Cab Tech Design Review

Design Details

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I. Introduction

We have chosen this design project because we identified a common inconvenience in the current taxi cab system which seems to have a very practical and logical solution. We felt we could come up with a solution which would revolutionize the way taxi companies run their business. Our idea would not only make a cab pick-up more convenient for the customer but also create a more cost efficient business environment for the cab companies themselves. What makes this idea exciting is that we see a great deal of potential and need for this type of system.

Our focus and main priority during the development of this project will be to implement a system which will ultimately achieve the elimination of taxi dispatching and also the need for calling to arrange a pick up. Other goals will be creating the cheapest and most effective system possible along with user friendly hardware designs which will make this service easily adoptable. Cab Tech will offer benefits and features for taxi companies as well as for taxi customers.

Cab-Tech Benefits

Taxi Company

- No Dispatching
- Reduced Overhead Cost
- Speedy Service
- Customers

Customer

- Reduced waiting time
- No calling in
- No Searching

Cab-Tech Features

Taxi Company

- Driver Physical Address Display
- Automatic Availability Check

Customer

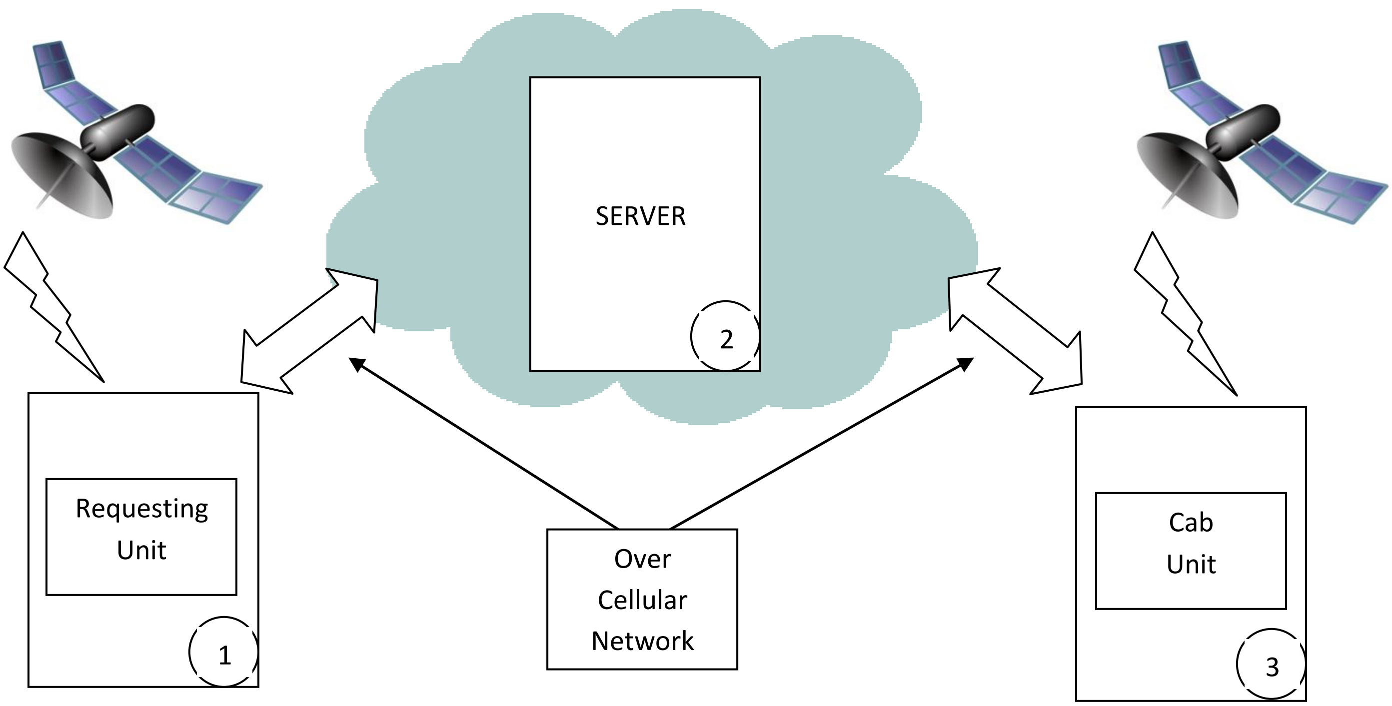
- One Button Pick-Up

II. Design

The design will be broken-up into 3 separate systems: the requesting unit (which models a cell-phone and will be simulated on the server to mitigate cost) the server, and the cab module. All three systems are important to the overall efficacy of the improved cab pick-up procedure. The design is introduced in a high-level scope which leads into the lower level blocks necessary for a complete design.

Commercial Outline

The server will maintain a database of all available cab GPS location and IDs, contain algorithms to compute “closest available cab to requesting unit” and correlate lat/long to physical address.



