Problem Statement

The Vanguard Engineering Group is dedicated to optimizing transmission performance through the development of an after-market electronic control system for automatic transmissions.

Functional Requirements

These functional requirements are the features that we must design and implement into the TORC Transmission Controller. These range from the basic functionality of an electronic transmission controller to other features, beyond shifting gears, which will add value and set this transmission controller apart.

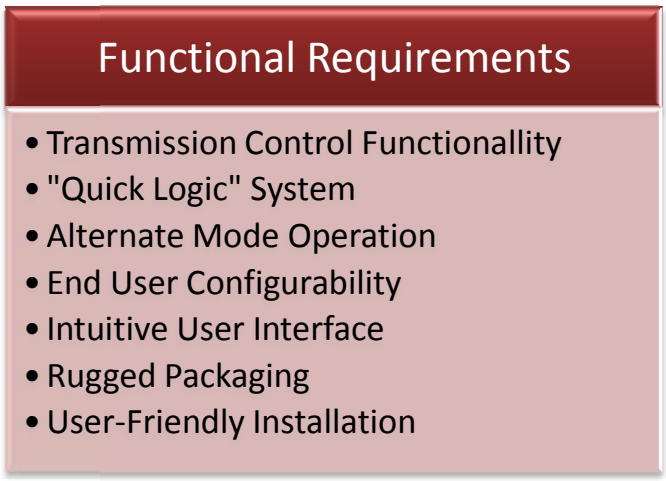

Figure 1. Functional Requirements

Transmission Control Functionality – This device will properly operate and control the functionality of the GM 4L60E automatic transmission using an electronic control system with data from the necessary sensors.

"Quick Logic" System – The controller will contain shifting algorithms that provide for the optimum performance of the transmission.

Alternate Mode Operation – A benefit of having an electronic transmission controller is that you can create alternate transmission modes. This allows the user to be able to change the shift timings to suit their current needs. Some basic modes that can be included are race mode, tow mode, and efficiency mode. This will change the timings to either increase a specific performance point or increase the gas mileage of the car.

End User Configurability – The end user will be able to configure certain aspects of the controller using his home computer, some interface software, and a communication link between the user's home computer and the transmission controller. Some options that can be controlled can range from custom timing modes to display information on an included LCD display.

Intuitive User Interface – This product will also include a user interface allowing for the display of statistics and diagnostic information. The user will also be able to select operating modes and control features fluidly using this interface.

Rugged Packaging – Although the optimum placement will be on the inside of the automobile, the device will have a rugged and attractive enclosure to prevent damage from neglect, abuse, or improper placement.

User-Friendly Installation – It is imperative to the success of this device that it is easy for the user to install. In order to support this ease of use, we will insure throughout our design that we are taking the end user into account. We will also create excellent documentation and installation instructions for the end user to insure the installation is easily done.

Conceptual Block Diagram

The conceptual block diagram is a high level representation of the system that we will implement for the transmission control. In the center, we have the enclosure containing the microcontroller and the heart of the system. The microcontroller takes in data from the necessary sensors and makes decisions as to which gear the automobile needs to be in by outputting to the mechanical control portion of the transmission controller. We have also included an overview of how the user will interface with the controller. When the controller is installed in the vehicle, we will have some form of display and an interface for selecting the current mode you want the transmission to be in such as race, tow, or economy. Also displayed is the high level representation of how the user will be able to configure the controller using a home computer.

