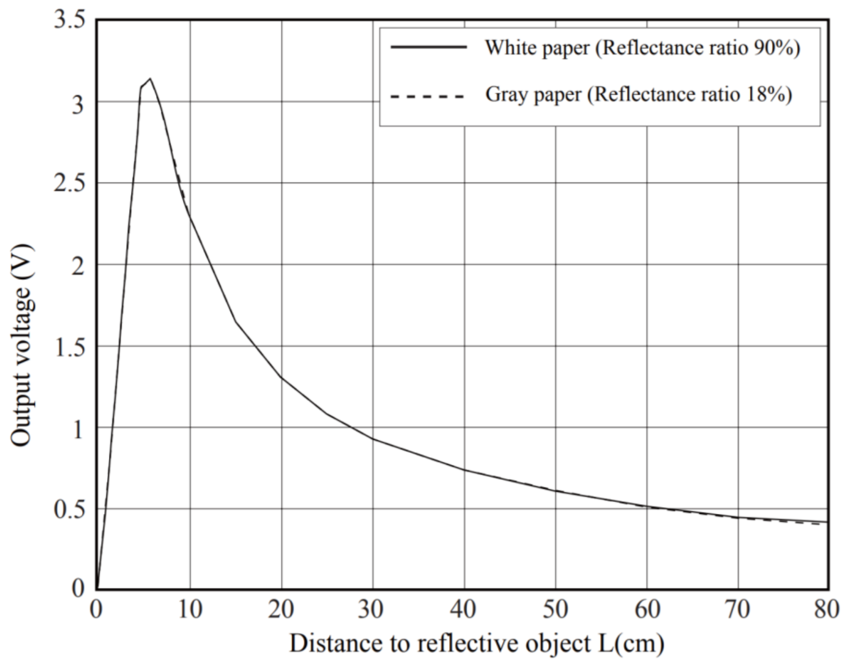

Figure 2: IR Sensor Output Voltage

However, this is not an exact representation of voltage output for a given IR sensor. The Sharp GP2Y0A21YK0F analog distance sensor datasheet specifies that the typical voltage output at L=80 cm is 0.4V [9]. However, there is ~37.5% tolerance to the voltage output value. We will now answer the question of whether or not a worst-case voltage output can still satisfy the system requirements.

$$0.4V*(0.375) = 0.15V$$

So there is a possibility of 0.15V variance (positive and negative) to the voltage output of the IR sensor when the object being detected is at the maximum distance possible to meet requirements. The lowest output value possible would therefore be the required voltage of 0.25V, which is the cutoff between a digital 0 and digital 1 output to the relays. So, according to our requirements, the system will still be able to meet its requirements even in the worst-case scenario for voltage output of the IR sensors.

However, the actual output voltage of the IR sensor when detecting a vehicle will likely stay safely away from the minimum 0.25 V level. This is because the distance from car to sensor is likely to be less than 80 cm (that is a far distance for the car to park away and is the absolute maximum it can be according to system specifications). In those cases, the voltage will be higher and the tolerance associated with that value will not dip the voltage to <0.25V in the worst case. Through this tolerance analysis, we can realize that the critical part of our system which performs vehicle detection will be able to do so as specified by the requirements.

2.11 IR Sensor Plot

We are using an IR Distance Sensor that outputs an analog voltage value when it detects an obstacle within a detection range of 10 to 80cm. The output voltage value of the sensor decreases with the increasing distance. The voltage value is maximum of 3.2V when the object is at a distance of 5cm and it decreases exponentially from this point to 0.4V at 80cm. We need to set a threshold voltage of 0.4V and any voltage above this level will indicate a vehicle is detected and then this information will be passed onto the Microcontroller to perform A/D conversion. The plot of the output voltage is seen in Figure 2 above.

