Utah State University

Passive Tracking Device
– Senior Project –
Project Proposal

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1 Summary

The Passive Tracking Device (PTD) is a passive tracking bug that can periodically transmit its location to a specified person or location. The PTD will be used in a low-power environment, specifically, ATVs (All Terrain Vehicles). Enterprise level firms often have a large number of ATVs that are difficult to account for. Using a GPS dongle, cell card module, and a micro-controller I will create a solution that can be marketed to these large businesses providing a cost-effective, low-energy monitoring system for their ATVs.

2 Introduction

There are many tracking solutions available for public and enterprise use but they generally all have the same problem. They are active tracking solutions. This means that the vehicle being tracked can only be tracked in real-time. The client of one of these active solutions could use the monitoring software to see on a map the location and movements of the vehicles in their fleet. While there are applications where active monitoring is necessary there are some major drawbacks to such a system. Three of the largest drawbacks are:

1. Active systems require large amounts of power and physical space
2. Active systems are quite costly
3. There are applications that don't require real-time updates of vehicle location

The PTD is a passive tracking solution that is targeted to counter these drawbacks of active solutions by functioning in low-power environments that do not require real-time updates at a reasonable cost. [1]

3 Problem

There are many businesses that use ATVs to accomplish their work. These businesses range from contruction companies to civil engineering firms, to the National Forest Service. Many times the larger the company the harder it is to manage the fleet of vehicles. The task of keeping track of these vehicles is further compounded by human error as well as geographical isolation and dispersion of resources. The PTD is targeted at making this task considerably easier. The PTD, once installed in an ATV, uses the internal battery of the ATV to periodically transmit it's location to the managing individual. This will help monitor vehicle usage as well as recover vehicles in the event of theft.

4 Objectives

The PTD will focus on counteracting the negative effects of active tracking solutions explained in the Introduction of this paper. The three project goals are:

1. PTD shall be small enough to be attacked internally to ATV battery [2]

[1] See the Problem and Objectives sections of this document for for information regarding this topic.

[2] For more information physical space constraints see the specifications document.

2. PTD initial cost shall not exceed $200.

3. PTD shall periodically transmit it's location and then return to low-power standby.

These goals will allow the PTD to be an appealing option for businesses to purchase in order to track their ATV fleet.

5 Solution

The PTD will consist of four subsystems to achieve the desired goals.[3] The four subsystems will be:

1. Microcontroller

2. GPS Module

3. Cell Module

4. Power Regulation

The PTD will function by recording it's geographical position using the GPS module. The GPS module will then send it's location to the microcontroller via serial communication. The microcontroller will then instruct the cell module to send a text message to a predefined number or address containing the devices location. Upon the completion of the sequence the system will enter a low-power stand-by state. The microcontroller will be the central system that will act as an intermediary between the GPS module and the cell module because these two modules are 'dumb' modules that complete a service but only when another service is directing them. The power regulation circuitry will consist of a set of switching regulators that provide constant power at the correct voltage for the sub-systems to function. Figure 1 shows a system block diagram setup in this configuration.

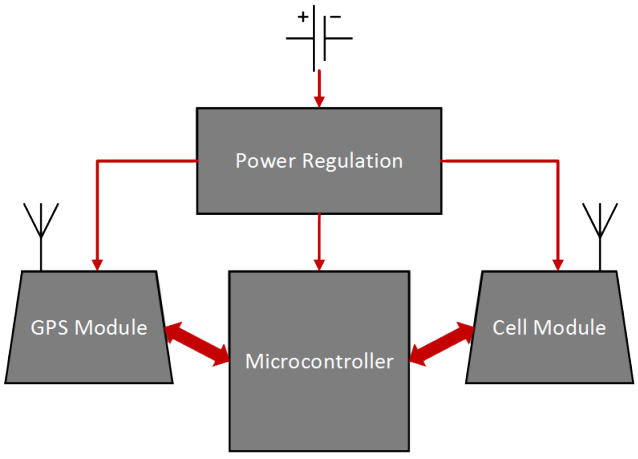


Figure 1: System Diagram

[3]See the Objectives section of this document for information on Project Goals

6 Methods

In this section I will expound upon each of the sub-systems and explain in greater detail their function and components.

The microcontoller that I will use will be the Tiva-C TM4C123G. This microcontroller was chosen because I have worked with it before and I have one on hand that can easily be used for prototyping. This microcontroler has plenty of the UART modules that allow for serial communication between the other module as well as a hibernation mode that will allow the microcontroller to enter and exit the low-power states required by this project.

The GPS sub-system will consist of three parts.

- GPS Module – Trimble Copernicas 2
- GPS Evaluation Board
- GPS Antenna – SPS antenna with SMA Connector

The Trible GPS module can update location at a rate of 1Hz and reports it's location via UART transmission. This module was selected because it has great reviews and uses the common SMA connector for the antenna. This connector allows for a wide variety of antenna choices.

