Samantha Module Mounting Experiment

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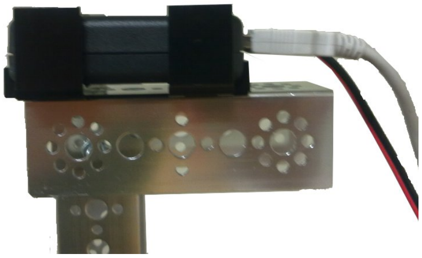
1 Background

Figure 1: Naming for each face of the Samantha module. The side not visible is the back.

(a) Vertical



(b) Horizontal

(c) Lateral

Figure 2: Naming for each orientation of how a Samantha module can be mounted on a robot. The perspective is a side-on view of the robot.

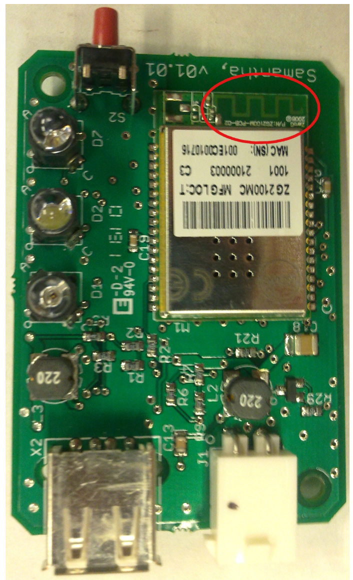


Figure 3: Internals of a Samantha module, with the PCB antenna circled.

2 Setup

There were three components to the experimental setup, the setup for the Samantha module, the setup for the Field Control System, and the setup for data collection. The Samantha module was connected to the NXT and DC Motor Controller as it normally would be on an FTC robot. I assembled a stable base to mount the Samantha module on using three 288 mm Tetrix beams connected orthogonally, with a 96 mm Tetrix beam connected orthogonally to the top of the vertical beam. The Samantha module was mounted vertically to the vertical beam and horizontally or laterally to the smaller horizontal beam. The entire setup was placed on top of an office cart. The NXT was setup to run the FTCTeleopFull sample program provided with the FTC version of LabView. The Field Control System (FCS) setup consisted of a Linksys E1000 router configured as described in the FCS instructions using WPA2 security, connected over wired ethernet to a laptop running the Field Control System software on Windows 7. For this experiment there would be no difference between a Linksys E1000 and a Linksys E3000 router since only the signal strength of the Samantha module was measured. The setup for recording data was a laptop running Kismet, a wireless network monitoring program, on Linux. The router, the FCS laptop, and the data collection laptop were all placed on top of a second cart so that they were at approximately the same height as the Samantha module. Each cart was moved to opposite ends of a long hallway, with the Samantha module 48.5 m (159 ft) away from the wireless router and data collection laptop. The two setups were placed as far apart as possible so that the experiment could confirm whether or not a connection could be maintained at a farther distance than would reasonably be used in practice or competition matches. If a particular mounting orientation of the Samantha module prevented the module from connecting to the wireless router or if the connection dropped during the test, the Samantha module setup would be moved incrementally closer to the router until a connection to the wireless router could be reliably established, determining the maximum range for that mounting orientation.

The Kismet software is capable of displaying a list of clients connected to an access point and the signal strength in dBm and the number of packets received for each client. This feature was used to measure the radiated power of the Samantha module at the same distance as the wireless router. Measuring the signal strength using Kismet was found to be the best method for observing the radiation pattern of the Samantha module's antenna. The procedure for testing was to observe and record the average signal strength as shown in Kismet, rotating the Tetrix base on which the Samantha module was mounted to measure the signal strength for each face of the Samantha module. In addition, the signal strength for a 45°angle between two faces of the module was also measured. Since a robot could be oriented in any direction relative to the direction towards the wireless router, rotating the Samantha module to measure the signal strength for each face would determine the range of possible signal strengths as a robot moves around the playing field. This procedure was repeated for each of the three mounting orientations.

3 Results

The first point of interest from the results is that none of the orientations of the Samantha module relative to the wireless router resulted in a dropped connection, even though the separation between the two setups was 48.5 meters, a much longer distance than a robot would be separated from the wireless router in a competition. This indicates that a dropped connection would not be primarily caused by the distance between the robot and the wireless router or by the orientation in which the Samantha module was mounted. A dropped connection would likely be the result of a combination of these factors and excessive interference from other devices operating in the same frequencies as the Samantha module. Therefore mounting the Samantha module in the optimal orientation could mitigate the effects of interference by increasing the signal strength between the module and wireless router but could not solve the problem of interference entirely.

Table 1: Average received signal power from the Samantha module

Orientation	Face	Avg. Power (dBm)
Vertical	Front	-56
Vertical	Side	-65
Vertical	Back	-64
Vertical	45° Front / side	-65
Horizontal	Top	-58
Horizontal	Side	-69
Horizontal	Bottom	-66
Horizontal	45° Top / side	-58
Lateral	Top	-63
Lateral	Front	-51
Lateral	Bottom	-61
Lateral	Back	-52
Lateral	45° Top / front	-52

Table 1 shows the average received signal power in dBm (decibels of measured power referenced to 1 milliwatt) that was measured for each mounting orientation and face of the Samantha module. Since dBm is a logarithmic scale unit, a signal that is 10 dBm stronger than another signal has a power that is 10 times greater in terms of watts, for instance -50 dBm is 10 nanowatts and -60 dBm is 1 nanowatt. Table 2 summarizes each mounting orientation with the lowest and highest averages from the first table. These values indicate relatively how weak and how strong the signal will be for a particular orientation of the Samantha module as a robot moves around the playing field, facing in arbitrary directions relative to the wireless router. The lateral mounting orientation has the highest averages of the three, with the vertical mounting orientation second.

Table 2: Range of average received signal power for each orientation

Orientation	Lowest Avg. Power (dBm)	Highest Avg. Power (dBm)
Vertical	-65	-56
Horizontal	-69	-58
Lateral	-63	-51

4 Conclusion

The results of this experiment indicate that at the same distance and with the same amount of background interference, mounting the Samantha module laterally, as shown above in Figure 2c, will result in the best overall signal strength given that a robot could be moving in any planar direction relative to the wireless router. Although this experiment only measured the received power from signals transmitted by the Samantha module, since the Samantha module uses the same antenna for transmitting and receiving data this implies that the relative strength of signals received by the Samantha module would follow the same pattern. However, since a reliable connection was maintained throughout all of the tests at a distance of 48.5 meters, the relative benefits of mounting the Samantha module laterally instead of vertically or horizontally would only be observed in a situation where there was enough interference for the relative difference in signal strength between mounting orientations to make a difference. Even though a team might not notice a difference from how they have mounted their Samantha module until they go to a competition where there is enough unavoidable interference that there are connection issues, it would be better not to have to remount the Samantha module at competition.

There are also a few other best practices that could improve the connection between the Samantha module and the wireless router. The Samantha module should be mounted with as much space as possible between the module and the Tetrix beam. The FCS computer should be connected to the wireless router with an ethernet cable instead of wirelessly to avoid unnecessary interference, and other nearby computers should be on wired networks as well if possible. The wireless router should be placed close to the field and high enough that every robot has a line of sight to the router even if another robot was in the way. There are advanced settings in the wireless router configuration that would affect communication with the Samantha modules in a high interference environment. Further experimentation will include simulating a high interference environment and testing the wireless router configuration.