Vehicle to Vehicle Communication (V2V) Device

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1 Introduction

1.1 Objective

Currently, the way smart vehicles work is that they have sensors all over the car to detect nearby objects and information about them. However, these sensors tend to be limited in accuracy past very short distances. And since cars travel at such fast speeds and have to continuously identify changing information in their surroundings, sensors often do not have enough range to identify the necessary information for complicated decisions (crash detection at intersections or highways, avoidance of erratic drivers, traffic decisions, etc.). With the rise in popularity of autonomous driving systems, reliably collecting data over long distances is becoming more and more crucial.

To get over this issue, we propose making a device that would attach to every vehicle on the road. This device would broadcast information about the vehicle (dimensions, speed, acceleration, position, heading, etc.) and receive information about surrounding similarly-equipped vehicles. Furthermore, each vehicle will transmit the information of all vehicles that it has data on, thereby creating a network of information exchange amongst vehicles on the road. By doing so, even if each vehicle can only transmit information within a 300 meter range, if there are enough vehicles in the area, information about the car can be transmitted to vehicles miles away.

This way, the guesswork is taken out of smart vehicles trying to figure out what other vehicles are doing around them. Instead, vehicles can directly receive this information from other vehicles on the road and spend more resources monitoring/tracking non-vehicular objects. This data could then be fed into an intelligent system (whether an autonomous car or just a smart system in a modern car) and could be used to make complicated decisions such as those described earlier.

1.2 Background

Motor vehicle crashes are a leading cause of death with an estimated 37,133 lives lost on U.S. roads in 2017 [2]. With a network of our devices, drivers and autonomous vehicles will be aware of the other vehicles on the road to make more informed decisions if there are high traffic locations or accidents on the road. It is estimated that using a V2V network, there could be a near 80% reduction in non-impaired crashes [3].

Current V2V concepts cover significantly more ground (by nearly 2 magnitudes) than sensor based detection, and are significantly more accurate in keeping track of vehicular surroundings when compared to sensors [3]. However, current concepts exclusively allow inter-vehicle communication and do not form a network. With our implementation, cars will have more data to make more informed decisions from even further. Vehicles will be able to make traffic decisions from so far away that the bottleneck will be transmission bandwidth limiting the number of cars' data that we can broadcast.

1.3 High-level requirements list

- Devices must be able to consistently transmit information from sensors.
- Devices must be able to communicate amongst one another within 500 meters.
- Devices must be able to transmit information about itself and other devices within range.

2 Design

2.1 *Block Diagram*

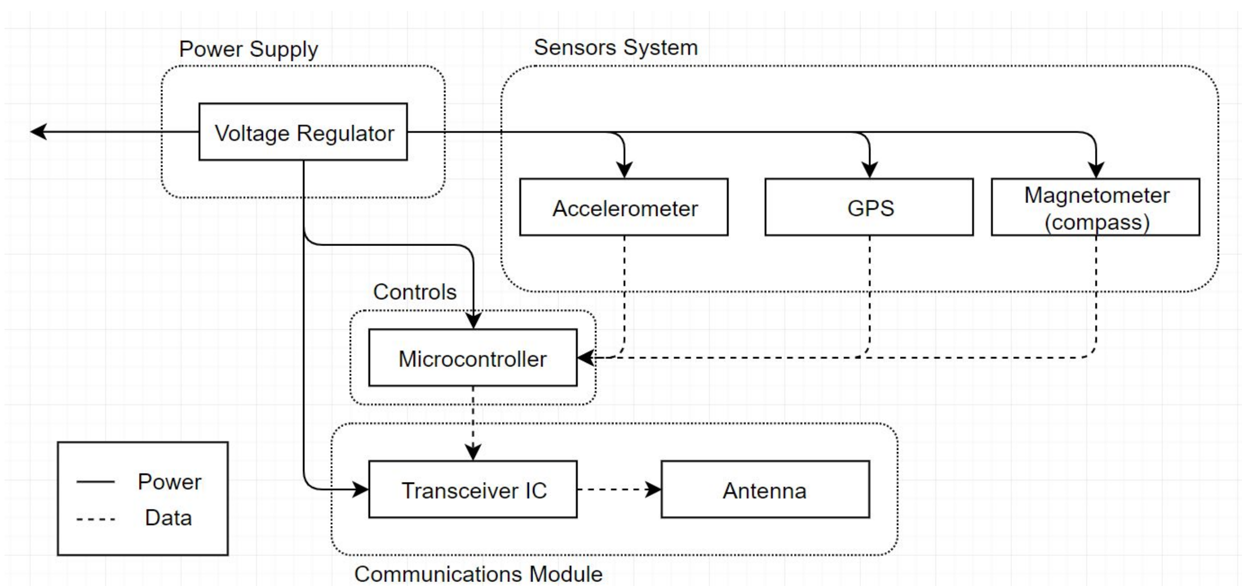

Figure 1. Block diagram

2.2 *Physical Design*

2.2.1 Power Supply

A power supply is necessary to power the components of the device. 12V is drawn from the vehicle and is then regulated to 3.3V which is then distributed through the rest of the system. This module will be required to continually power the system at the appropriate voltage.

2.2.1a Voltage Regulator

The integrated circuit requires 3.3V to be distributed to the system. The chip must handle the 12V from the car at 2.1A to 4.8A, and continually output 3.3V.