The cell sub-system chosen for the project also consists of three parts.

- Cell Module – SM5100B
- Cell Evaluation Board
- Cell Antenna – Quad-band Duck-bill Antenna

The SM5100B module was selected because it can operate on all major US cell carriers. The SIM card of one of these carriers can be seated in the evaluation board which connects to the module and antenna. This cell module adds the functionality that the PTD will not change behavior when the SIM card is changed except for the PTD's cell number. The evaluation boards are necessary in the case of both the cell and GPS modules to easily interface and prototype the design. The PTD requires two different antennas because GPS and cell signals are carried on vary different bands of communication.

The last system that is required is the Power Regulation Circuitry. The circuit needs to source a constant 5 Volts to the microcontroller and 3.3 Volts to both of the other modules. This will be done using switching regulators. Switching regulators will be used instead of linear regulators to maintain a low-power mode of operation. A linear regulator would provide and source the correct amount of power but would also drain the battery even when in the low-power state of operation.

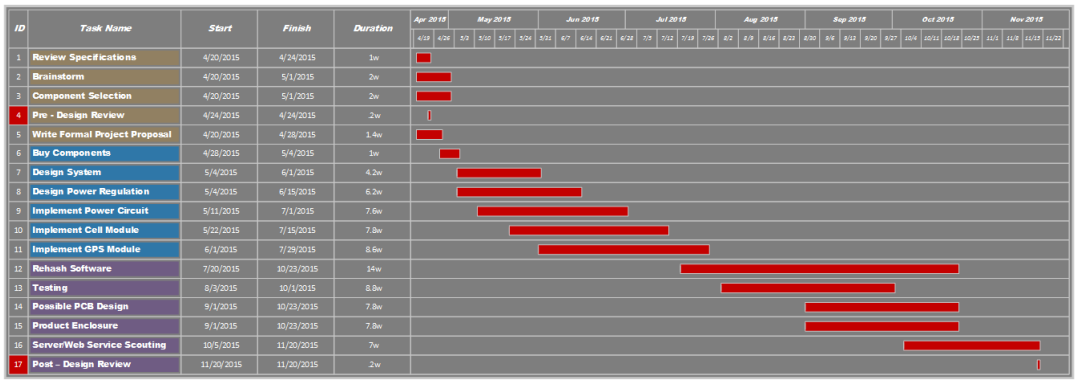
7 Resources

The resources that will be absolutely necessary for this project will be the data sheets of the distinct components. These data sheets will outline the function and communication standards that will help me configure and interface correctly with the devices. Other resources will be people that will help guide decisions about the design such as Prof. Cripps and Prof. Moon.

The EMI regulations by the FCC can be found in the documents provided in the PTD Specification Document. These documents are also outlined in the References Section.

8 Schedule

The project is to be completed at the end of November, 2015. This allows me sufficient time to plan and design, prototype, and test the PTD for the next 7 months. These three phases are outlined in the Gantt Chart in Figure 2.



ID	Task Name	Start	Finish	Duration
1	Review Specifications	4/20/2015	4/24/2015	1w
2	Brainstorm	4/20/2015	5/1/2015	2w
3	Component Selection	4/20/2015	5/1/2015	2w
4	Pre - Design Review	4/24/2015	4/24/2015	2w
5	Write Formal Project Proposal	4/20/2015	4/28/2015	1.4w
6	Buy Components	4/28/2015	5/4/2015	1w
7	Design System	5/4/2015	6/1/2015	4.2w
8	Design Power Regulation	5/4/2015	6/15/2015	6.2w
9	Implement Power Circuit	5/11/2015	7/1/2015	7.6w
10	Implement Cell Module	5/22/2015	7/15/2015	7.8w
11	Implement GPS Module	6/1/2015	7/29/2015	8.6w
12	Rehash Software	7/20/2015	10/23/2015	14w
13	Testing	8/3/2015	10/1/2015	8.8w
14	Possible PCB Design	9/1/2015	10/23/2015	7.8w
15	Product Enclosure	9/1/2015	10/23/2015	7.8w
16	Server/Web Service Scouting	10/5/2015	11/20/2015	7w
17	Post – Design Review	11/20/2015	11/20/2015	2w

Figure 2: Project Schedule

9 Qualifications

Another resouce that I have is familiarity with embedded projects. This is due to course work that I completed at Utah State University. The skills necessary to design a stable, functional system have been key in completing other projects to date. These projects include:

- Custom Computer Case Cooling and Monitoring System
- Hardware Keyboard Keylogger
- Custom Therostat System
- FPGA Butterfly Puf TRNG

Each of these projects included unique problems and technical set-backs that have helped me develope problem solving and debugging skills.