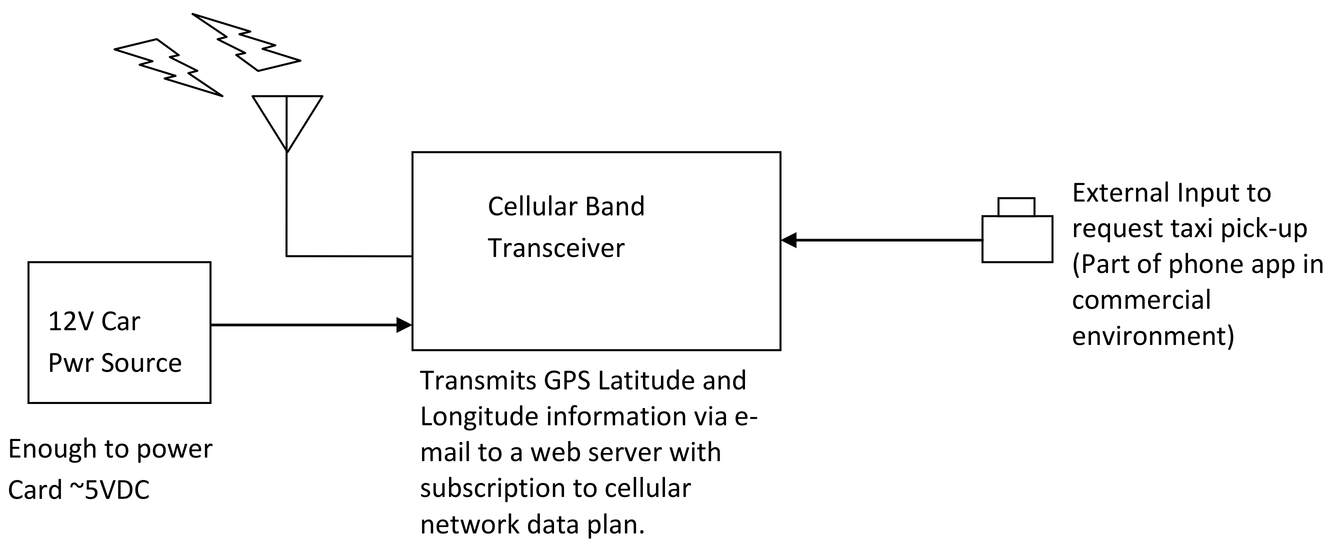
With an intention to request a “pick-up,” the user presses a button that sends this unit’s latitude and longitude location over a cellular network to a web server

The cab unit receives an address location for the requesting unit’s location which is displayed on its display. Available cabs transmit their current location to the web server at about 30 second intervals.

Module 1: (Requesting Unit)

Block Diagram:

*To be implemented on the server to save costs



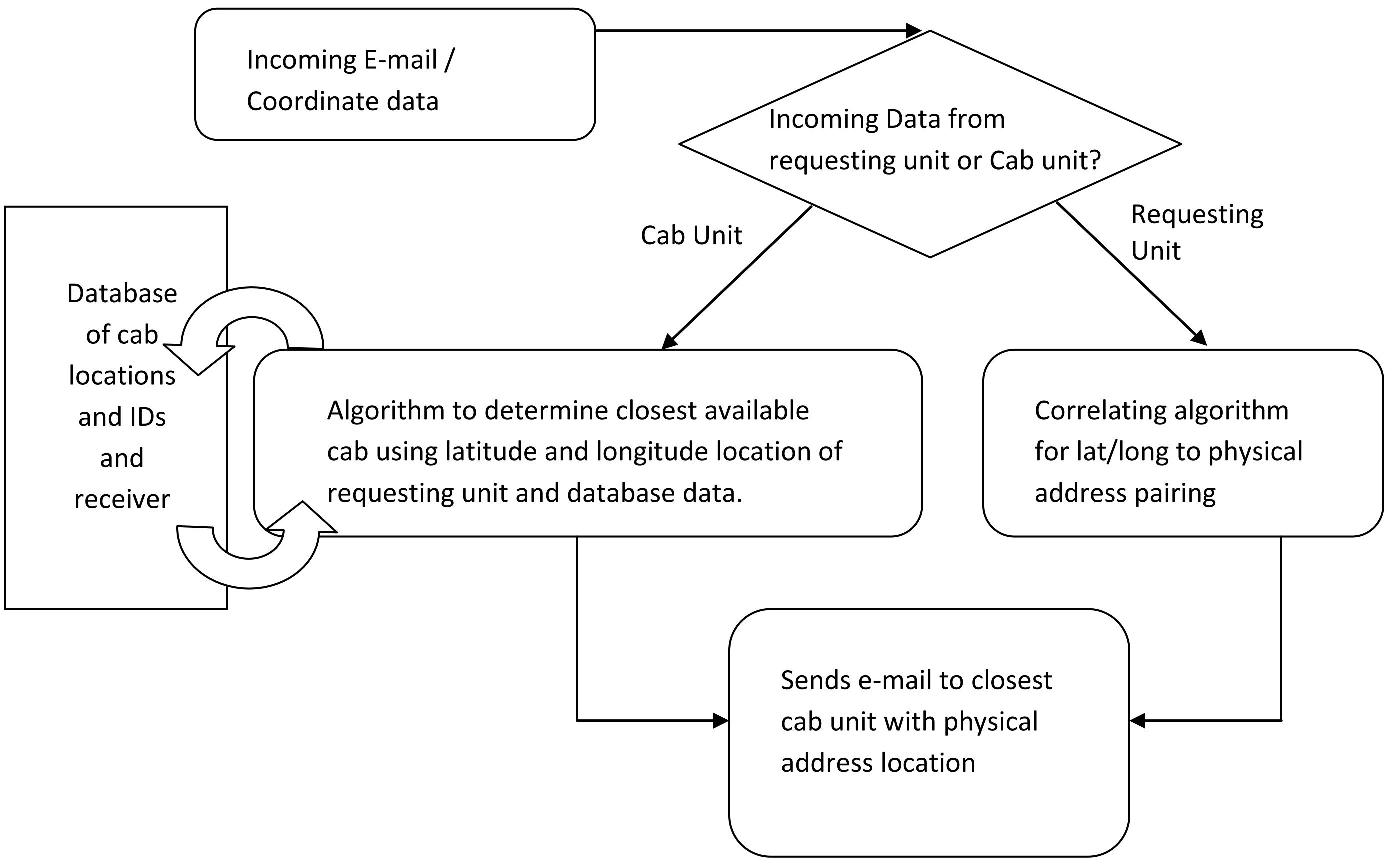
Performance requirements:

- Provide GPS data in the same format a GPS enabled phone would provide it

The requesting unit should behave similar to what current cell phone GPS transmission performance specifications are. It will be built on the server sending e-mail packets with Lat/Long information so that it may correlate its position to a physical address using online resources (Google maps perhaps). The cab unit will use the information provided by the GPS to pick-up the requesting customer.