3 Schematics

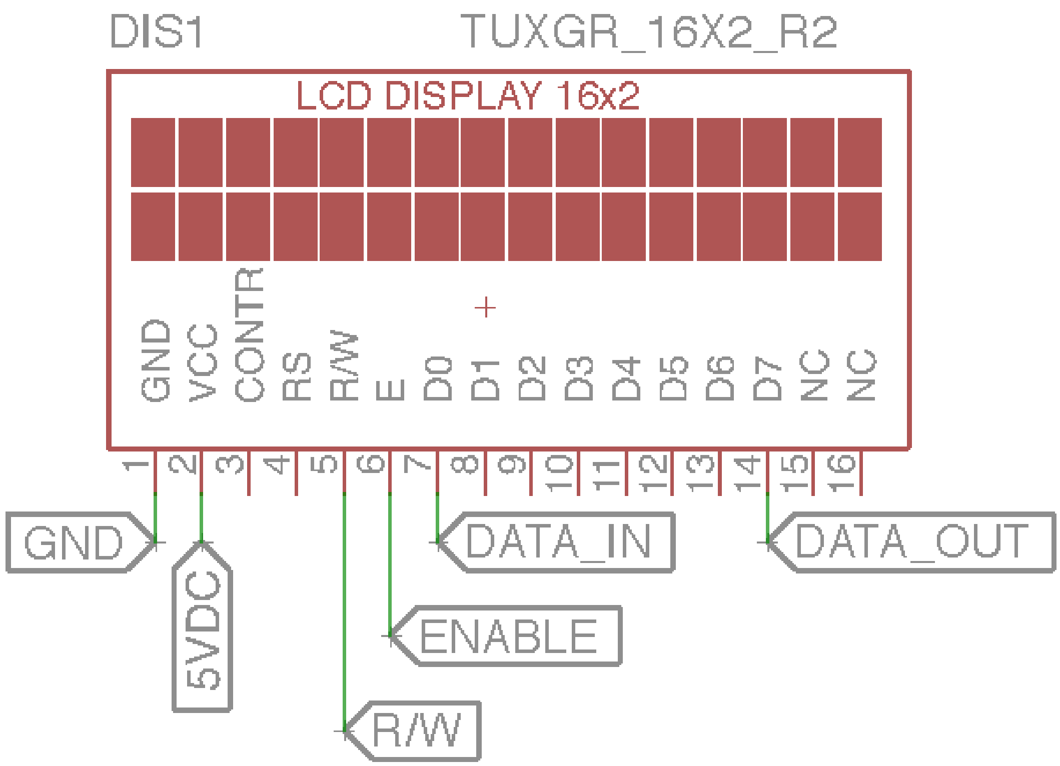

Figure 3: LCD Display Schematic

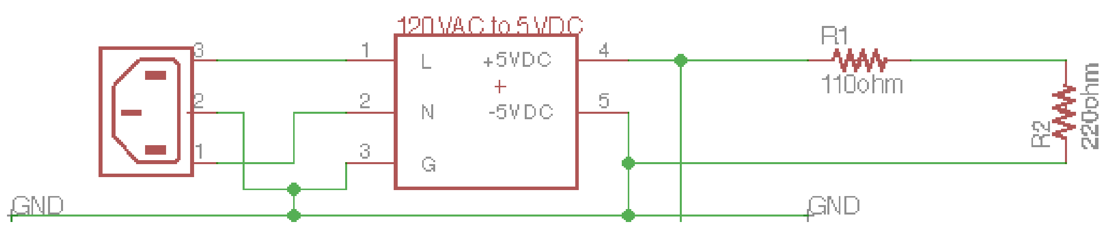

Figure 4: Power Supply Schematic

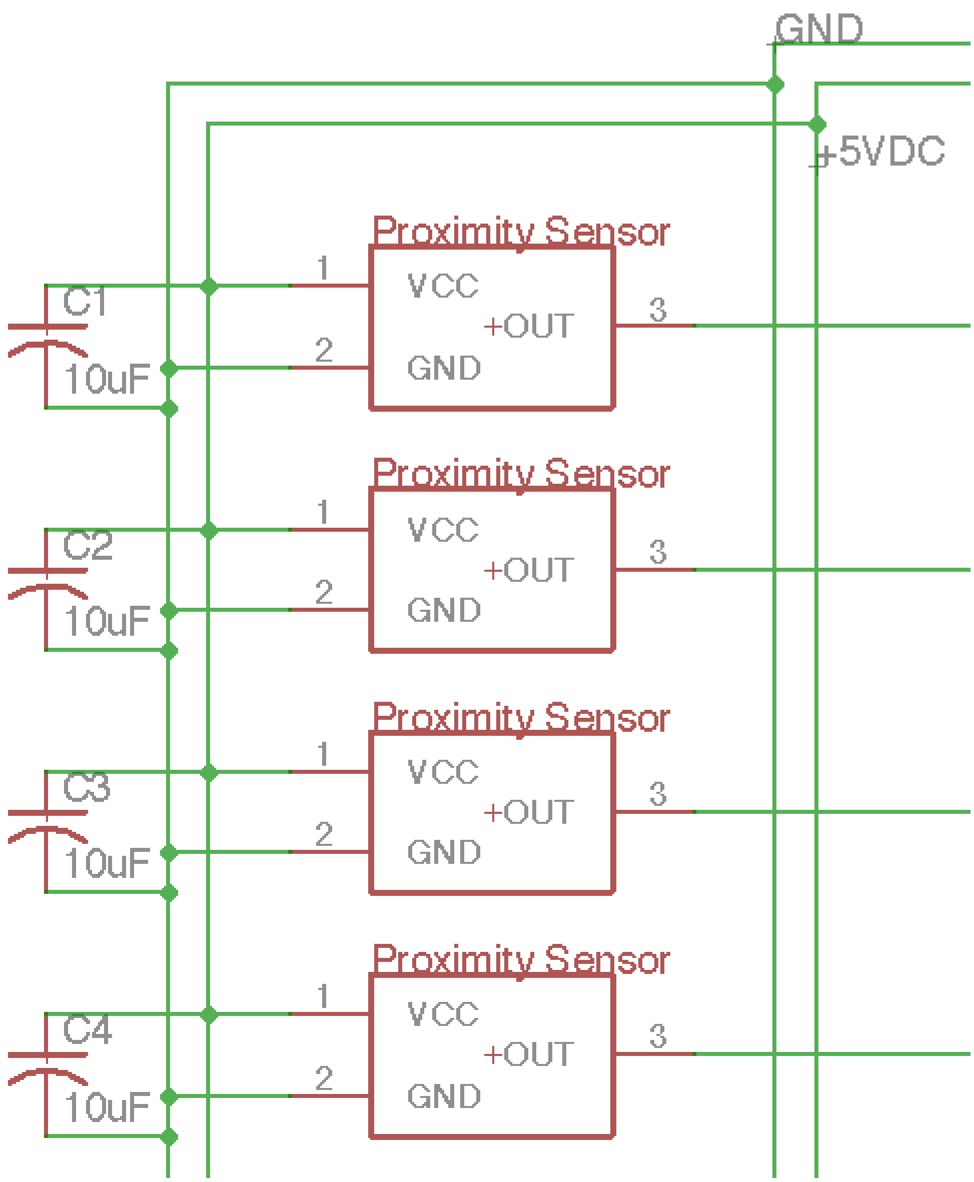

Figure 5: Proximity Sensor Schematic

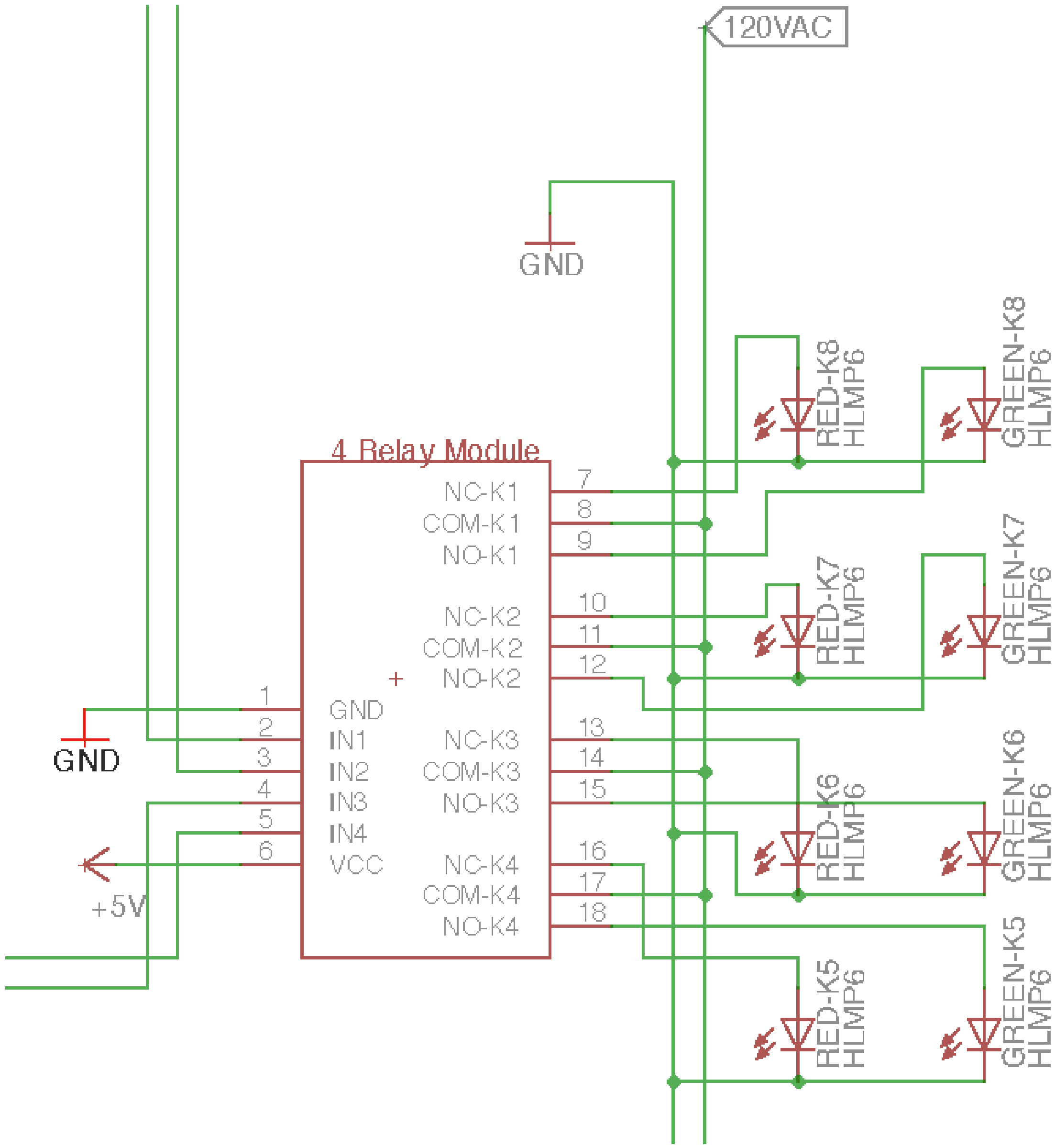

Figure 6: LED Module and Relays Schematic

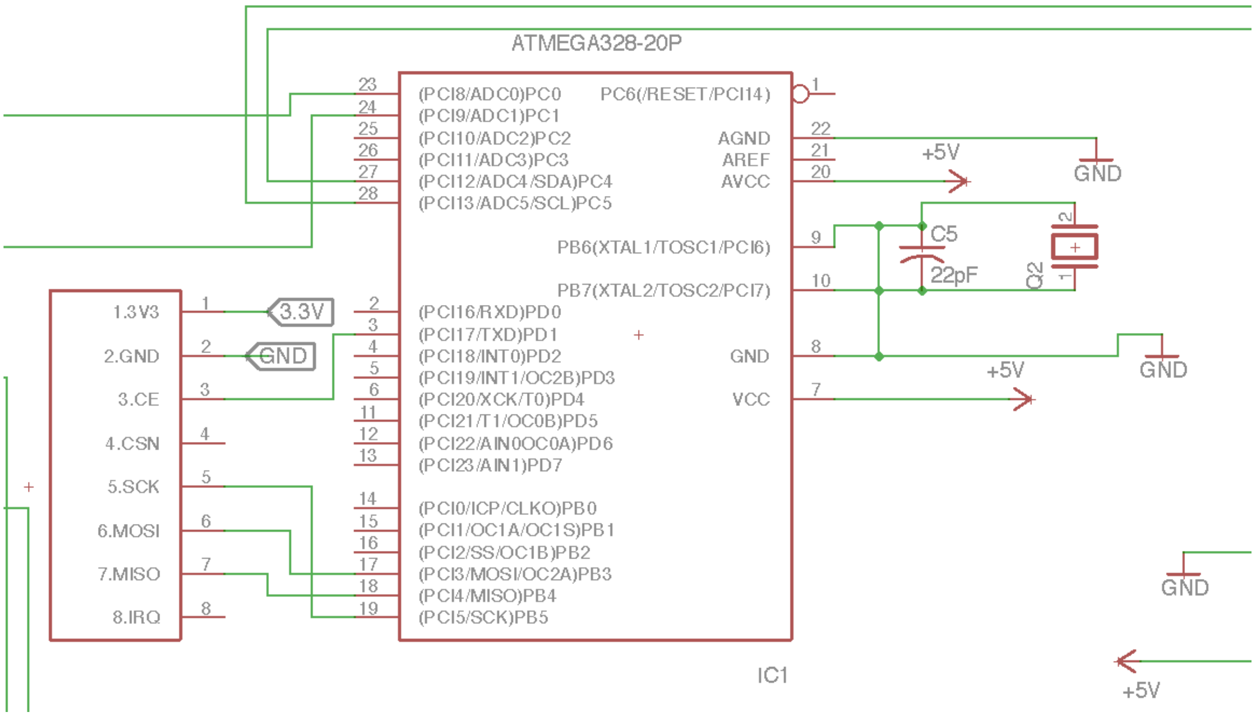

Figure 7: MCU & RF Transceivers Schematic

4 Flowcharts/Other Diagrams

4.1 MCU Polling Scheme

In the system to be designed, there are multiple slave RF transceivers and a single master RF transceiver which will