Electrical Overview

Year: 2023 Semester: Spring Team: 10 Project: Parking Tracking System

Creation Date: ­February 1, 2023 Last Modified: February 8, 2023

Author: Dan English Email: englishd@purdue.edu

Assignment Evaluation:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Electrical Overview** |  | x3 |  |  |
| **Electrical Considerations** |  | x3 |  |  |
| **Interface Considerations** |  | x3 |  |  |
| **System Block Diagram** |  | x3 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

General Comments:

1.0 Electrical Overview

For our project design, we will be using a 32-bit microcontroller for tracking how many cars enter and exit the garage and computing how many available parking spaces are left in the garage at any one time. The microcontroller will also manage all peripherals and hardware located on the device, especially the wifi module used to communicate between our Aggregator Module (AM) and Car Detection Modules (CDM). The microcontroller on the AM will manage the network of CDMs to compute the total number of available spaces and system configuration from a user. The microcontroller on the CDM will manage the processing necessary for determining if a car has entered or exited the garage based on the data from the sonar sensor.

For communication between the AM and CDMs, we will use a Wi-Fi SOC module. The chip contains an antenna for wireless communication and a small processing unit for operating the wifi. The 802.11 b/g/n protocol and TCP/IP protocol stack handling are included in this module and will be used for communication [1]. This module will be used for connecting to or creating a wifi network in order to send and receive data between the AM and the other CDMs. Using wireless communication allows the AM to be more centralized within the garage while still being able to receive data from the CDMs located at each entrance and exit. The microprocessor will communicate with the wifi module using a UART interface.

For displaying the number of available parking spaces in the garage to the customers and drivers, we will use two large seven-segment LED displays. Since these displays will operate at a much higher voltage and current than the microcontroller can provide, we will use shift registers and MOSFETs to provide power to each segment depending on the desired digit to display. The microcontroller will write a byte to the shift register over an SPI bus, and the output values of the shift register will be connected to the gates of the MOSFETs, which will connect the corresponding segment to ground, allowing power to be supplied to the segment and light up the LED.

For configuring the system, the AM will contain a 16-button keypad and 2x16 OLED display. The microcontroller will communicate instructions and status updates to display on the OLED using an SPI interface. The keypad will allow the user to control the configuration process and input data. The microcontroller will read the user inputs on the keypad through a debounced matrix circuit that will decipher which of the buttons was pressed.

For detecting cars entering and exiting the garage, we will use a sonar sensor. The sensor outputs a logic high pulse for a certain length of time that corresponds to the distance measured from the sensor to the closest object. The microcontroller will use GPIO pins to tell the sensor to take a measurement and read its output.

For power, the AM and CDM have different needs and will use different parts. The AM will use a AC-DC adapter to plug the device into the wall and supply it with DC power. The AM board will contain a switching regulator and a linear regulator to drop the input DC voltage to lower voltages utilized to power and operate the chips on the PCB. The CDM will use a portable power bank to power the device and a linear regulator to drop the input DC voltage to a lower voltage for chips on the PCB.

2.0 Electrical Considerations

The microcontroller will operate at 48 MHz, which is the max frequency for our selected device [2]. This will allow us to run all of our processing as fast as possible without having to change our microcontroller selection. Due to the lack of complexity within our computations and lack of high-speed processing needs since cars will be entering and exiting the garage slowly, we do not need a greater frequency in order to compute everything in time without consequence.

We have two separate, yet similar, power budgets: one for our AM, and one for our CDM. The AM will be plugged into the wall, so no battery monitoring or lifetime analysis is necessary. The input of the AM will be 12V, 5A from the AC-DC adapter. The large seven-segment displays will be connected to this 12V bus and draw about 20 mA per segment. Therefore, for both digits, the max current draw will be 320 mA, resulting in 3.84 W max power consumption (max referring to all segments being lit at the same time). The other component on this bus will be the switching regulator, which will output 5V, 1.5 A. Recently, we changed our component selection, and, as a result, there are no more components on the AM that will require 5V. Therefore, we will look into a 12V to 3.3V switching regulator over our current 12V to 5V one. Thus, the only thing on the 5V bus will be the linear regulator, which will output 3.3V, 0.8A. All of the other components of the AM will be on this 3.3V bus, including the microcontroller, wifi module, OLED, shift registers, and keypad. The microcontroller, OLED, shift registers, and keypad draw a combined current of 100mA while the wifi module will draw a max of 100mA on its own. The efficiency of the linear regulator has been measured to be about 60% based on experiments conducted by us in lab. Therefore, if the 3.3V bus consumes 660 mW, then the power consumed by the linear regulator will be 440 mW.