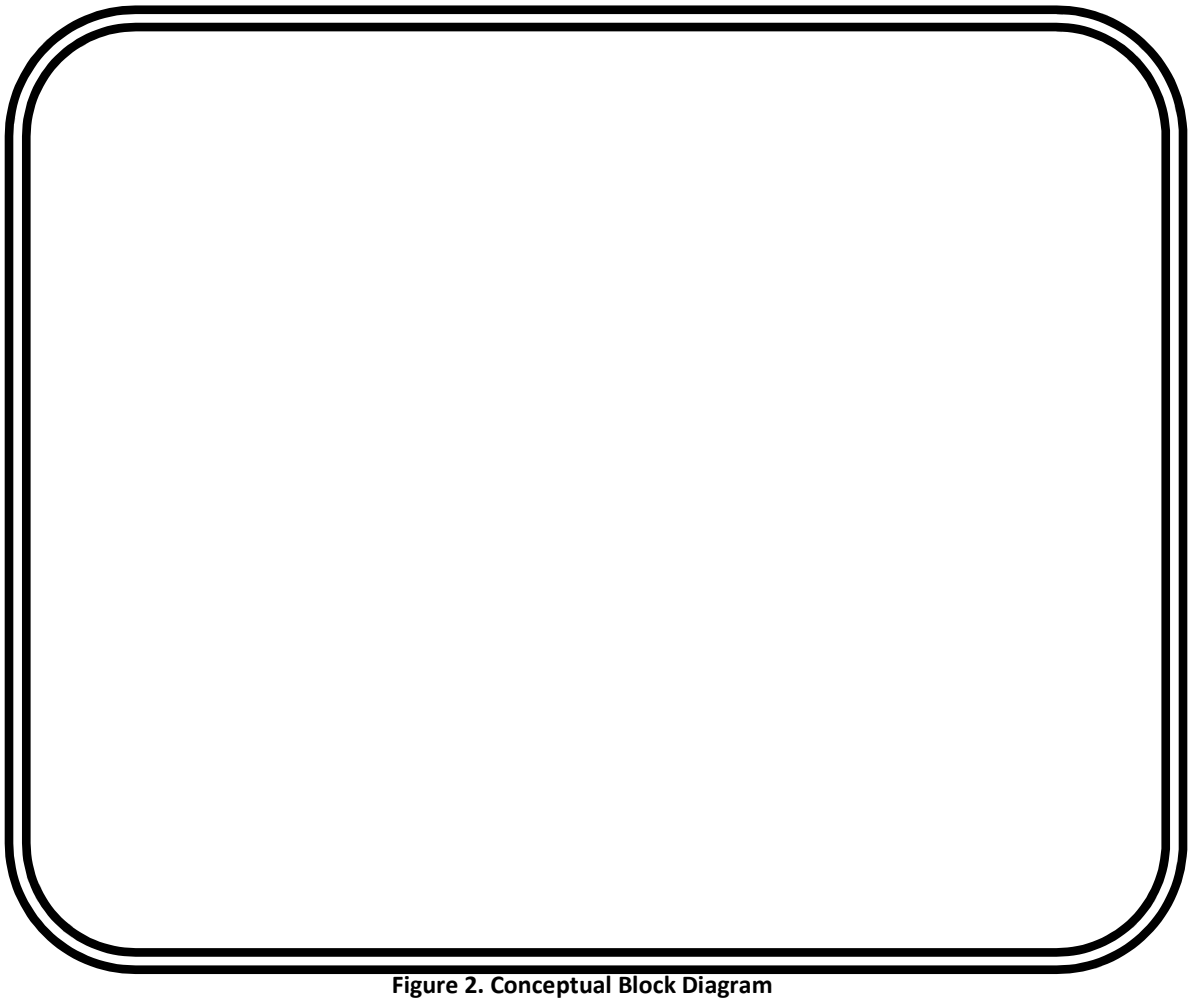

Figure 2. Conceptual Block Diagram

Performance Requirements

Transmission Control Functionality	• Controls overall operation of the automatic transmission. • Provides reliable service that is robust and handles errors.

"Quick Logic" System	• Processing power
	  • 16 bit processor
	  • Sensor Readind (A/D, Signal Conditioning, DIO)
	• Efficient Software Architecture and Timing

Alternate Mode Operation	• User Input System • System Feedback To User • Alternate Shift Timing Algorithms
End User Configurability	• Executable Software Package • Serial Communications (RS-232, DB9 Cable) • Reprogrammability of Controller
Intuitive User Interface	• Character of Graphical LCD Display • PMP Communications With Controller • Display Unit Enclosure
Rugged Packaging	• Attractive Enclosure • Environmental/System Testing • Proper Hardware Specifications
User-Freindly Installation	• Color Coded Wiring Harnesses • Installation Manual • Installation Video Guide

Technology Survey Assessment

- Transmission Control Functionality
  - Microcontroller based system
    - Pros:
      - Contains several on-chip peripherals
      - Development team is most familiar with these devices
    - Cons:
      - Less customization ability
  - ASIC based system
    - Pros:
      - Extremely customized system
      - Faster operation
    - Cons:
      - Expensive
      - Time consuming
  - FPGA based system
    - Pros:
      - Faster operation
    - Cons:
      - Development team has little experience with these devices

Vanguard Engineering has chosen to use a microcontroller based system. A microcontroller based system will provide all of the needed functionality and a low price and with the least amount of learning curve for the development team.

