

Beyond Tracking

The Renaissance Men

4/21/2008

The Beyond Tracking system is a long range wireless RF network for distributing GPS location data, real-time bus seating availability, and other real-time information useful to both city transportation services and their patrons. This will be accomplished with the implementation of a communication protocol that will enable the distribution of among the network minimizing the losses and collisions. Goals for this semester are oriented towards delivering a reliable product with a marketable image.

Table of Contents

- Project Features and Objectives 3
 - Features 3
 - Objectives..... 3
- Analysis of Competitive Products 3
 - Advantages..... 3
 - Disadvantages 4
- Concepts and Technologies 4
- Project Architecture 5
 - High Level Description 5
 - Flowchart and Diagrams 6
 - Hardware 7
 - Software 7
- Project Responsibilities 9
- List of Materials 10
- Gantt Chart 11
- Appendix A: Flow Charts 13
- Appendix B: Source Code **Error! Bookmark not defined.**

- Figure 1: High Level Flowchart 5
- Figure 2: PCB layout 6
- Figure 3: Gantt Chart..... 11
- Figure 4: Base Station a..... 13
- Figure 5: Base Station b. 14
- Figure 6: Base Station c. 16
- Figure 7: Substation a. 17
- Figure 8: Substation b. 18
- Figure 9: Substation c..... 20
- Figure 10: Bus..... 21

Project Features and Objectives

The Beyond Tracking system is designed to meet a growing demand among both public transport systems and their patrons for real-time information on service availability. In addition, Beyond Tracking has been designed with the idea of expandability. Useful data, other than location of public buses, could be transferred using the system's network that will be available to the end user.

Features

Beyond Tracking System will consist of the following:

- Real time location information
- Real time information on number of riders on individual buses
- Virtually no upkeep costs
- Unlicensed band
- Expandable network coverage
- System can be integrated with a wide variety of user interfaces such as real time internet maps, text messaging systems, or dedicated bus kiosks.

Objectives

Objectives for project this semester: continue work from Junior Design:

- Move breadboard design to PC board
- Improve hardware reliability
- Standardize power requirements
- Rewrite network code to GREATLY improve reliability and efficiency
- Provide a product demo with a marketable image.

Analysis of Competitive Products

Similar products are available that solves the same problem. However there are some differences:

- ▶ Cellular network is used (as opposed to a private RF network)
- ▶ Current products only provide coordinate data, not other data such as number of passengers.

Advantages

- ▶ Cellular network is reliable.
- ▶ Maintenance is not required (other than the cellular modems located in the vehicles)

- ▶ Faster data transfer

Disadvantages

- ▶ High Cost: Cellular service fee is required monthly
- ▶ Only GPS data is transferred
- ▶ Customer does not have power over the network. Does not have the freedom to use it for other applications.

Concepts and Technologies

There were a large array of communication and tracking technologies that we evaluated when we optimized the cost/benefit of our system.

Among the communication schemes evaluated were:

- Long range transmission in both licensed and unlicensed bands
- Cellular network leasing
- Daisy chained short range RF transceivers (Xbee)
- Piggybacking data over present bus radio system, and so forth

Positioning systems evaluated included:

- GPS
- Transponders
- Various triangulation schemes
- RF proximity to road side receivers, and
- Double integration of accelerometer data.

In the end, we determined that the low cost upkeep, development, and production of using GPS for positioning and using long range unlicensed ISM band RF transceivers for communications was the best option.