Module 2: (Server)

Flow Chart:



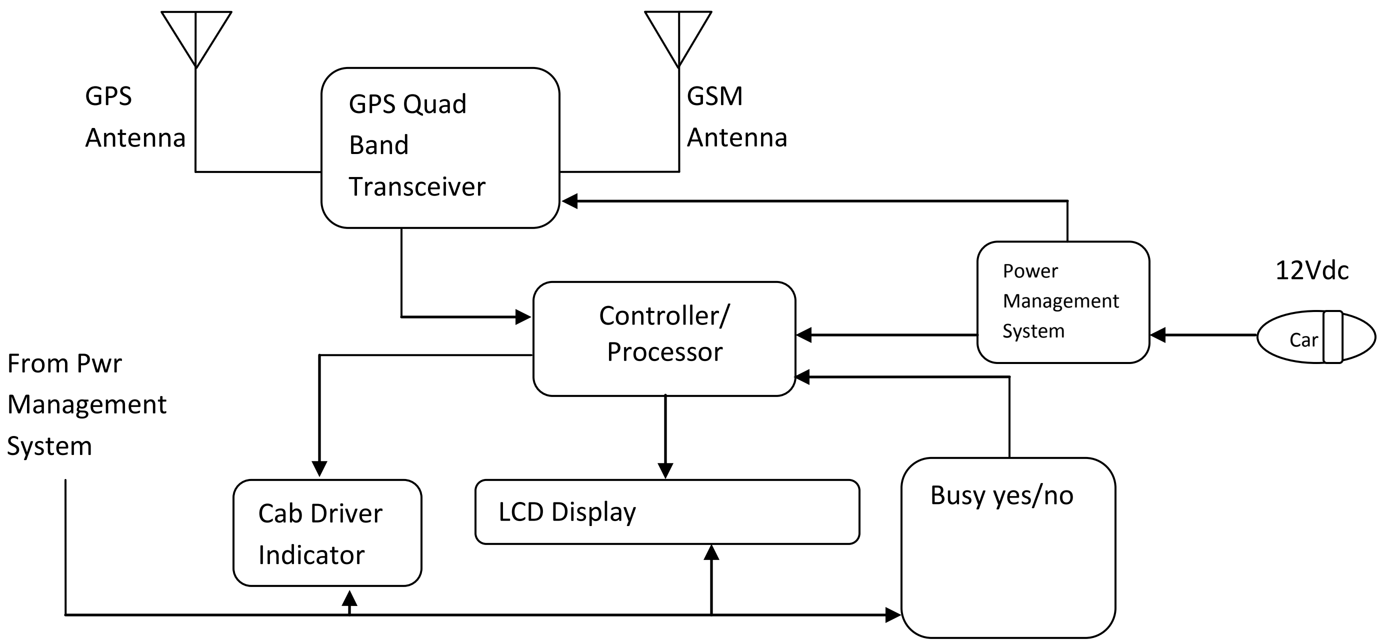
Performance Requirements:

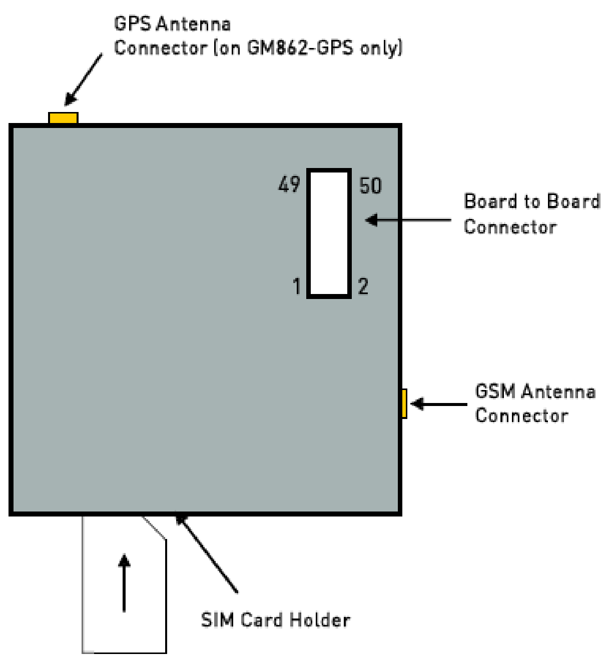
- Email account capable of 100MB storage
- MySQL Database 10 X200
- Secure SSL, SSH Access
- Language Support: Perl, PHP, Python, Java

The server is our central hub for information and computing. It would receive lat/long information from both transmitting units and an available/unavailable signal from the cab module. Then interact with the database and received information to send an address back to the cab unit for display processing.

Module 3: (Cab Module)

Block Diagram:





Block Description:

Cab Driver Indicator

The indicator will light and/or emit a sound whenever a new customer address is received. The design consideration will be such so that the incoming information is evident to the driver.

LCD Display

Displays the street address / intersection received from the controller. Could potentially be involved in the driver indication process.

Power Management System

Provides power from the 12 Vdc available in the car to the cab module.

GPS Receiver

Receives radio signals from satellites and calculates latitude/longitude from those signals. Sends the latitude/longitude value to the controller.

GPS Receiver / Cellular Band Transceiver

Receives intersection or address from the server via e-mail and sends it to the controller to be processed

Transmits the combined Cab GPS location and busy signal received from the controller to the server.

- Transmits every 30 seconds in the form of an e-mail if the busy y/n signal is set to available.
- Does not transmit if the last signal sent had a busy y/n signal set to busy and starts transmitting when the busy y/n signal is set to available.

Busy Y/N

- Has a switch that the cab driver can toggle between. The two options are busy and available and indicate whether the taxi driver is busy or not.
- Green/Red LEDs to indicate what position the switch is in.
- Connected to the controller, which in turn uses the busy y/n signal as part of the e-mail sent to the server and to determine whether the Transceiver is active or not.