- "Quick Logic" System
  - AVR 8 bit microcontroller
    - Pros:
      - Cheap
      - Well supported
    - Cons:
      - Contains too few peripherals
  - PIC 16 bit microcontroller
    - Pros:
      - Cheap
      - Well supported
      - Sponsor supports this device
    - Cons:
      - Slower than 32 bit micros
  - PowerPC 32 bit microcontroller
    - Pros:
      - Fast operation
      - Team has previous experience with this device
    - Cons:
      - Expensive
      - Unnecessary for this implementation

TORC will be developed using a 16 bit PIC microcontroller. More specifically we plan to use a PIC24. This decision was based on the fact that PAINLESS, our sponsor, has built previous devices with this controller and would like to continue using it for new design projects.

- Alternate Mode Operation
  - Selected through separate interface device
    - Cons:
      - Expensive
      - Requires multiple enclosure designs
    - Pros:
      - User-Friendly
      - Highly customizable
  - Selected From Interface on Control Unit
    - Cons:
      - Less user-friendly
      - Adds to control unit complexity

- Pros:
  - Cheaper

➢ Include selection of mode in configuration software
- Cons:
  - Dependant on configuration software
  - Less user-friendly
- Pros:
  - Cheap
  - No extra hardware requirements

For this functional requirement the TORC design group has decide to include the alternate mode operation selection in a separate user interface. This makes our device more user-friendly and will add value to the system. This system will also be able to function in other ways than just the alternate mode selection.

❖ End User Configurability

➢ PC Configuration software
- Pros:
  - Most robust system
  - Easily upgradeable
- Cons:
  - Requires user to have a PC
  - More extensive implementation process

➢ Control unit hardware based configuration
- Pros:
  - Cheap
  - Easy to use
  - Easier implementation for design team
- Cons:
  - Not upgradeable
  - Limited by control unit dimensions

➢ Configuration through user interface
- Pros:
  - Adds functionality to the user interface
  - Allows user to configure in car
- Cons:
  - Depends upon user interface implementation
  - Limited with small screen and form of input

Vanguard Engineering has chosen to develop a software executable for the configuration method. This will allow for more options and upgradability for the system. It will also be more user-friendly.

- Intuitive User Interface
  - Graphic LCD
    - Pros:
      - More robust display
      - More attractive
    - Cons:
      - Expensive
      - More difficult implementation
  - Character LCD
    - Pros:
      - Cheap
      - Easy to use
    - Cons:
      - Less Attractive
  - Touch screen
    - Pros:
      - Most user friendly interface
      - Allows for more options
    - Cons:
      - Cost prohibitive
      - Development time outweighs benefits

For the TORC user interface our design group will most likely implement a graphical LCD display. This allows for a more pleasant and diverse interface while still maintaining low cost levels and development times.

- Rugged Packaging
  - Custom Enclosure
    - Pros:
      - Can allow for better fit
      - Adds aesthetic value
    - Cons:
      - Expensive
      - Requires increased design time
  - Existing Enclosure
    - Pros:

- Cheap
- Less design time required

▪ Cons:

- Less custom appearance of device
- Could be hard to track down a proper fitting enclosure

➢ No Enclosure

▪ Pros:

- Cheapest method

▪ Cons:

- Leaves device with little protection
- Extra detail will be needed for mounting and placement of the device in a vehicle

Vanguard Engineering plans to investigate further the custom enclosure option so that we can give TORC a custom feel that we feel will help the device appeal in the after-market arena. If this is too cost prohibitive we will acquire a pre-built enclosure for our system.