Project Architecture

High Level Description

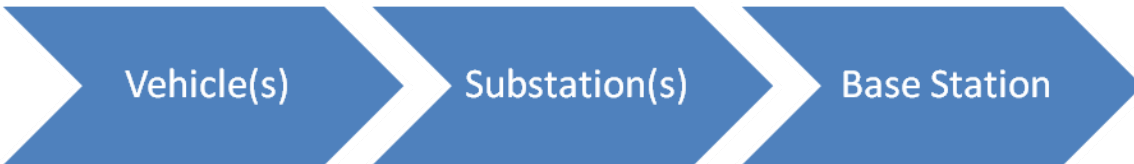


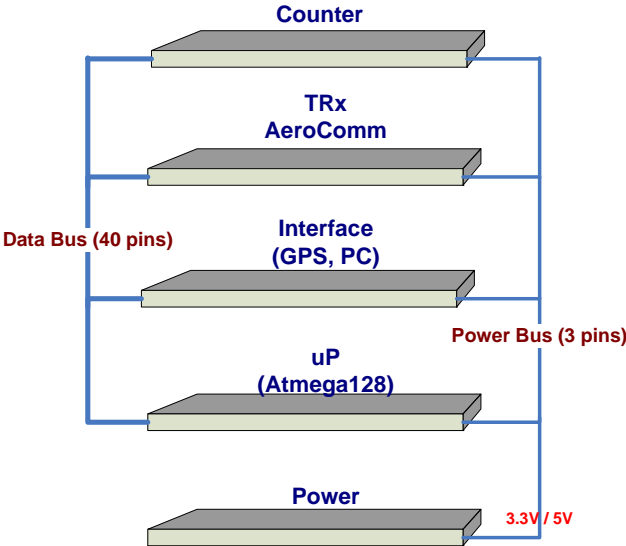
Figure 1: High Level Flowchart

- ▶ A GPS is installed in each vehicle. Its coordinates is sent to the nearest substation upon request from the respective substation.
- ▶ Likewise, the substation sends the data of the vehicles in its area to the base station
- ▶ The Base station gathers the data from all the substations, hence all vehicles, and plots them on the screen.
- ▶ This process is performed in an organized manner such that no more than one transceiver is using the frequency channel at the same time. This will prevent any data collisions and loss of data.

Flowchart and Diagrams

Figure 2: PCB layout

PCB Layout



Hardware

Each block in the diagram shown above consists of the same exact hardware. This is one of the main features of Beyond Tracking, the easiness of expansion without the need to design different hardware for the different sections of the system.

Each unit consists of a series of layers. These are:

1. **Power Management:** This layer supplies 3.3V and 5V to all layers. Having two voltage levels in the system makes the expansion of the system less restricted.
2. **Communications:** This layer contains the transceiver (AeroComm 4490) in charge of the wireless communication.
3. **Processor:** This layer contains the microprocessor. This is the unit that controls the whole unit and interacts with other units using the communication protocol we developed. Beyond Tracking is equipped with an Atmega128 microprocessor.
4. **Control:** All the main functions are set in this layer. The vehicle, substation, and base station pins are located in this layer. Also, a set of debugging functions can be set here as well.
5. **Input/ Output:** Here is where the GPS and the computer are connected to, for the vehicle and substation, respectively. Notice that this layer is not used for the substation unit since its only role is to pass the data from the vehicle to the base station.
6. **Counter:** This layer is an add-on of the system. This is one of the features that Beyond Tracking has, expandability. With this add-on, it is possible to keep track of the amount of people inside the vehicle at all times. This layer is used only in the vehicle unit.

In case of failure of the hardware, it is possible to debug and fix the source of the problem very quickly thanks to the ability of isolate each part of the unit.

Software

See Appendix A for flowcharts.

As already mentioned, the hardware was designed in such a way that all units will consist of the same parts. Similarly, the software was developed in such a way that all units have the capability of being a vehicle, a substation, or the base station. All units have the same software, but the user selects which part of the software it wants to run. This is selected using the control layer. (The User Manual contains all functions that can be set using the control layer; this is located in Appendix B)

The interaction among the vehicles, substations, and the base station is accomplished thanks to the communication protocol developed for Beyond Tracking. This process is as follows:

1. Base Station requests the location for vehicle # 1. This request is sent to the substation # 1.

2. The substation sends back an acknowledgement (ACK) to the base station. If the base station does not hear from the substation, it will request data again for 3 times. If it does not receive data after 3 tries, it will blink an LED as a signal of error.
3. Once the ACK is received, the base station will wait for the data. As the data is received, it will strictly make sure the data is not corrupted. If it finds an error, even a single character, it will not accept it as good data. It will request for data again.
4. After the first vehicle was successfully located, the base station will request the data for the next vehicle.
5. After the data is received, the base station will output it to the computer through the USB port. This will be saved to a text file which will be read by Flash and plot it on the screen.
6. Similarly, the substation will perform the same steps as the base station (step 1 through 3, and 5). The only difference is that if it cannot find a vehicle, it will not signal an error.
7. The vehicle will only be in charge of waiting for a request. Then it will receive the GPS data, format it (according to our protocol) and send it to the substation.

This process is performed indefinitely, unless the control layer has been set to debugging mode.

Beyond Tracking is also equipped with a series of small debugging functions. This is set by clearing all the pins for vehicle, substation, and base station. The purpose of these functions is for purely testing. Different parts of the code can be tested to make sure that the hardware is functioning properly.

Project Responsibilities

Preliminary

Task	Ashley	Raul
Overall Layout	X	X
uP/TRx Selection	X	X
Flowchart	X	X

Hardware : Raul as leader

Task	Ashley	Raul
Components Selection		X
Components Purchase		X
PROTEL Design		X
Boards Population	X	X
Boards Debugging	X	X

Software: Ashley as leader

Task	Ashley	Raul
Implementation of Testing Code for boards	X	
Implementation of important functions (UART, formatting, etc) used in main program	X	
Implementation of Communication Protocol	X	
Debugging of Code	X	
Implementation of Timers	X	X
Implementation of Counter (CPLD)		X

Concluding

Task	Ashley	Raul
Flash Interface		X
Final Report	X	X
Poster		X

TESTING	X	X
----------------	---	---

List of Materials

Part	Cost per unit
Transceiver - AeroComm	\$70.00
Antenna - 900 MHz 5dBi	\$25.00
GPS - Garmin 18 PC	\$70.00
uP - Atmega128L	\$14.00
FT232 - USB	\$5.71
USB socket	\$2.40
LM3102 - Regulator	\$2.20
PCB Manufacturing	\$33.00
Miscellaneous (caps, inductors, power jacks, resistors, LED's, etc)	\$10.00