receive data transmitted from the slaves. However, since the transceivers are communicating on the same frequency, it is impossible to have both slave transceivers transmitting data simultaneously and have the master transceiver process both data signals simultaneously. Therefore, we propose a polling scheme to resolve this issue.

The idea behind the polling is simple: a slave must be asked to transmit its data before it actually transmits its data. This ensures that one slave does not transmit at the same time as another slave. The master transceiver module, therefore, must be in charge of communicating to the slaves their respective times to transmit. The following outline shows what the general polling scheme is:

1. Master transmits a START message with slave ID 1 to be received by slave 1.
2. Slave 1 receives the START message, checking that the ID transmitted by the master is actually 1. Slave 2 also receives the START message, but disregards it because the slave ID is not 2.
3. Slave 1 transmits the data message (binary array of its proximity sensor data) with its slave ID in the message.
4. Master receives the data message from slave 1 and processes it. If master does not receive a data message within a specified timeout window (e.g. 0.5 s), repeat steps 1-3.
5. After the specified timeout period, master transmits END message with slave ID 1 to be received by slave 1.
6. Slave receives the END message, checking that the ID transmitted by the master is actually 1. Once again, slave 2 ignores.
7. Repeat steps 1-6 with alternating slave IDs (1, then 2, then 1, then 2, etc.) so that the different slave transceivers take turns transmitting their data to the master. This will allow a continuous update of information to the LCD display.