❖ User-Friendly Installation

➢ User's Manual

▪ Pros:

- Can be included with retail package
- Requires no other materials

▪ Cons:

- Can be more confusing than a live video

➢ Installation Video

▪ Pros:

- Provides better visual aids
- Can be provided on a website

▪ Cons:

- Requires some hardware, such as computer or DVD player

➢ Live Help

▪ Pros:

- Can help solve problems
- Provides better service to the customer

▪ Cons:

- Expensive
- The development team will be unable to implement this system

Vanguard Engineering will provide both a manual and a video in their deliverables. This gives the user two options of how they would like to learn the installation methods and it will not be difficult to implement both of these. The customer satisfaction will most likely outweigh the time spent on developing both forms of installation instructions.

Functional Block Diagram

The functional block diagram covers the design of our system in a more detailed level. As shown in this diagram, the PIC24FJ128GA010 is the microcontroller being used in our system. This will be the controller that is used to control the transmission using the sensor data and digital inputs that it receives.

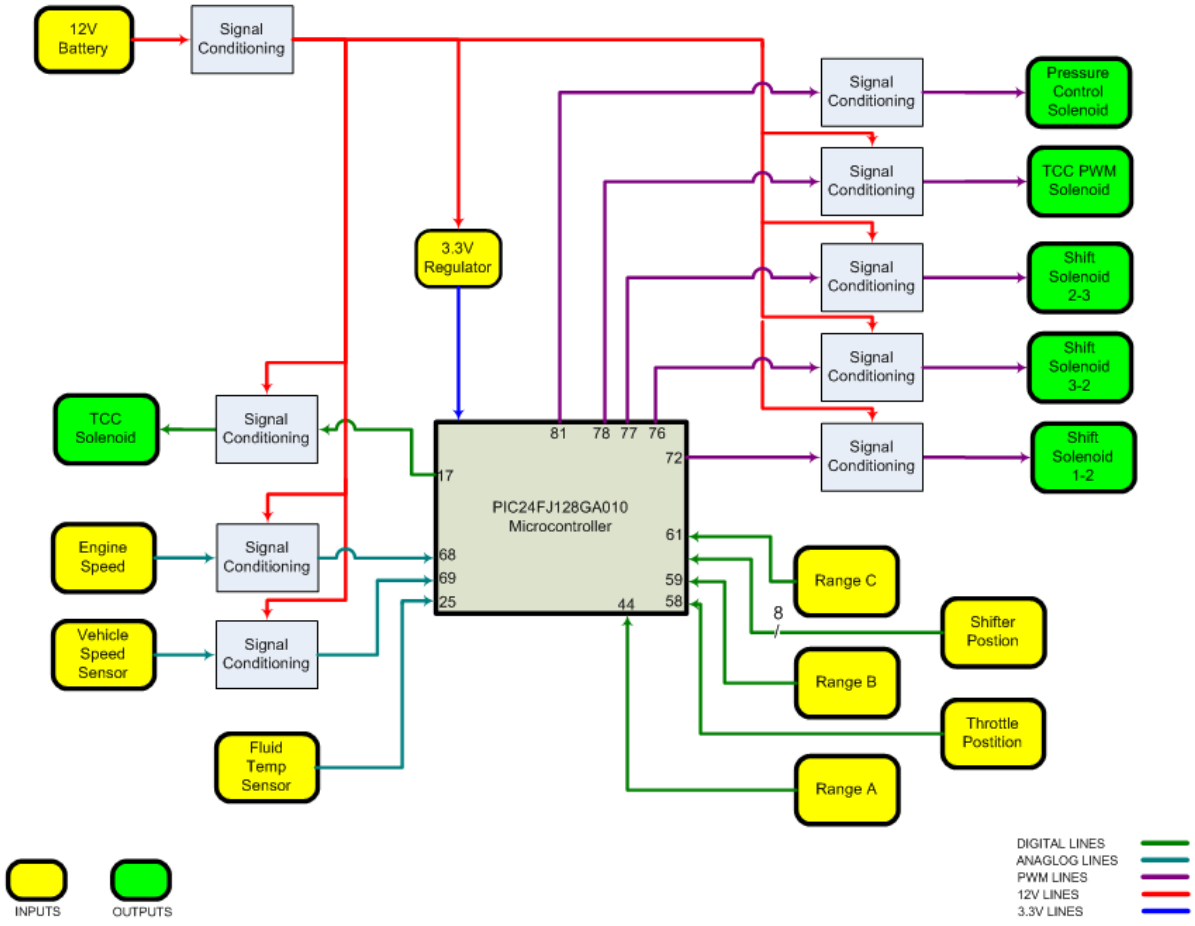

Figure 3. Functional Block Diagram

In the block diagram, there are several inputs into the microcontroller. Most of these inputs are sensors inputting the necessary data needed to determine proper shifting. Some of the main sensors that are used to determine gear selection are engine speed, vehicle speed, and throttle position. Using these inputs along with the shifter position digital input, we can select the proper gear. Once the controller has selected the proper gear that the transmission needs to be in, it will output to the proper shift solenoids, which will mechanically force the transmission into the proper gear.

Another portion of the transmission that we must control besides the gear selection is the torque converter or TCC. One benefit of controlling the TCC is the ability to improve the gas mileage of the car. This can be done by disabling the torque converter when it is no longer needed, thus improving gas mileage.

Using this controller, we will also be able to include an LCD module for a useful and attractive user interface. Along with this module, we will include a way for the user to select which shifting mode they would like to use such as race mode or efficiency mode.

Deliverables

Deliverables are the elements that we will present to the project stakeholders to demonstrate the growing value of this project. These are markers of achievements like milestones; only these markers have specific value to the stakeholders and are actual tangible elements that prove the design group is making progress. It is important that these deliverables are presented throughout the course of the project so that the stakeholders can make informed evaluations of the team's progress.

Figure 4. Deliverables

Parts List