Total per vehicle	\$234.51
Total per substation	\$226.40
Total per base station	\$234.51

Gantt Chart

Task Name		Planned	Extension	Down time	Assigned Lead
Introduction - Preliminary Project Proposals (team)	0	1	0	0	Team
Research/ Project Abstract (team)	1	1	0	0	Team
Preliminary Design Report	2	1	0	0	Team
Power Management	3	1	1	0	Raul
Order Parts / PCB Design and Population v.1.0 / Testing	3	4	1	0	Team
Code - GPS Formatting and Transmission	7	1	1	0	Ashley
Code - Interrupt Routines	8	1	1	0	Raul
Code - Data Tabulation	9	1	1	0	Ashley
Code - Data Request	10	1	1	0	Ashley
Counter - CPLD	4	2	1	0	Raul
Demo Software	10	2	1	0	Ashley
Aesthetic Engineering/ Website	8	3	1	0	Raul
Testing and Troubleshoot	12	1	1	0	Team
Demo	14	1	0	0	Team

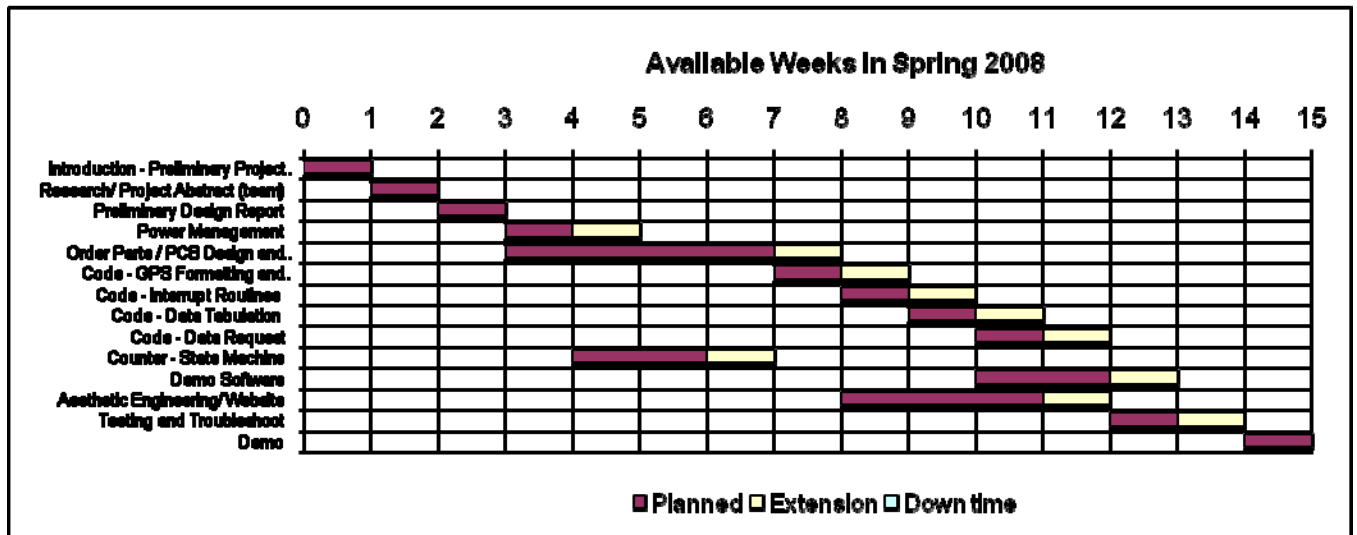


Figure 3: Gantt Chart

Appendix A: Flow Charts

Base Station Flow Chart - Main

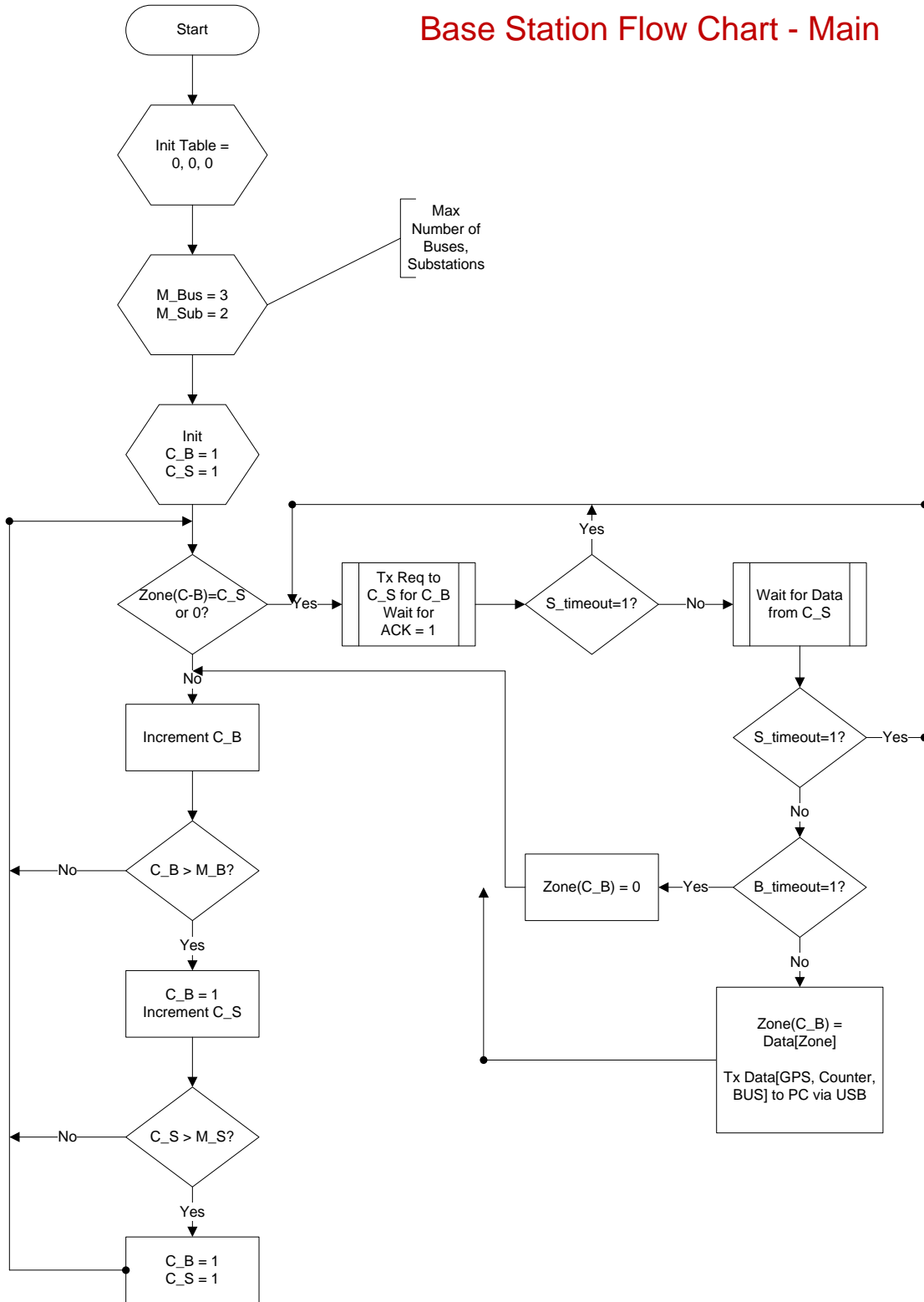


Figure 4: Base Station a.

