700 MHz Propagation Measurements and Modeling Project

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ABSTRACT

The goal of the 700 MHz propagation measurements and modeling project was to develop detailed scatter plots that would display path loss through indoor environments. This project will further the research in the understanding of how propagated signals react against such environments like the basement of Rickover; thus, creating a generalized channel model for our given project area. The project will obtain this data through the use of a fully automated positioning measurement table, that will increment itself in the x and y direction allowing for us to take multiple readings at one time. Our measurement plan consisted of taking measurements down two hallways and in one classroom with the intent to gain results that we could compare against each other. The project was not merely hardware based, but also software based. We created a MATLAB code to compile and analyze the multipath received signal generated by the oscilloscope attached to the receiver. Lastly, after developing all the proper code and understanding how the hardware works our future goals is to further our research in modeling Cognitive Radio systems by taking measurements in outdoor environment amongst various locations on the Naval Academy grounds.

INTRODUCTION

In February 2008 the 700-800 MHz spectrum became available for purchase. This spectrum was of high interest for numerous corporations such as Google, for reason that there exist numerous possibilities in the development of wireless devices in this frequency range. With that the problem to be addressed is to analyze the effects of broadcasting a 700 MHz wireless signal in an indoor environment with various objects present. These measurements will be taken by a pre-built mobile receiver platform that will send its findings to a MATLAB for further study. The time table for the project was twelve weeks.

METHODOLOGY

The problem to be addressed is the development of an accurate path loss model for the basement of Rickover. The channel sounder used a conical monopole antenna to propagate an amplified broadband signal spread over a 750 MHz bandwidth using a pseudo noise (PN) sequence device.

The measurement table, also equipped with a conical monopole antenna, was programmed through Labview to move about a 45cm by 45 cm grid, taking an average of 127 samples/sec from the oscilloscope. Each measurement started approximately 4 feet from the transmitter and varied from 6 to 18 feet for every subsequent measurement position.

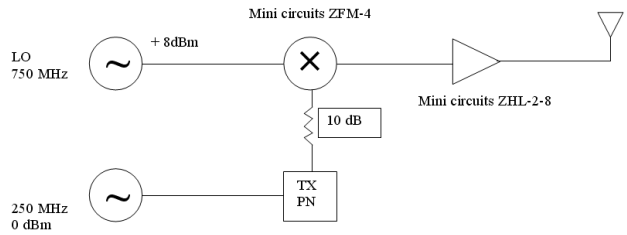

Figure 1: Transmitter block diagram

A mobile receiver was moved to varying distances from the transmitter to receive the signal. The signal is filtered and despread using a PN sequence matching that of the transmitter.

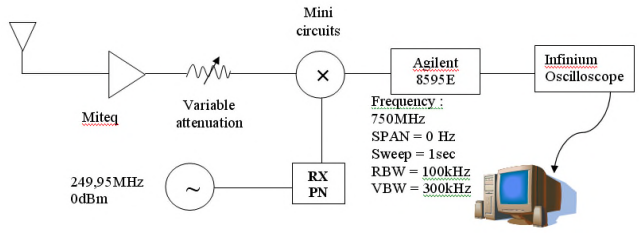

Figure 2: Receiver Block Diagram.

With the information collected from the receiver we were able to view it in the LabView Channel Sounder, which we fed into MATLAB for further analysis. The receiver setup sends the information into the LabView Channel Sound via General Purpose Interface Bus (GPIB), whereupon the data is stored. Data was processed post-measuring using MATLAB software to ascertain necessary information with the intention of analyzing and visualizing the environment.

RESULTS

Measurements for this experiment were conducted in the Basement of Rickover Hall at the United States Naval Academy. The basement consists of a long rectangle of hallways with multiple perpendicular hallways, creating a grid of rooms. Measurement scenarios were created to

conduct line of sight (LOS) measurements as well as no line of sight (NLOS) measurements.
Table 1 summarizes the results of the 6 scenarios, totaling to 142 measurement positions.