Controller

When new caller information from the Transceiver arrives, the controller activates the cab driver indicator, processes the address received and sends it to the LCD Display.

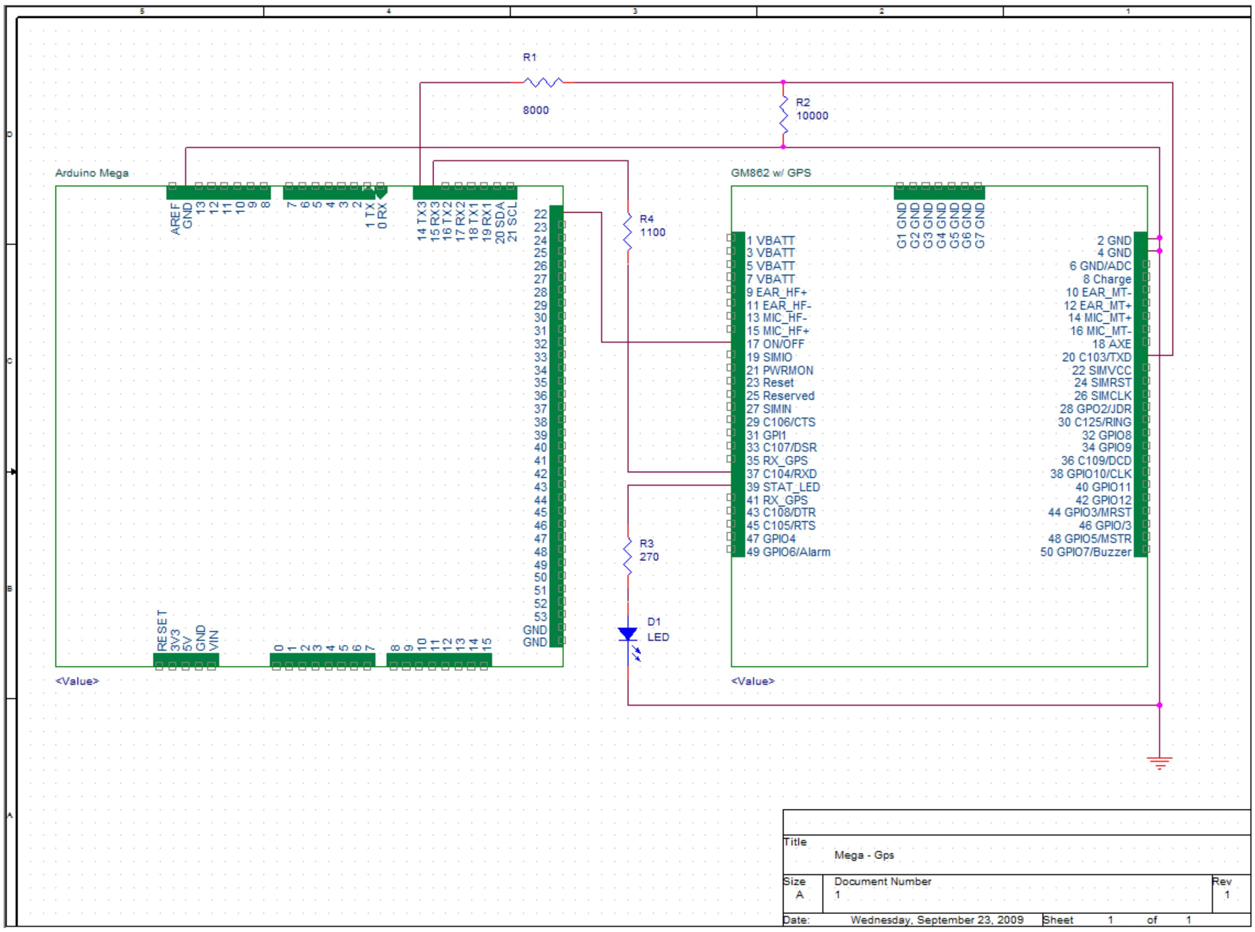
Combines the Cab GPS location from the GPS Receiver and the signal from the busy y/n module and sends that to the Transceiver to be transmitted to the server.

- Controls how often the transceiver transmits
    - Sets transmission to about once every 30 seconds when the busy y/n signal is set to available
        - when the busy y/n switch is changed from busy to available, transceiver immediately sends a transmission and continues to send one every time interval until busy y/n changes from available to busy.
    - transmits once and stops the transceiver from transmitting after the busy y/n signal is on busy.
        - when the busy y/n switch is changed from available to busy, transceiver immediately sends one transmission and stops transmitting until busy y/n changes from busy to available.

The Cab Unit is our main hardware component . The Cab Unit combines the lat/long from its GPS receiver and the busy y/n signal and sends the result as an e-mail packet to the server. It does this at about 30 second intervals. When the Cab Unit receives a caller location from the server via e-mail packet, it alerts the cab driver with the cab indicator and displays the location received on the LCD display. At that point the cab driver would flip the busy y/n switch (to busy) and the Cab Unit would immediately transmit a lat/long and the busy y/n signal (busy) to the server and stop transmitting and receiving. When the cab driver finishes picking up and dropping off the caller, or whenever the cab driver is ready, the cab driver would flip the busy y/n switch to available and the Cab Unit would once again start transmitting at 30 second intervals and receiving.