Base Station Flow Chart – Subroutine 1

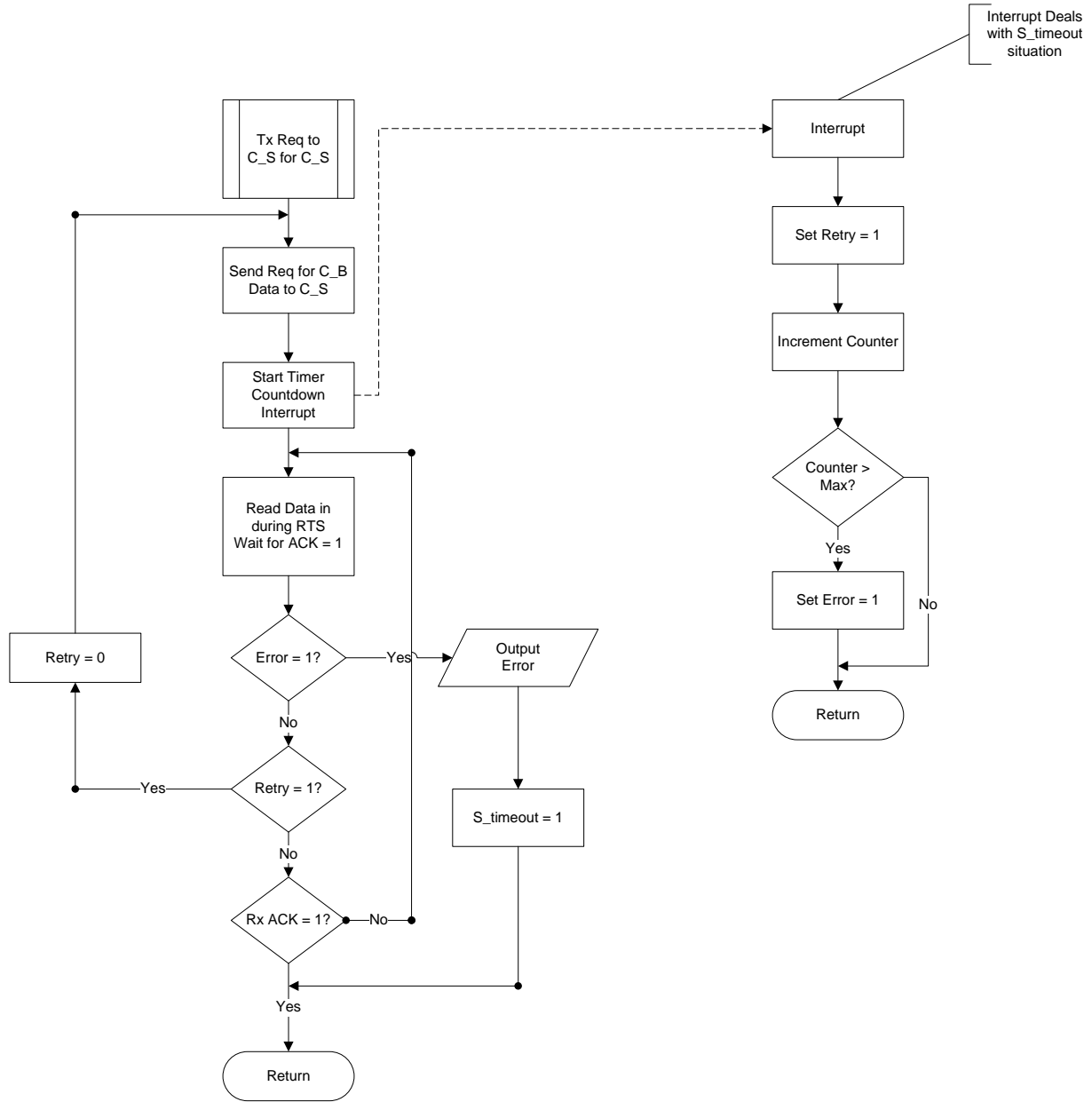


Figure 5: Base Station b.