The parts list will contain in detail all of the parts that we use in our design. This is valuable to our stakeholders so that they can determine the cost of each part and will know which parts to order to make more devices.

Functional Diagram

The functional diagram will be presented as a deliverable to the stakeholders. This functional diagram will include the entire system schematic in a form that includes all of the components and how they are connected together. The functional diagram is the best way to get quick information on the system design of the TORC transmission controller.

Hardware Schematics

The hardware schematics will include the pin layouts, connections, and circuit drawings of the hardware we design. This in addition to the parts list will include all the information one would need to replicate our hardware design.

PCB Layout Design

Our printed circuit board will contain all of the hardware necessary for our final prototype in an efficient package. This PCB will allow for the concise and easy fabrication of our hardware and will fit in the enclosure that we design.

Commented Source Code

In the creation of our controller, we will also create the source code for both the transmission control and the user configuration software. This source code will contain the algorithms that allow the controller to read the sensor data and control the shifting of the transmission's gears.

User Configuration Program

The user configuration program is the software executable that the end user will use to configure the controller. This software will be provided in its final form and will be able to be used with the final prototype to customize certain features.

Flow Chart and Algorithm Pseudo-Code

Along with our final source code our team will also provide a flow chart and pseudo-code of the source code explaining the algorithms used and how the program functions.

Cost Analysis

Included with the rest of the deliverables will be a cost analysis of the project. The cost analysis will ensure that the cost of design and production fall in line with what the stakeholders deem suitable for the TORC control system.

Test Plan and Test Data

Including the test plan and the test data in our deliverables will allow the stakeholders to see how we have tested our design and what the results are from those tests.

User's Manual and Installation Video

A copy of the user's manual and installation video will be delivered to the stakeholders. This manual will give a technical description of the device as far as the end user is concerned. This will allow them to gain an understanding of what the device does and a little bit of how it functions.

Pre-Production Prototype

The final prototype will be one of the last deliverables. This deliverable will include our final design along with its enclosure and all of the wiring necessary to install the controller to a GM 4L60E.

Project Documentation and Final Report

Along with the final prototype we will also include the final report and documentation covering the entire scope of the design project and the final design.