Schematic Diagram

Telit GM862 GPS Module to Controller Input:



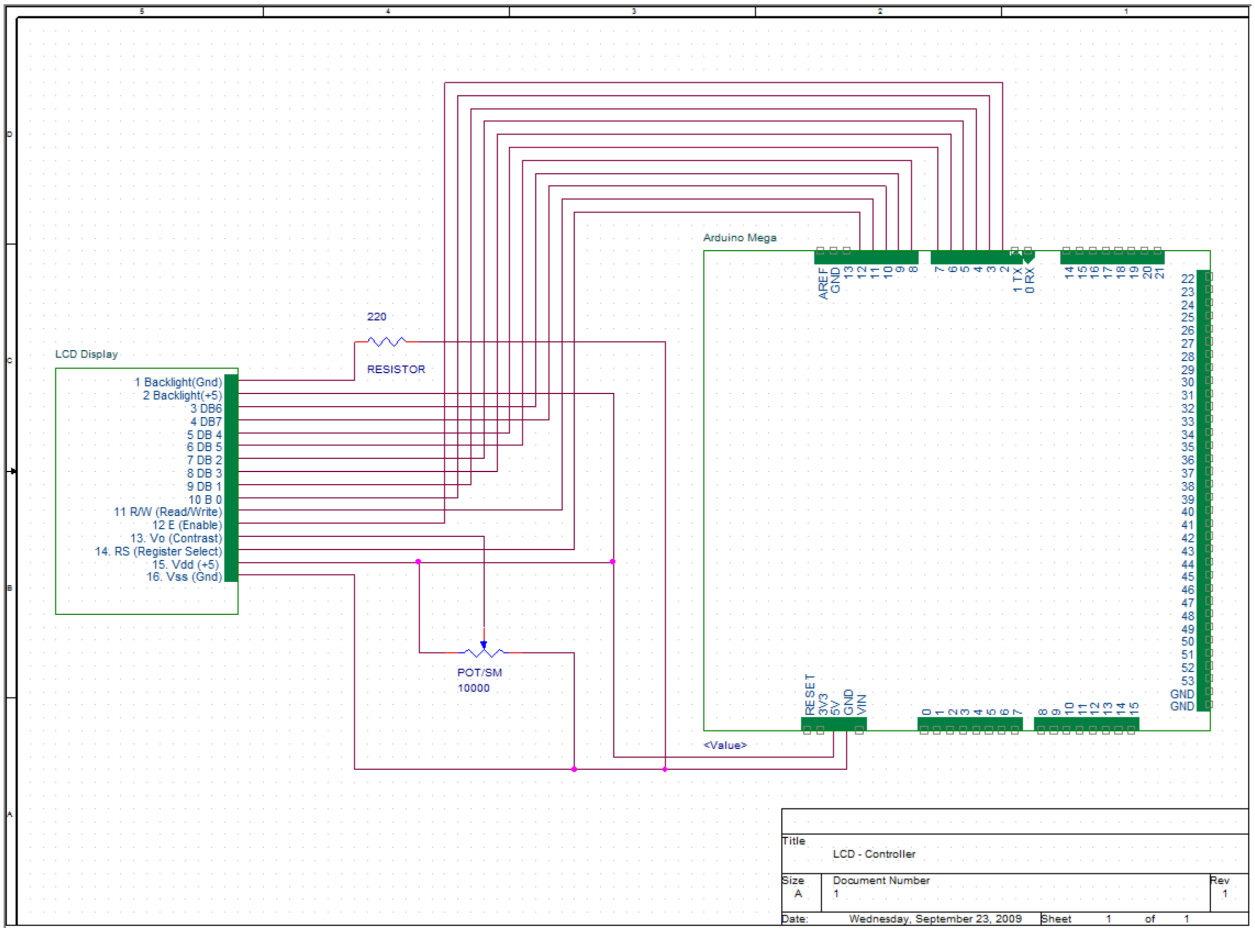
The controller input and interconnect for our board will consist of the GPS module and an Arduino microcontroller board which will essentially maintain the processes within the GPS transceiver in sync with real-world needs. For instance, if the cab becomes busy and is unable to pick up any person then a busy switch will be available and the switch will tell the microcontroller to somehow let the server know that the cab has become unavailable for customer pick up. Above is the schematic diagram

Using a voltage divider between the pins of the Arduino Mega and the GM862, the Arduino Pins run at 5V and the GM862 pins at 2.8V.

$$\frac{V_{out}}{V_{in}} = \frac{Z_2}{Z_1 + Z_2}$$

LCD to Microcontroller

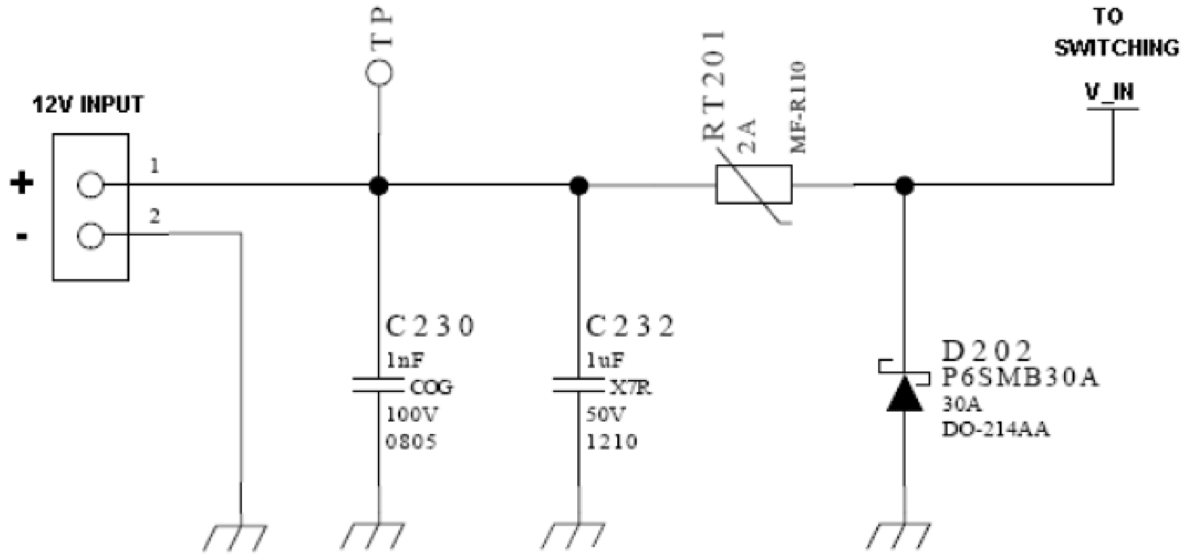
The microcontroller to LCD interface is shown above. The LCD shown in the schematic is an