Base Station Flow Chart – Subroutine 2

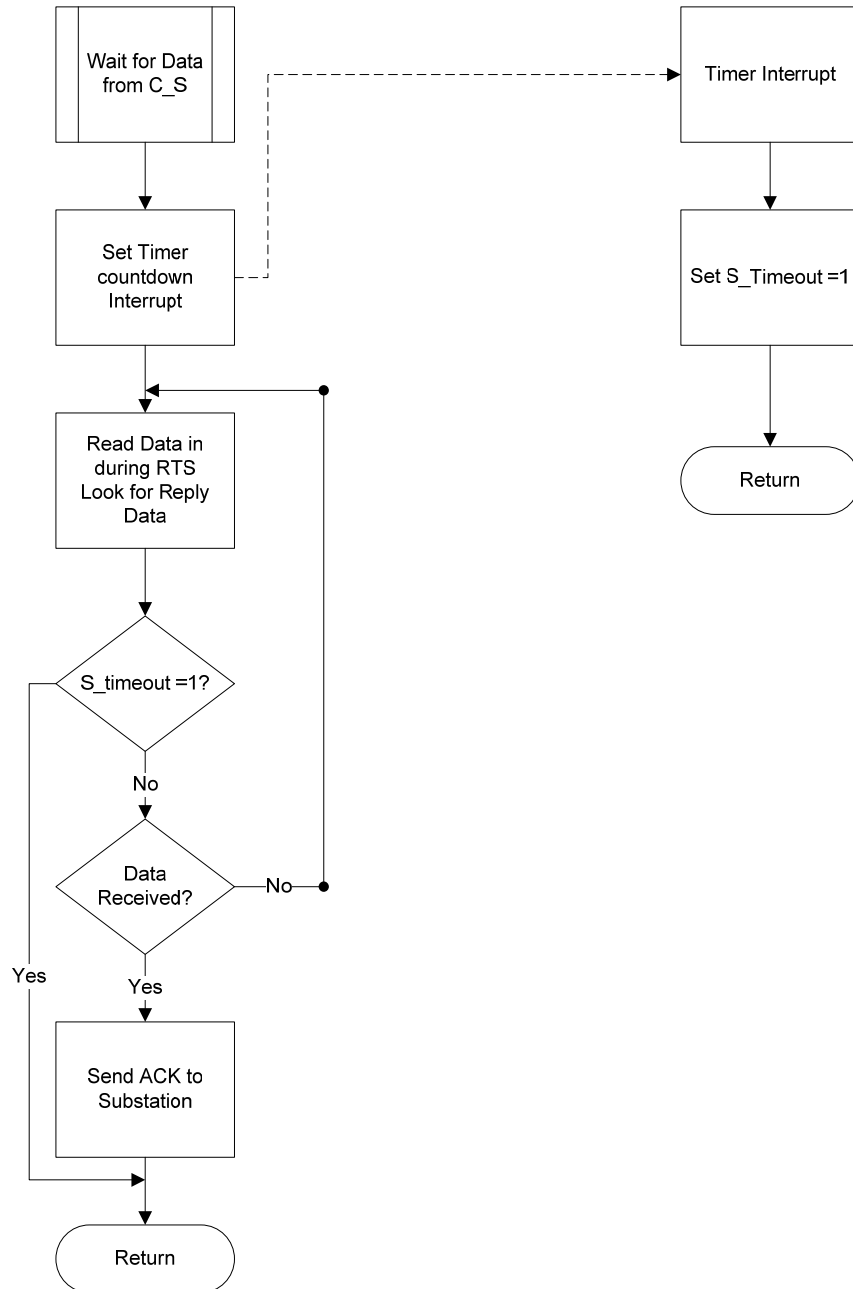


Figure 6: Base Station c.