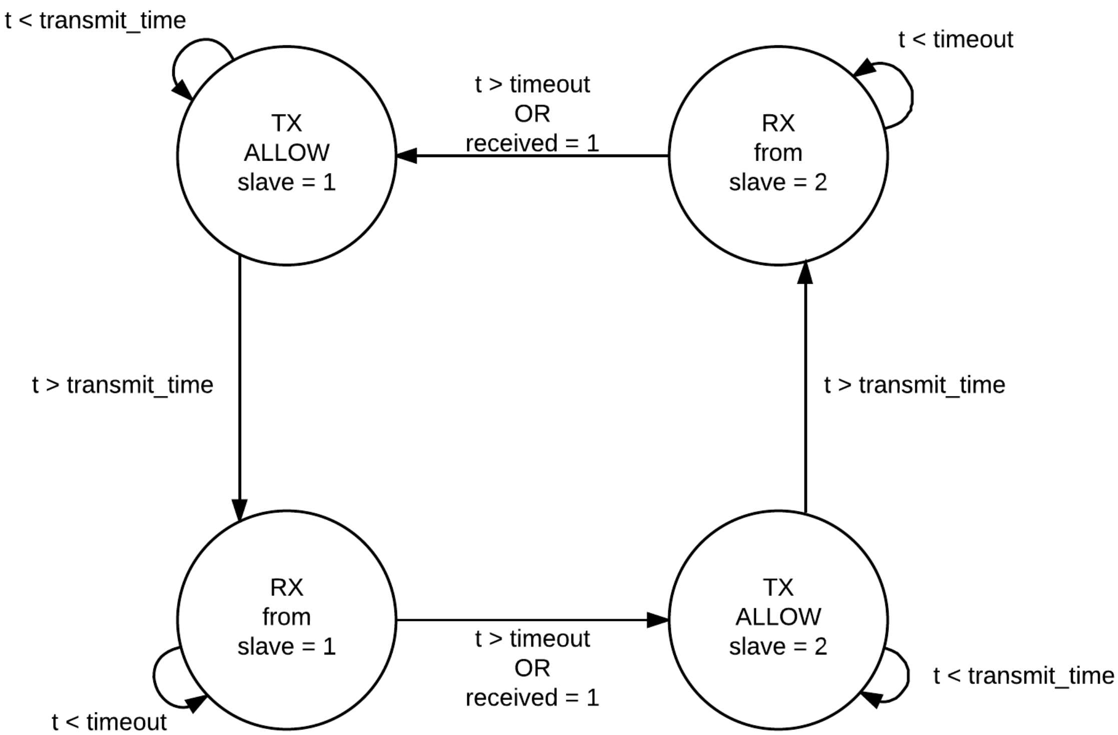

Figure 8: Master RF Transceiver FSM

This FSM describes the behavior of the master TX/RX protocols. The machine starts in the **TX ALLOW slave = 1** state. Here it will transmit permissions to the 1st slave module for a specified time transmit_time. After this time it will transition to the **RX from slave = 1** state. Here it will listen for the slave = 1 broadcast of its occupancy data for a specified time timeout. It will then transition to the **TX ALLOW slave = 2** state when one of two conditions are met: either the timeout has been reached, or the master unit has successfully received the occupancy data from slave = 1. The behavior for **TX ALLOW slave = 2** and **RX from slave = 2** is exactly the same as their slave = 1 variants. After receiving the data from slave = 2 (or after the timeout is reached), **RX from slave = 2** will transition back to **TX ALLOW slave = 1**, its initial configuration. From here the sequence will repeat indefinitely.

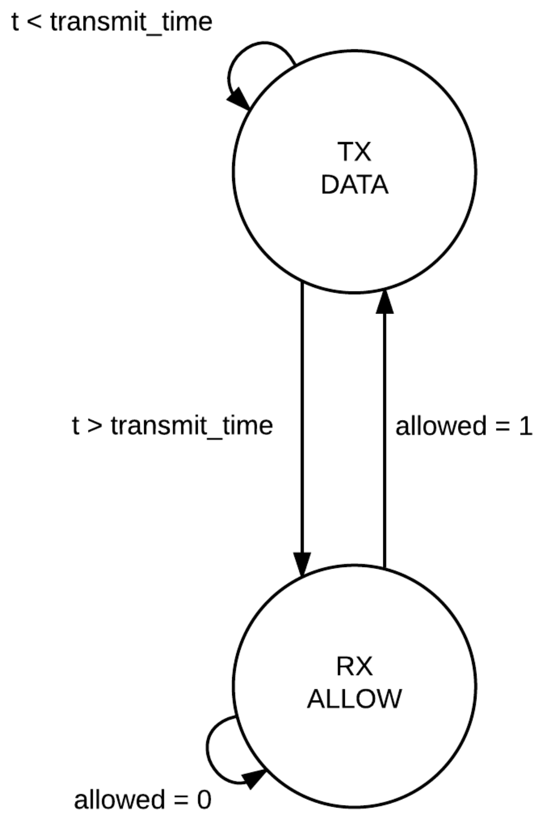

Figure 9: Slave RF Transceiver FSM

This FSM describes the behavior of the slave TX/RX protocols. The machine starts in the **RX ALLOW** state, where it will be listening for permission to start transmitting from the master transceiver. Once it gets permission (allowed = 1), it will transition to **TX DATA** state, where it will broadcast its occupancy data for a specified time, transmit_time. After this time it will stop transmitting and transmission back to the **RX ALLOW** state. Here it is back in its initial configuration and will continuously cycle through this sequence.