10 Costs

As can be seen in Figure: 3, there are costs associated with the project prototyping that will not be present in the final product. These costs are a necessary cost in order to easily connect and interface with the discrete modules. The third column shows the cost of the component that is attached to an evaluation board and the fourth column shows the cost of the components on their own.

The costs of the cell service will also likely be smaller because such a small amount of data is needed to transmit the device's location. This will also depend on the geographical location of interest to the client.

Component	Model	Price (Evaluation Board)	Price (Discrete Component)
Microcontroller	TI Tiva-C TM4C123G	$13.00	~ $5.00
GPS Module	Trimble Copernicas 2	$74.95	$44.95
GPS Antenna	SPS 3V SMA	$12.95	$12.95
Cell Module	SM5100B	$119.90	$59.95
Cell Antenna	Quad-band Antenna	$7.95	$7.95
Cell Card/Service	T-Mobile Unlimitted	$79.95/6 Months	~ $13.00/Month
Power Regulation		~ $40.00	~ $40.00
Total		**~ $348.70**	**~ $183.80**

Figure 3: Project Cost Table

11 Conclusion

The PTD will provide a small low-power passive tracking solution to businesses and enthusients to track their ATVs. The PTD adds another spin on tracking devices that currently are not availble on the market because of the unique space and power constraints that ATVs require. Although this project has focused on ATVs, the PTD could be installed in any system that has a 12V. batteery such as a truck or snowmobile.

This product can be expanded past the scope of this project by PCB design as well as enclosure manufacturing. Another future innovation would be to create a database hosted on a web server that could be used as a central management hub for clients. This would be of great use to large customers that require many PTDs to track their entire fleet. A private inhouse option could also be provide for those businesses that would like to host their own tracking server.

The PTD is unique in the way that it provides the tracking solution. The unique aspects will allow the PTD to be a welcome tracking solution in todays economy.

12 References

The regulations in the following documents shall be met to allow the PTD to be legally used in most of North America (US and Canada).

- The United States (US) FCC Part 15-2008.
- Canada's Industry Canada ICES-003:2004 Issue 4.

13 Appendix A

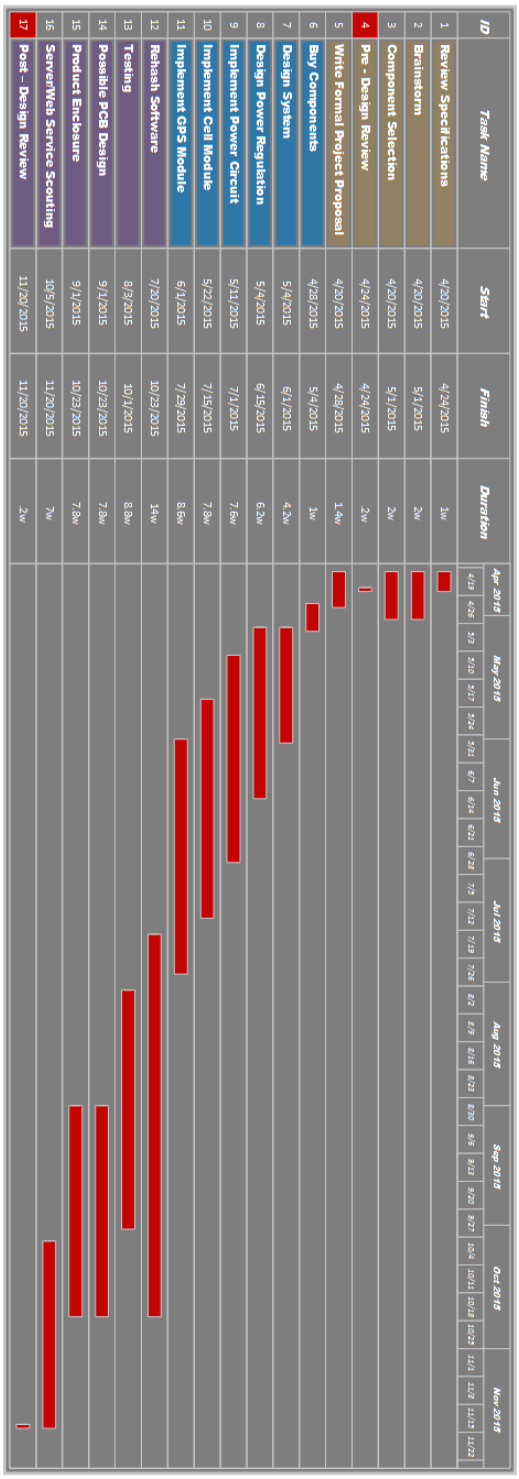


Figure 4: Project Schedule Vertical