Table 1: Summary of 750MHz Measurement Results in Basement of Rickover Hall

Location	n	$\overline{\tau}$ (ns)	σ_τ Min/Max/Avg (ns)	$\tau_{Max\ 20dB}$ Min/Max/Avg (ns)	# Multipath Min/Max/Avg	Ricean K-Factor
Hallway 1 LOS	1.7522	19.70	12.3 / 23.9 / 18.4	46.2 / 96.4 / 70	5 / 26 / 13	11.48
Hallway 3 LOS	2.3072	28.40	23.23 / 39.18/ 29.78	62.80 / 116.8 / 91.62	2 / 22 / 13	9.7
Hallway 2 Diffraction	3.3068	42.98	15.78 / 104.98 / 30.47	63.20 / 116.8 / 91.62	6 / 32 / 18	10.37
Classroom 1	2.1081	33.49	19.15 / 34.31 / 27.57	74.40 / 122.80 / 100.67	9 / 30 / 18	12.16
Classroom 2	2.0027	27.93	18.91 / 28.16 / 22.06	64.20 / 92.20 / 75.74	18 / 34 / 25	12.08
NLOS	3.8073	63.32	27.90 / 222.41 / 45.22	93.60 / 756.00 / 154.43	3 / 33 / 22	10.32
All Data	2.5062	36.0	12.3 / 222.41 / 29.22	46.2 / 750 / 102.78	3 / 34 / 17	10.71

The path loss data obtained through the MATLAB algorithm was plotted with respect to distance of the receiver from the transmitter. Figure 1 displays the results.

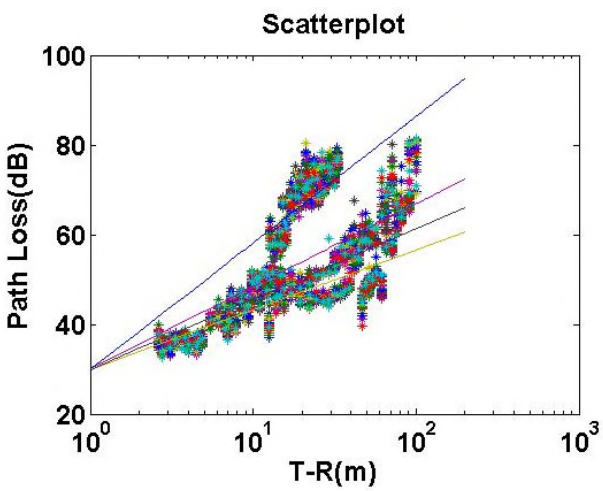

Figure 1: Scatterplot of Indoor Measurement

DISCUSSION

Given three different scenarios: line of sight, diffraction, and non-line of sight the results were able to produce an average Ricean K-factor value greater then 8. This shows that in the basement of Rickover there is minimal fading given the surroundings, which in turn allows for the path loss exponent to be reasonably close to 2. Besides fading there existed other external distortions that affected RMS delay and the path loss exponent. They included curious observers walking past the transmitter, machines from surrounding labs broadcasting signals, and the amplifiers attached to the receiver becoming slightly over heated due to extended use. A solution to these problems was implemented in the form of increasing the receiver's sample rate. This was able to provide more accurate results.

CONCLUSIONS

This projected yielded favorable results as can be seen in the path loss exponent value. These results are significant to understanding the behavior of wireless signals in varying environments. Research will be continued in the spring semester developing an understanding of how a wireless signal would react in an outdoor environment.

ACKNOWLEDGMENTS

Second Lieutenant Arnaud Godard France Army contributed numerous hours to the development of the MATLAB code and to taking measurements in the basement of Rickover.

REFERENCES

[1] Rappaport, Theodore S. Wireless Communications Principles And Practice. 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2002.