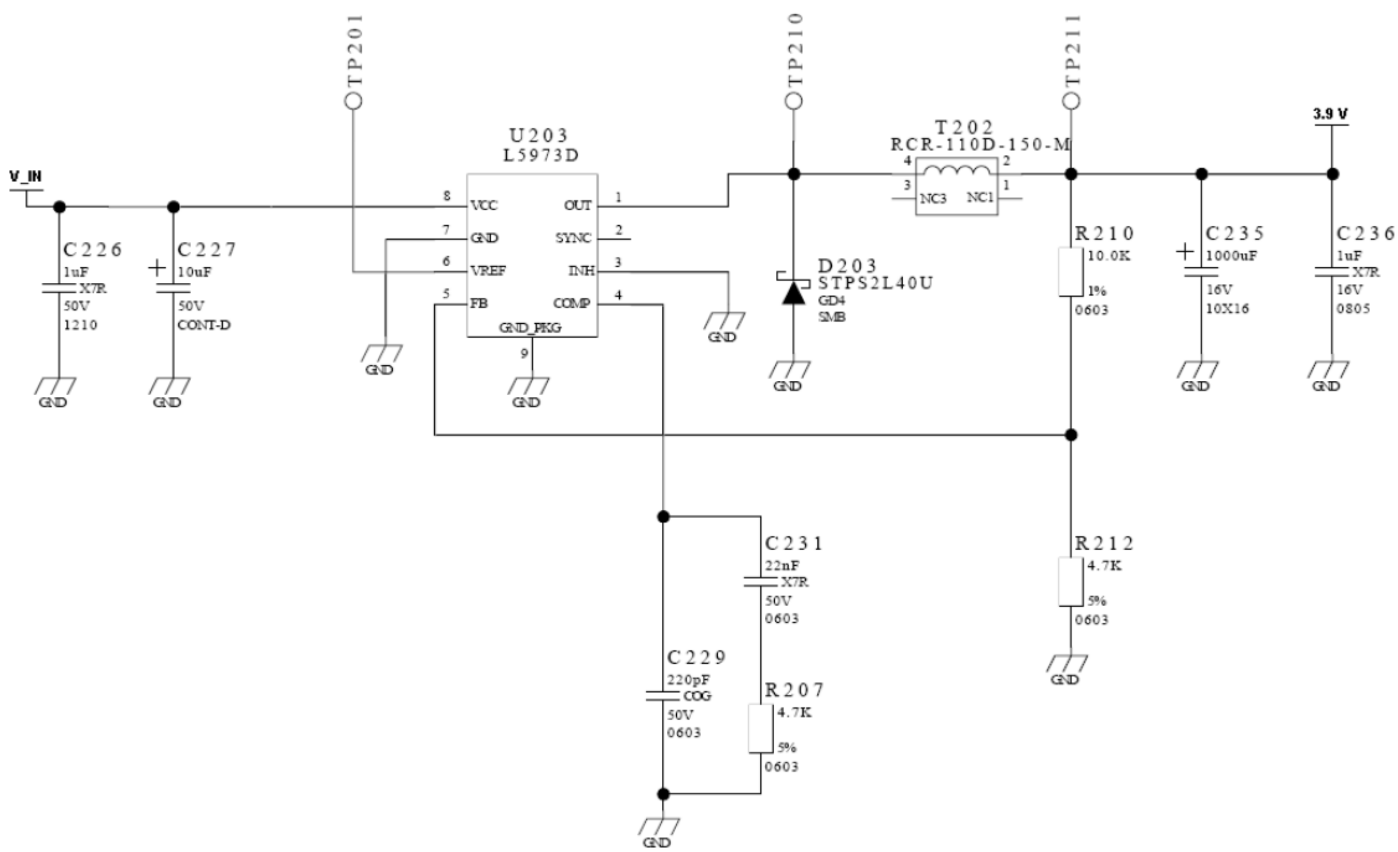


Alesis 9-40-1381-C but the pin layout is similar for any HD44780 Character LCD. The 10k pot adjusts the contrast of the LCD.

Performance Specifications

- LCD screen of no less than 40 digits
- Power management system needs to provide 75 mA (based on the SparkFun Quad Band Module)





SWITCHING REGULATOR

Due to the big difference between the car's 12Vdc and the 3.8Vdc nominal voltage required by the GPS unit a switching power supply is a more adequate design choice in order to protect the hardware against current and voltage spikes. A switching mode conversion is also more efficient than the linear design because it does not dissipate as much heat as the linear circuit components. The voltage output of a car battery can rise from 12 to 15.8 and the GPS module has a 2A peak current and all of these dynamics must be controlled for circuit protection.

The capacitors serve the function of clamping voltage. In DC state, capacitors become open circuits so all the current runs along the "main" line. If the voltage begins to fall, the capacitors release stored voltage to maintain the input at around 12 V. The suppressor diode is necessary for large voltage/current spikes that may be a potentiality in a car's auxiliary power supply.

The input on the VCC end of the voltage switching unit should be a steady 12 Vdc with these safeguards. The step-down switching regulator uses transistors to turn the device on and off at a predetermined duty-cycle to control the voltage output.