Substation Flow Chart - Main

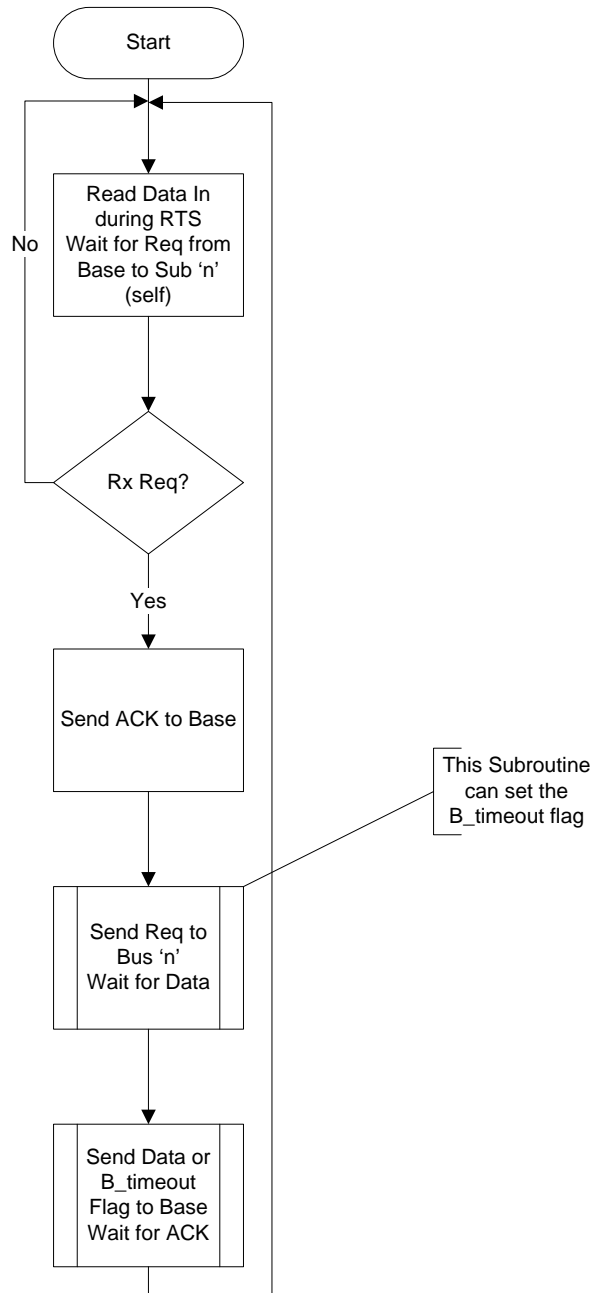


Figure 7: Substation a.