2.2.2 Sensors system

An array of sensors will be responsible for collecting data and sending it to the control unit. The sensors will track the vehicle's speed, acceleration, direction, and position.

2.2.2a Accelerometer

The accelerometer, chosen as KXTJ3-1057, operates between 1.71V to 3.6V. The sensor has extended configurable g-ranges, from ±2g to ±16g. The device is aimed to detect significant changes in acceleration in the vehicle.

2.2.2b GPS device

The GPS breakout operates between 3.0V to 5.5V with an operating current of 25mA for tracking and 20mA during navigation. It has a positional accuracy of less than 3 meters and is responsible for outputting the vehicle's coordinates.

2.2.2c Magnetometer

The magnetometer, chosen to be DRV5053, operates between 2.5V to 38V. The sensor has very low sensitivity to voltage and temperature changes. This sensor will be responsible for outputting a direction of the vehicle.

2.2.3 Controls

The controls are responsible in managing data that is received and outputted from the device. The controls will be responsible for communicating the most recent information and sending the correct notification.

2.2.3 Microcontroller

The microcontroller, chosen to be F280040PMQR, operates between 2.8V to 3.63V. It must operate between -40 to +125 degrees Celsius. This component must be sufficiently quick in communicating to the transceiver.

2.2.4 Communications Module

The communications module is required to transmit and receive data to other identical units. The data from the control unit will be sent to the transceiver IC to be broadcasted 900 MHz through a compatible antenna.

2.2.4a Transceiver IC

The transceiver, chosen to be ADF7021-VBCPZ, operates between 2.3V to 3.6V. It has an operating current of 16.3mA for receiving and 13.8mA for transmitting, and it must operate between temperatures of -40 to +85 degrees Celsius. Another requirement is for it to work in the MHz range, so this transceiver covers 80 to 960 MHz.

2.2.4b Antenna

The antenna operates between frequencies of 791 to 960 MHz. It can operate between temperatures -40 to +85 degrees Celsius. It supports gains of -3.9 dBi, -3.1 dBi, and -4.3 dBi.

2.3 Risk Analysis

For our project, one of the biggest risks will be the microcontroller. The microcontroller will have multiple jobs and must not bottleneck the entire device. First and foremost, the microcontroller will have to create a single data packet from sensor information and stored information of other cars. Simultaneously, it will have to constantly collect all new data packets that the receiver picks up and process it accordingly. It will have to decode the signal, process the information (a device might get multiple packets from different sources containing information about a certain vehicle, but the device will only retain the most recent information), and then store the relevant data. There will be synchronization issues that the microcontroller must handle (data packets being sent require reads and data packets being received require writes). We plan to program our microcontroller in C so we can handle the aforementioned risks and optimize synchronization.

3 Ethics and Safety

Safety is the essence of our project. One of the sole purposes of vehicle to vehicle communications is to lower risks and increase safety in all types of vehicles, especially since failures in this type of technology can lead to fatal accidents in the real world. Our goal in this prototype is to minimize packet loss to less than 1%. Meaning that 99/100 data packets that are transmitted are successfully received. Furthermore, we want to minimize latency to <100ms. Meaning that from the moment a signal is broadcast from the transmitter, the receiver on another device (<500m away) will be able to process the packet in less than 100ms.

Although the device has protective functions embedded in its components that prevent damage from overvoltage surges and undervoltage conditions, there remains some potential safety hazards in the device[5]. In the case of undervoltage and reverse polarity, the device will be protected but will not function as expected. This may lead to safety concerns for systems that rely on this device, such as other nodes or drivers.

Unexpected temperatures and high electromagnetic fields can also be potentially harmful to our system, not only to the PCB fabrication, but also to the sensors that we use [5]. To prevent this, we will monitor temperature usage regularly and make sure our device is capable of withstanding above average levels of magnetic fields that vehicle components are exposed to.

Naturally, with any sort of network where information is exchanged, one of the key ethical concerns is that of privacy. Since we are creating this technology, we are responsible for its usage, as specified by IEEE Code of Ethics, #5: “To improve the understanding of technology; its appropriate application, and potential consequences” [1]. There runs the risk of malicious forces using the data that these devices collect for alternative means. For this reason, we plan to cleanse any and all data that is going through the vehicular network so that it contains no private data of the individual (ie names) or the vehicle (ie destination). We will limit our processing to only handle the data we allow, so any other transmitted information would not be processed into readable data.

References

[1]"IEEE Code of Ethics", *Ieee.org*, 2019. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 16- Sep- 2019].

[2]*Transportation.gov*, 2019. [Online]. Available: https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf. [Accessed: 19- Sep- 2019].

[3]T. Kevan, "V2V Technology: A Work in Progress - Digital Engineering", *Digital Engineering*, 2019. [Online]. Available: https://www.digitalengineering247.com/article/v2v-technology-work-progress/. [Accessed: 19- Sep- 2019].

[4]"The Code affirms an obligation of computing professionals to use their skills for the benefit of society.", *Acm.org*, 2019. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 19- Sep- 2019].

[5]“Power Supples.”, Omron, 2019. [Online]. http://www.ia.omron.com/product/cautions/22/safety_precautions.html. [Accessed: 19- Sep- 2019].