Figure 3. Line regulation

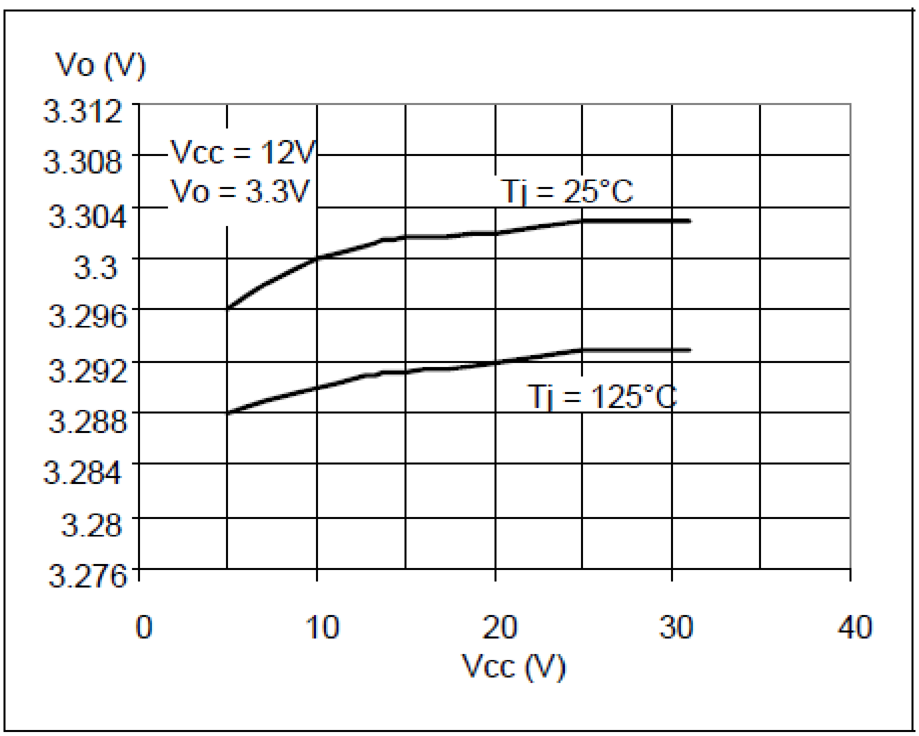
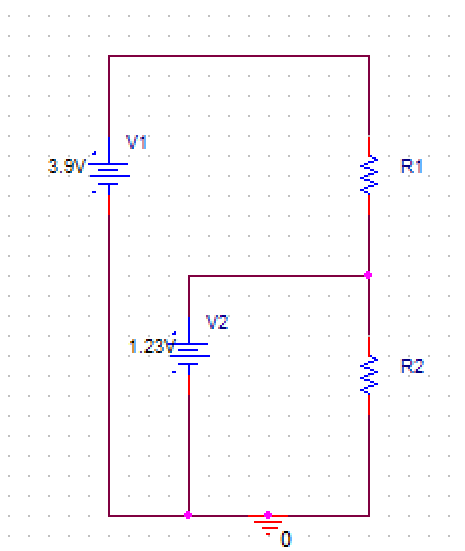


Figure 3 gives us shows the relationship between output voltage and input voltage at two temperatures. The one we are interested in is room temperature (25 degrees). When VCC is 12V the switching unit outputs 3.3V. This value is using the resistors provided in the diagram by the manufacturer. According to the Telit GPS manufacturer by using 2 different resistor values at the output our output changes from the manufacturer's 3.3V to the 3.9 necessary to run most operations on the GPS unit.

Preliminary Test Results

We wrote mathematical models for what the output circuit should look like in DC steady state so that we could analyze how it would behave under these conditions. What we came up with was the circuit below and this is because a capacitor in steady state behave like a break in the circuit and the diode should be reversed biased under these voltage conditions.



$$Where : V1 = 3.9V \text{ and } V2 = 1.23V \text{ according to the manufacturers technical data}$$

$$Adjusting\ the\ resistance\ values\ results\ in\ a\ change\ in\ the\ voltage$$

Testing Planning and Verification

Our design includes both hardware and software interacting together. In order to test their functionality we would first have to test each module individually. The main components that we would need to test for this design are the server and the transceiver. Both of these modules can be tested for proper behavior by sending them packages of data by email, waiting for a proper response and then analyzing the data by matching it with our logic and math. The transceiver includes circuit level components which we would first need test before we can send it an email.