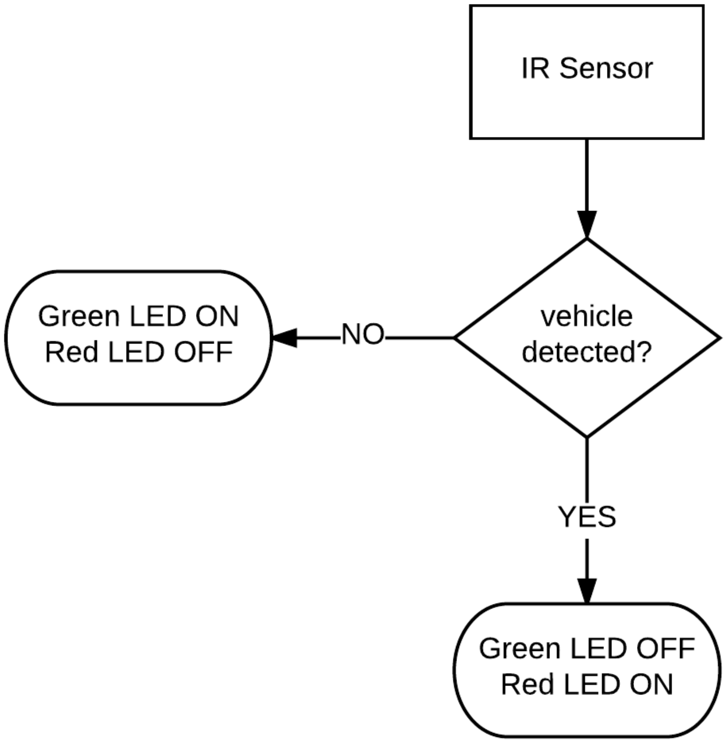

Figure 10: Flowchart for IR Sensor/LED Interaction

This simple flow chart describes the behavior of the LED circuit. The data from the IR sensor will be used to determine if a vehicle was detected or not. If a vehicle was detected, the red LED will be turned on and the green LED will be turned off. Otherwise, in the case a vehicle is not detected, the green LED will be turned on and the red LED will be turned off, indicating a vacant spot.

5 Cost Analysis

We assume our hourly salary to be $40/hour and 10 hours per week for each of the group members.

$$total = 3 \times \frac{\$40}{hr} \times \frac{10\ hr}{week} \times 16\ weeks * 2.5$$

$$total = \$48{,}000$$

Description	Part No	Manufacturer	Quantity	Cost/unit	Total Cost
AC 110V-220V To DC 5V 5A (25W) Converter	B01HY4SIJO	NeeKeons	1	$10.99	$10.99
IR Analog Distance Sensor	GP2Y0A21YK0F	Sharp	4	$9.00	$36.00
Green LED Bulb 1W	PLT LED-A19-GREEN	PLT	4	$2.44	$9.76
RED LED Bulb 1W	PLT LED-A19-RED	PLT	4	$2.44	$9.76
Lamp Holder (Home Depot)	100356849	Leviton	8	$1.33	$10.64
Wireless Transceiver Module 2.4GHz	B06WLH4ZG6	Longruner	1 (Pack of 3)	$13.99	$13.99
4 Channel 5V Relay Module	B00KTEN3TM	JBtek	1	$6.99	$6.99
USBtinyISP Programmer	B01FDD4EP0	SenMod	1	$10.99	$10.99
Atmega328p-pu Chip	B01263IMU8	Atmel	4	$4.12	$16.48
Standard 16x2 Character LCD Display	HC1624	Tsingtek	1	$3.90	$3.90
Assorted Mechanical Parts			1	$20	$20
Total	**N/A**				**$149.50**

6 Schedule

Week	Tasks
10/9/17	• Receive parts ordered for the project. • Finalize schematics of subsystems in design. • Characterize the IR sensors to ensure that they are working properly. Check MCUs, RF chips, LCD display, relay module for functionality
10/16/17	• Start physical design/layout of power supply module (communicate with machine shop) • Characterize the IR sensors to ensure that they are working properly. Check MCUs, RF chips, LCD display, relay module for functionality. • Test and verify proximity sensor module (IR Sensors/Relays) and LED module. Requires programming of MCU to perform the necessary A/D conversion.
10/23/17	• Finish prototype subsystem consisting of proximity sensor module, LED module, and MCU A/D conversion. • Test and verify RF transceiver chips, LCD display, and MCUs. Begin prototype subsystem consisting of IR/slave RF transceiver module/master RF transceiver/central hub/LCD. • Begin writing polling scheme software to program MCU.
10/30/17	• Combine two prototype subsystems to form single prototype consisting of all modules for a single parking spot. • Continue writing and testing polling scheme software. • Finish power supply module and test and verify.