Substation Flow Chart – Subroutine 1

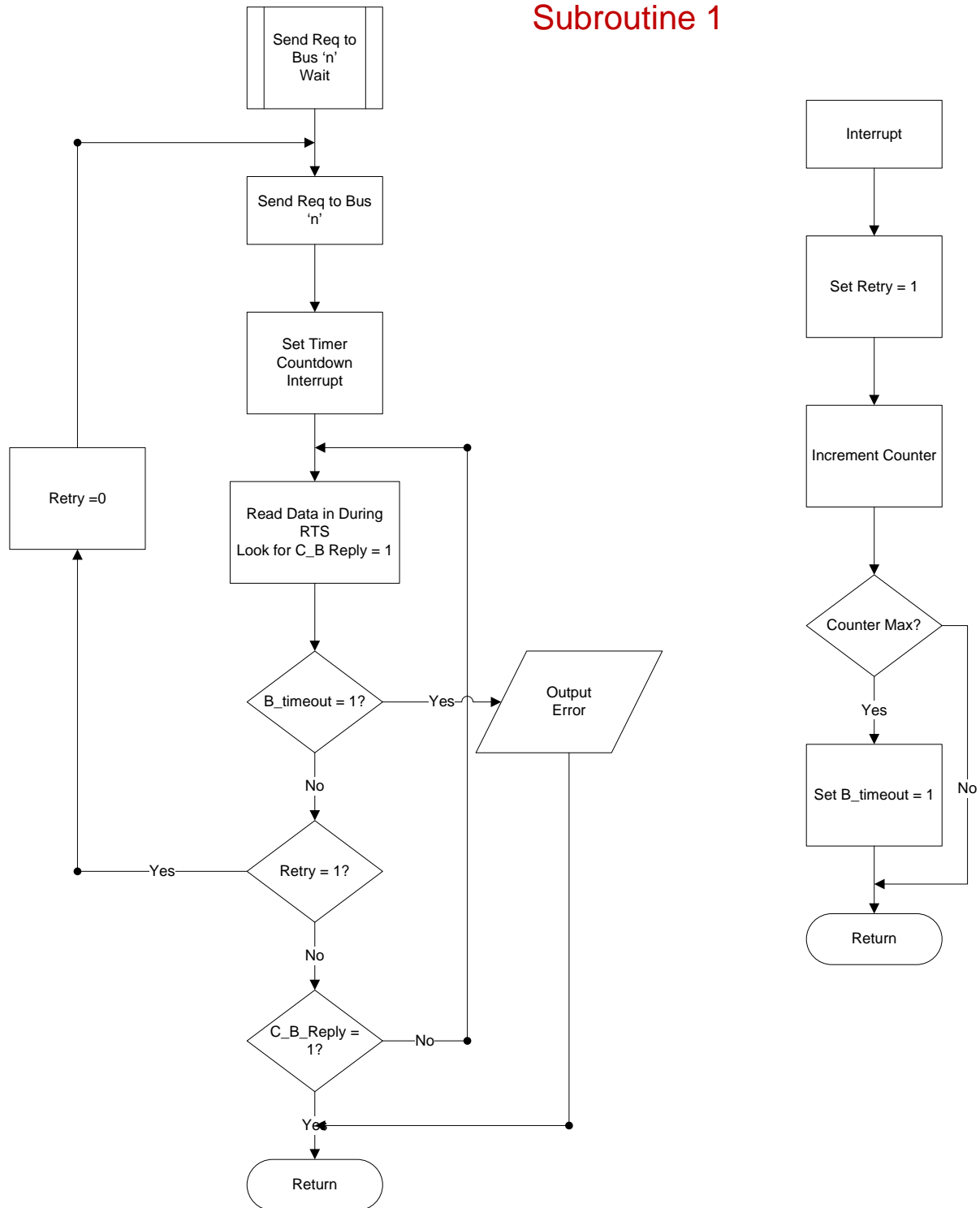


Figure 8: Substation b.