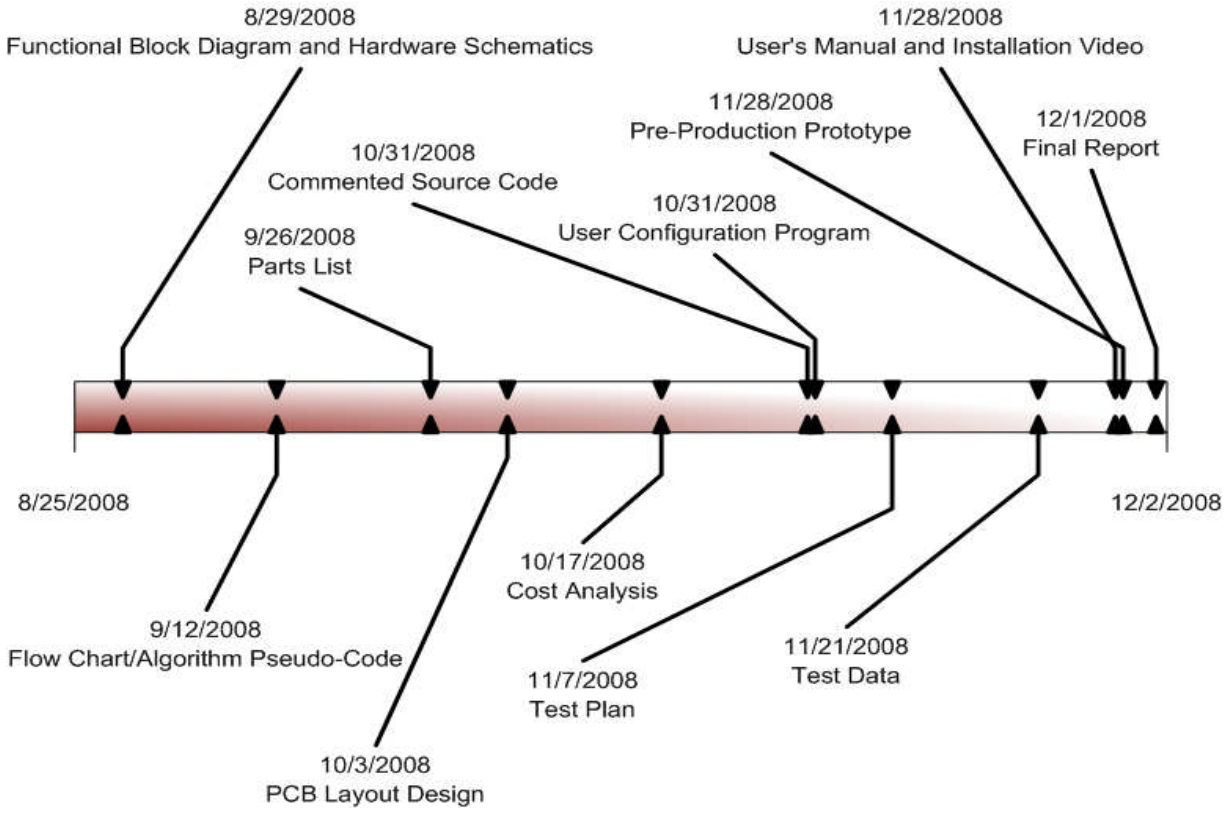

Figure 5. Deliverables Timeline

Milestones

The project milestones are the high level goals that VEG has set to accomplish throughout the course of this design project. Whenever a milestone is reached it will mark a significant stage of completion in the development process. The final milestone is the only milestone that really counts but setting several milestones will keep the project on track and allow for the development of a better product.

Figure 6. Milestones

Completion of Research

Although research will continue throughout the entire process, there is still a milestone when all of the necessary research is done so that the team can begin to move to the design phase.

Development Environment Established

Determining the software environment and the main hardware with which we will be working with will be one of the first steps in starting the design phase.

Hardware Design Specifications Completed

At this milestone, we will have determined all of the sensors that we will be using and all of the necessary circuitry and hardware needed to complete our design. Hardware specifications such as wiring and harnesses will be completed for this milestone.

Hardware Prototyping Completed

After the specification we will piece together a rough prototype in which we can determine if our designs will function as required. This milestone will be considered completed when all of the hardware that we have specified for design has been implemented in a rough from.

PCB Design and Implementation Completed

The rough prototype will need to be developed into a PCB design, which will be our final hardware schematic and design. This design will then be what we work with in testing and software development for the remainder of the project.

Transmission Control Software Completed

This milestone marks the completion of the transmission control software. This will be all of the software that is required to read the transmission sensors and control the operation of the transmission successfully.