11/6/17	• Finish integration of the single prototype system and debug. • Begin scaling up to four parking spot system by combining multiple "prototyped" systems (having multiple IR → slave transceivers, having multiple slave transceivers → master transceiver) • Finish writing and debugging polling scheme software. Test and verify MCUs for the polling.
11/13/17	• Debug and test full-scale system design. Focus on making sure RF transmission is occurring properly. • Begin physical layout for the full-scale design in order to demonstrate outside in parking lot conditions (work with machine shop)
11/20/17	THANKSGIVING BREAK
11/27/17	• Prepare and perform mock demo of project to TA. • Finish physical layout of the system for testing outside. • Test total integrated system outside in a parking lot and record video for official demonstration • Create initial draft of final report.
12/4/17	• Official demonstration of project to course staff. • Prepare a mock presentation for course staff (first draft of final presentation). • Continue revising drafts of final report.
12/11/17	• Revise and submit the final report. Practice final presentation and present to class staff. • Finalize and turn in lab notebooks. • Perform lab checkout.

At the submission time of this design document, the exact distribution of work between group members has yet to be decided. As the project progresses, the distribution of work between the three group members will be decided.

7 Ethics and Safety

There are two main safety concerns during development and operation of our project. One concern during development would be dangers that could arise from using the soldering iron to build our modules. At least one of us in our group is already heavily experienced with using soldering irons, and we will follow any and all safety and lab use guidelines to minimize the risk of danger. The second concern is the shock hazard. In our scaled-down version, 5V is being used to run all of our modules, with the only instance of 120 VAC being used as input to our power module. There is of course a shock hazard when working with any type of electricity, especially so when working with AC power. In the normal-sized design, 120 VAC would be used slightly more as it would also be powering the LEDs and thus be running through the LEDs, the relays, and the power module. This hazard affects us during development as well as customers during operation. To minimize this hazard, we plan to make sure all power lines are properly insulated and grounded if necessary. All of our modules will be carefully designed and built to minimize the chance that an outsider can be exposed to the internals of each circuit. Customer interaction is strictly limited to viewing the LCD display, which should not contain any physical hazards, but customers will still be around the other modules that present a shock hazard so it is still important to take these hazards into consideration.

We do not foresee any major ethical concerns with this project. A detailed reading of the IEEE Code of Ethics [7] reveals we need to ensure we meet code #1 considering the safety of the public. As explained above, this will be done by minimizing exposure a user has to dangerous voltages, and only allowing our system to be put into operation if it presents no physical hazards that have not already been accounted for. Any design flaw in our project that could present a danger would be immediately disclosed to any affecting parties. Similarly, reading over the ACM Code of Ethics [8], we need to ensure we meet code 1.2 which states to avoid harm to others. This will be ensured using the same methods to meet the IEEE code, guaranteeing safety to the public (and ourselves) at all costs.

References

[1] Sarah Rich, 'Smart Parking Tech Might be Paying Off in U.S. Cities', GovTech, 2011. [Online]. Available: http://www.govtech.com/transportation/smart-parking-tech-us-cities.html [Accessed: 21-Sep-2017].

[2] Kevin McCoy, 'Drivers spend an average of 17 hours a year searching for parking spots', USA Today, 2017. [Online]. Available: https://www.cnbc.com/2017/07/12/drivers-spend-an-average-of-17-hours-a-year-searching-for-parking-spots.html [Accessed: 21-Sep-2017].

[3] Joe Colangelo, 'Some Statistics on Suburban Parking', 2017. [Online]. Available: http://www.boxvehicleapp.com/single-post/2017/05/16/Some-statistics-on-Suburban-Parking [Accessed: 21-Sep-2017].

[4] Matt Richtel, 'Now, to Find a Parking Spot, Drivers Look on Their Phones', New York Times ,2011. [Online]. Available: http://www.nytimes.com/2011/05/08/technology/08parking.html. [Accessed: 21-Sep-2017].

[5] Vera-Gomez, Quesada-Arencibia, et al., 'An Intelligent Parking Management System for Urban Areas', 2016. [Online]. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4934356. [Accessed: 21-Sep-2017].

[6] Kiunsys, 'Parking Spot Sensors - System' [Online]. Available: http://www.kiunsys.com/products/parking-spot-sensors-system. [Accessed: 21-Sep-2017].

[7] IEEE, 'IEEE Code of Ethics' [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 02-Oct-2017].

[8] ACM, 'ACM Code of Ethics and Professional Conduct' [Online]. Available: http://www.acm.org/about-acm/acm-code-of-ethics-and-professional-conduct. [Accessed: 02-Oct-2017].

[9] Sharp, ‘Sharp GP2Y0A21YKOF Datahsheet’ [Online]. Available: https://www.pololu.com/file/0J85/gp2y0a21yk0f.pdf [Accessed: 05-Oct-2017].