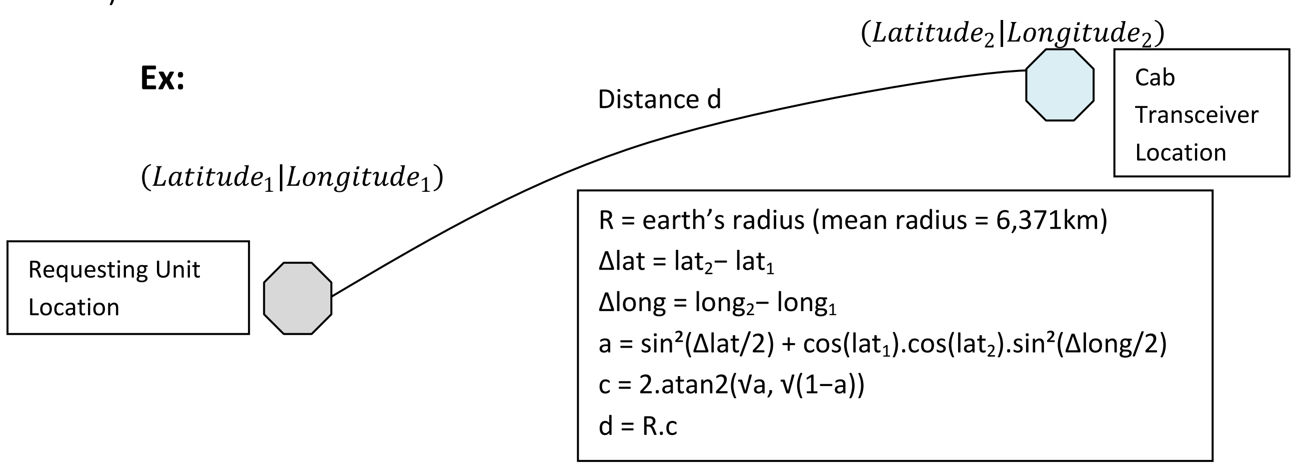
Testing for Server

Process

1) Send generic emails to server which would replicate emails being sent by requesting unit and transceivers.
    - The requesting unit email package will contain the following:
      Phone Number: 7082334322 Latitude: 4916.45,N
      Longitude:12311.12,W
      Email message in the form of: 7082334322/4916.45,N/12311.12,W
    - The Transceiver unit email package will contain the following:
      Phone Number: 7082334322 Latitude: 4916.45,N
      Longitude:12311.12,W BusySig: 0/1
      Email Message in the form of: 7082334322/4916.45,N/12311.12,W/0

   Send output emails being generated from server to an email account which we could then open and analyze the data to see if the server is outputting the correct values. If the server is computing the nearest cab correctly and sending the correct address then it would be functioning properly. We can do the math ourselves using the Haversine formula below to find out the distances and ultimately the nearest cab to check if the algorithm is working and that cab is actually the nearest cab to the requesting units coordinates.
2)

Ex:



Testing for Transceiver

To test our transceiver we would have to test each component within the transceiver first, by assuring that the power supply is working correctly for the entire circuit and also the GPS we can then move on to testing the GPS, Micro Controller, and finally the LCD display.

Power Supply

Some preliminary tests we can run on the transceiver are regarding the power supply. The power supply for the GPS module is especially important to us because it has to be able to provide a large amount of current (2A peak) at an instant when the antenna is transmitting a signal and then go back to the standby amount it needs to operate when there is no signal being transmitted. Therefore this power supply has a special switching chip to allow us to have the high switching frequency we need for the regulator to respond quickly enough to the current peaks absorption. The power supply has to also regulate the voltage coming in because we are using a car supply and our input voltage will range between 8V and 15V. The GPS module operates at a range of 3.4V to 4.2V, the desired output of our power supply will be 3.8V. We can test this by simply measuring the voltage at the output of the power supply to make sure that it is the desired 3.8V and then run a simulation using PSpice to simulate a load which can instantly drain 2A. Also within our power supply we can run a simple test to see how clean our voltage coming in is, we can hook up an oscilloscope to the point on the power supply right after the first diode (DZ201) in the schematic, the supply should have considerably less noise than it would if the diode is not working properly.

Requirements to test for in power supply:

1) 3.8V output
2) 2A peak current load(Switching Power Supply)
3) Clean voltage source(Using diode)

GPS Module

This module is being tested by having emails being sent from it go to a generic email address which we could then check to see if it is in correct format and has proper values. The GPS module will also pass on data to the controller so we will have to ensure that it is working properly before we can really test the the controller and LCD.

Controller & LCD

The controller and LCD modules do not have circuit level components and all the testing to ensure that these two are working properly would have to be by monitoring and analyzing data coming out of the controller.

Tolerance Analysis

To have the controller module work correctly, the voltage drawn by the power management system from the car has to be between 3.22V and 4.5V DC (optimally at 3.8v).

For current, the unit consumes:
-power is off < 26uA
-idle - 2.6mA
-dedicated mode - 200ma
-GPRS 10 - 370ma

III. Cost and Schedule

Salary per hour of each person on team:

Each person on team will charge $30.00/hour

For a grand total of 15 hours per week X 15 weeks = 225 total hours per person on project.

Member	**Transceiver Labor(hrs)**	**Requesting Unit Labor(hrs)**	**Server Labor(hrs)**	**Simulation/Debugging (hrs)**
Edit	0	15hrs*3wks = 45	15hrs*8wks = 120	105
Geovanie	15hrs*5wks = 75	0	0hrs	105
George	0	0	15hrs*8wks = 120	105

Total/Col(hrs)	75	45	240	315

TOTAL: 675hrs

Total hours spend by all members being 675 hours yields a total labor cost of **$20,250**.

Item	Quantity	Parts Cost ($)	STATUS
Server (Go Daddy)	1	(4.99/month * 4) = 20.00	
Quad Band Module/cable/ Dev Board **GM862 Eva Kit-USB**	1	277.65	
O2 Wireless - Universal SIM Card	1	9.99	
Arduino Mega	2	49.63*2=99.26	
Parallel 40 character display	1	25.00	✓

Resistors:	16	71¢*16=11.36	
100k	2		✓
47k	2		✓
27k	1		✓
22k	1		✓
220	1		✓
100	1		
4.7K	4		
10k	2		
Potentiometer 10k	2	2.00	✓
NPN Transistor	2	2*0.31=0.62	
Switches	5	3.00	
LEDs	3	3.00	
Voltage regulator	5	3.00	✓
Amplifier	4	2.00	
Capacitors:	18	47¢*18 = 8.46	
C226 1uF			✓
C227 10uF			✓
C229 220pF			✓
C230 1nF			✓
C231 22nF			✓

C232 1uF **C235 100uF** **C236 1uF**			✓
Diodes: **D203(STPS2L40U)** **D202(P6SMB30A)**	4	37¢*4 = 1.48	
(L5973D) IC REG SWITCHING STEPDOWN	2	1.6*2 = 3.2	
RCR-110D-150-M	2	1.7*2 = 3.4	
MF-R110	2	.38¢*2 = .76	
Quad-band GPRS Antenna*	1	(25.90)	
Quad-band Cellular Attennae*	1	(15.90)	
Interface Cable MMCX to SMA*	2	(17.90)	
Quad-band Cellular Duck Antenna*	1	(15.90)	
Total		474.18	

Cost for labor and parts come out to a total project cost of:

$20,730.00