Substation Flow Chart – Subroutine 2

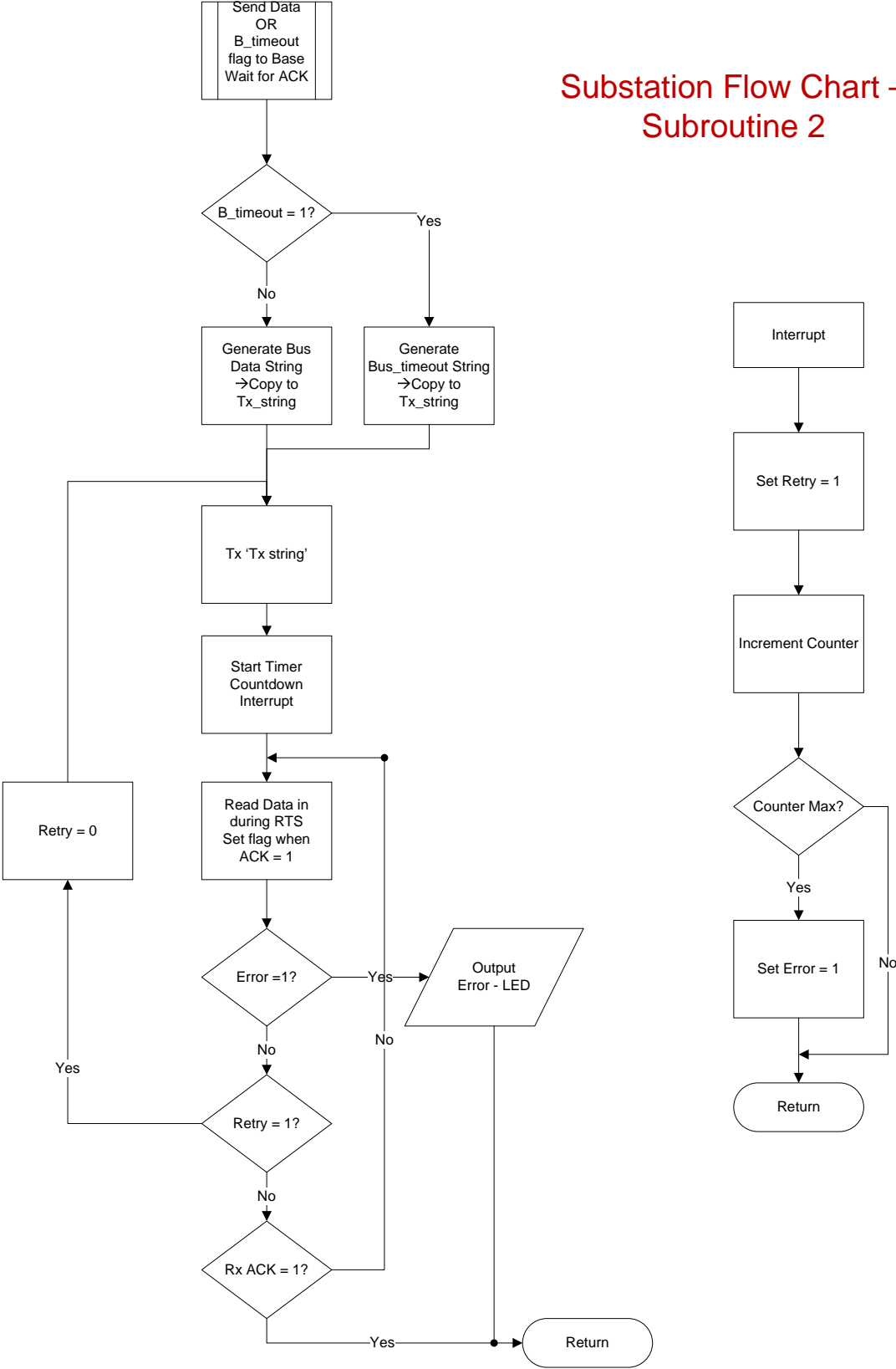


Figure 9: Substation c.

Bus Flow Chart - Main

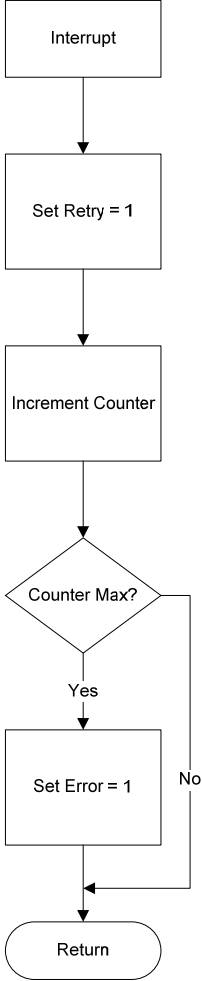
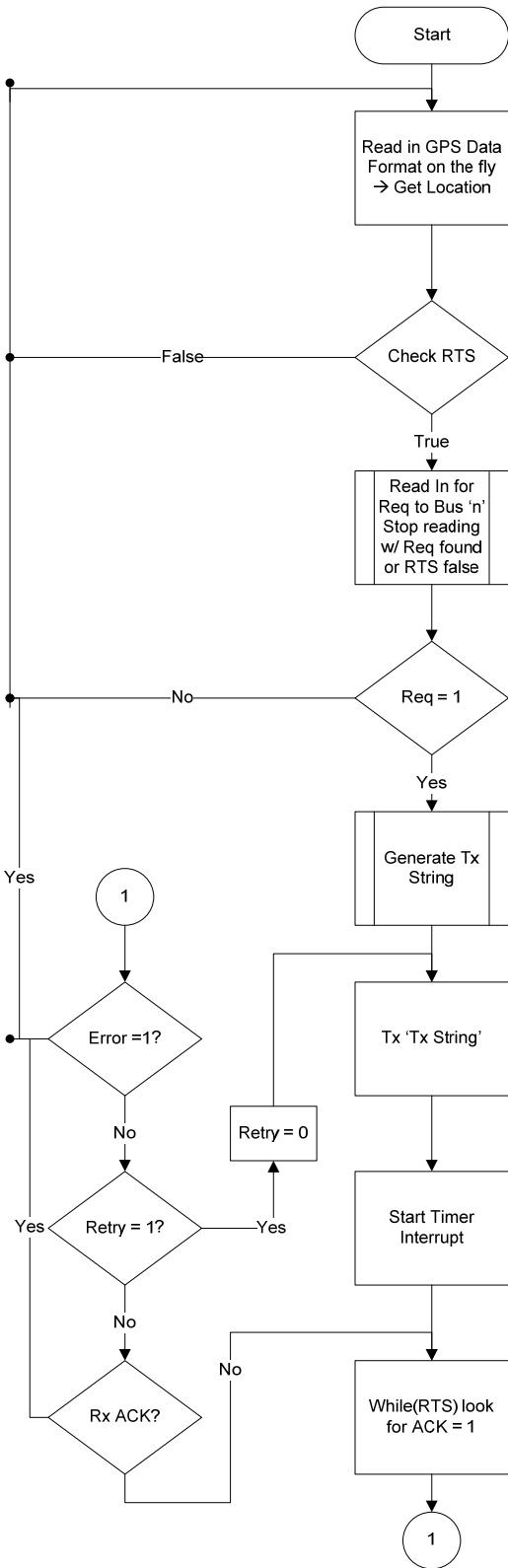


Figure 10: Bus

User Manual

Input Voltage