User Configuration Software Completed

The user configuration software is a separate entity from the transmission control software and is a separate milestone. This will require a different style of programming that our group has little experience with, and it will be a great accomplishment.

Hardware Testing Completed

Testing is a necessary phase in our process. When the hardware design that we have implemented is done being tested, we will be one major step closer to an initial prototype.

Software Testing Completed

It is necessary that our control software and configuration software is tested extensively before the system testing is done. We may be testing this device on an actual transmission and anything but minor errors could cause expensive damage. If the software is tested extensively, then we can eliminate this chance and will have created a functioning program that we can further test as a system.

Initial Prototype Completed

Combining all of the software and hardware that we have created into an initial prototype will be a great achievement for our team. This will mark a closing to the majority of the design and implementation work and the beginning of our system testing.

System Testing Completed

This testing stage will be the benchmark for determining whether or not our system is going to function as required. When this stage is completed our only step will be to create a final prototype and make sure that we have finished all of our work packages.

Pre-Production Prototype Completed

This milestone will mark the closing of our project. It is at this point that our team will have created a device that is to our satisfaction and that we feel will please our stakeholders. It may not mark the end of our team's work, but it will be the end of all design and implementation for this final prototype.

Milestones Timeline

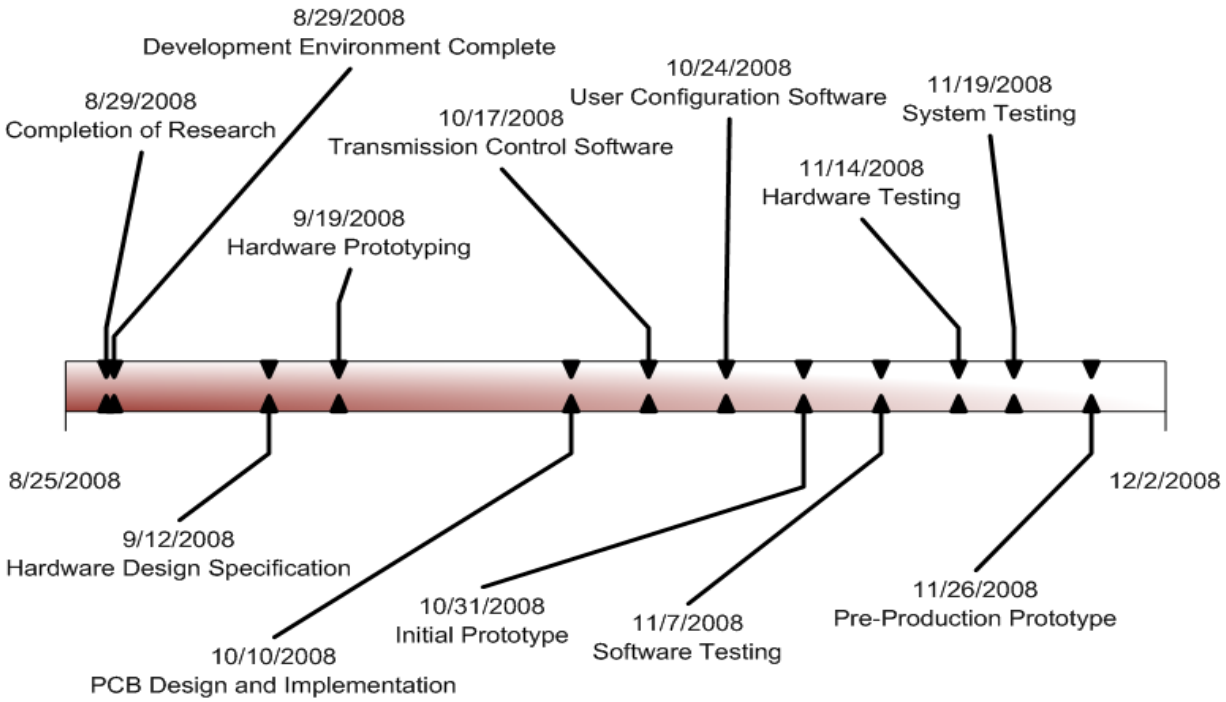

Figure 7. Functional Requirements