The CDM will be plugged into a portable power bank that is rechargeable. The time of operation allowed by one full charge will be dictated by the energy storage capability of the power bank and the power consumption of the CDM. The power bank is rated at 38,800 mAh and outputs 5V, 2A [3]. The sonar sensor operates at 5V and draws 15 mA. A linear regulator will drop the voltage down to 3.3V with an output current up to 800mA. The microcontroller and wifi module will be connected to this 3.3V bus, which will draw a max of 130 mA when communicating over wifi and 100 mA when idling. Thus, the total power consumption will be 0.13\*3.3 + (0.13\*3.3) / (0.6) \* (0.4) + 0.015\*5 = 790 mW. At 38,800 mAh, the power bank can supply the CDM for 38,800 \* 5 / 790 = 10.2 days.

3.0 Interface Considerations

We will use SPI and UART for communication on the board. We will use wifi to communicate between modules.

The microcontroller will interface with the shift register chip by using SPI and an extra GPIO pin. SPI will be used for the data shifted in and the clock signal to move the shift register, and the extra GPIO pin will be used to control the output latch clock signal, which latches the shift registers value into the output flip flops.

The microcontroller will interface with the OLED display by using SPI. SPI will be used for the data of the characters to display and the clock signal to load the data into the display’s memory.

The microcontroller will interface with the wifi module by using UART. The UART will have a baud rate of 115,200, eight data bits, one stop bit, no parity bits, and 16 oversampling. The UART will be used to send data to the wifi chip to be sent over wifi to another module within our design and to receive data from the wifi chip that has been sent from another module within our design.

The wifi modules will use IEEE 802.11 b/g/n protocol to communicate with each other. The Aggregator Module’s wifi chip will create and host a network, to which the Car Detector Module’s wifi chip’s will connect. Over this network, the CDM will send data packets consisting of the number of cars and which direction they went: either entering or exiting the garage.

4.0 Sources Cited:

[1] “ESP-01/07/12 Series Modules User's Manual V1.3,” AI Thinker [Online]. Available: <https://www.universal-solder.ca/downloads/esp8266_series_modules_user_manual_en.pdf>. [Accessed: 02-Feb-2023].

[2] “STM32F091CBU6,” STMicroelectronics. [Online]. Available: <https://estore.st.com/en/stm32f091cbu6-cpn.html>. [Accessed: 04-Feb-2023].

[3] “Portable Charger 38800mAh,LCD Display Power Bank,4 USB Outputs Battery Pack Backup, Dual Input USB-C Phone Charging Compatible with iPhone 13 Pro Max/13 Mini/12,Android Samsung Galaxy/Pixel/Nexus/iPad,” *Amazon.* [Online]. Available: <https://www.amazon.com/Portable-Charger-38800mAh-Charging-Compatible/dp/B09H4GLZXT/ref=sr_1_1_sspa?keywords=usb%2Bbattery%2Bpack&qid=1674243979&sr=8-1-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEzMFNFVksxN0w3N1ZEJmVuY3J5cHRlZElkPUEwNDk2NzgyMjg0TVhHMFNJUDlTRCZlbmNyeXB0ZWRBZElkPUExMDMxMjY3Mzg1V1FVUFEzTjUwNSZ3aWRnZXROYW1lPXNwX2F0ZiZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU&th=1>. [Accessed: 04-Feb-2023].

Appendix 1: System Block Diagram

Diagram

Description automatically generated

Figure 1: Functional Block Diagram of Aggregator Module

Diagram

Description automatically generated

Figure 2: Functional Block Diagram of Car Detector Module