UWB Antenna

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Abstract

The Ultra Wideband (UWB) Antenna will be an antenna that operates over UWB frequencies, 3.2 GHz to 10.6 GHz. An antenna is a transducer between a guided wave propagating in a transmission line, and an electromagnetic wave propagating in an unbounded medium, like air. UWB signals are pulse-based waveforms compressed in time, instead of sinusoidal waveforms compressed in frequency. The antenna will operate similar to any other antenna seen in industry. The impedance will be closely matched, or the Voltage Standing Waveform Ratio, VSWR, will be less than or equal to 2. The main goal of the project is to build a working antenna that is used for UWB applications.

Introduction to Antennas and Ultra Wideband

As stated in the abstract, an antenna is a transducer between a guided wave propagating in a transmission line, and an electromagnetic wave propagating in an unbounded medium, like air. All wireless systems have a transmitting antenna and a receiving antenna. The transmitting antenna is the antenna that obtains the signal from the source. The receiving antenna is the antenna that outputs the desired signal to a receiver. Antennas are used for many applications; one of the more recognizable applications is radio. The receiving antenna on a car collects the signal from the radio station and outputs the signal into the receiver. Music can now be heard in the car. The application being used in this project will be ultra wideband (UWB) wireless systems.

UWB is defined as a system having a bandwidth greater than 500 megahertz (MHz). UWB ranges from 3.1 GHz to 10.6 GHz. UWB signals are pulse-based waveforms compressed in time, instead of sinusoidal waveforms compressed in frequency. The advantages of using UWB frequencies are higher bandwidth, reduced fading from multi-path, and low power requirements. Figure 1-1 is an example of a UWB signal. The figure shows the difference between a narrowband signal and a UWB signal. The bandwidth of the UWB signal is much larger than the narrowband, which means UWB signals can operate over wider frequencies.

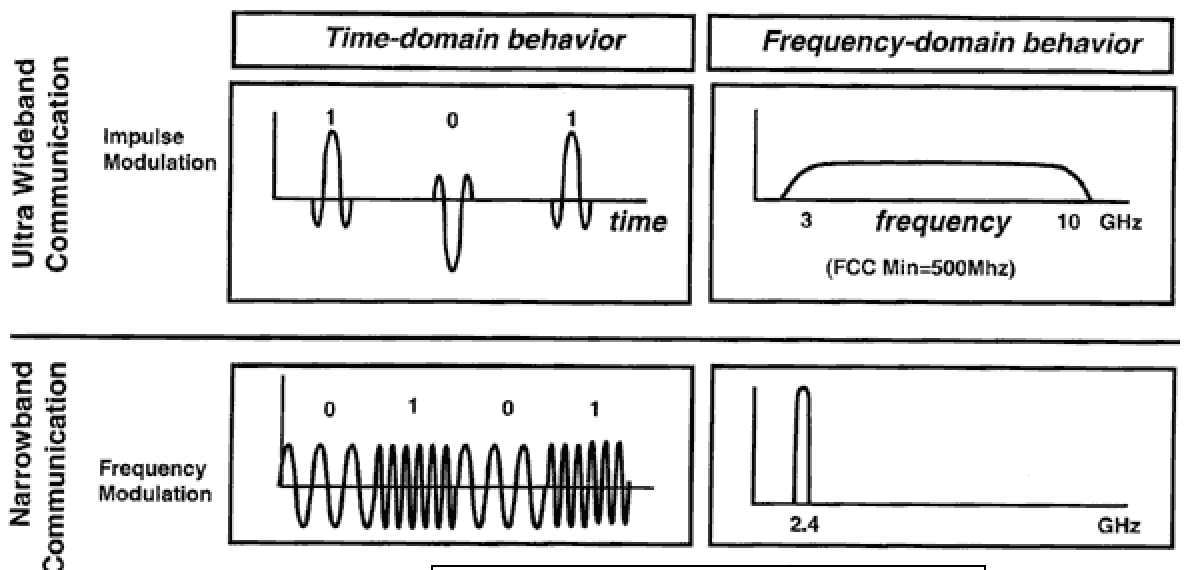

Figure 1-1
Difference between UWB and Narrowband

Overall System Block Diagram

The input UWB signal of the antenna will go to the antenna. The antenna can be transmitting or receiving. The signal travels through air and ends up at the receiver, or the spectrum analyzer. (See Figure 2-1.)

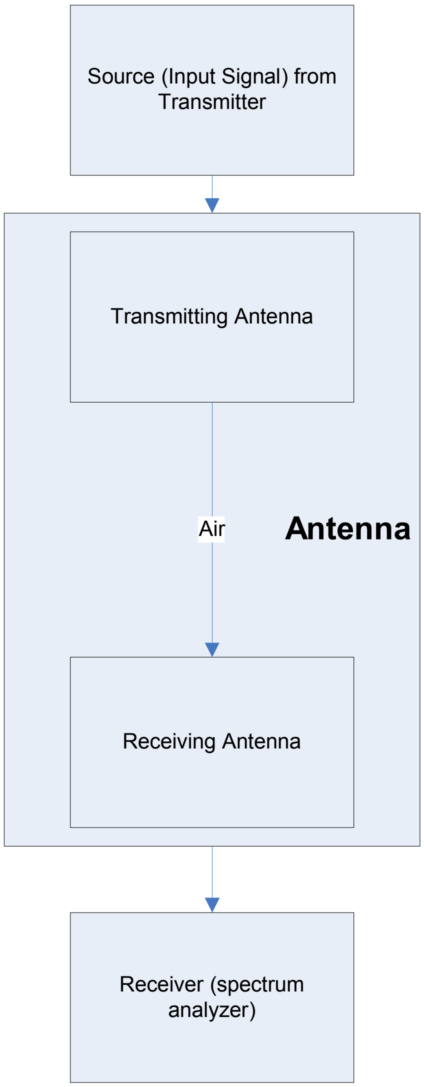

Figure 2-1
Overall System Block Diagram

Source

The source is what generates the signal. The signal will be a UWB signal, which means the signal's frequency will be 3.1 GHz to 10.6 GHz. The source of the UWB antenna has not been chosen yet.

Antenna

The antenna is the brunt of the project, and the antenna must be able to transmit or receive UWB frequencies. Whether the antenna is transmitting or receiving has not been decided yet, but a transmission line will have to be made so there is impedance matching for the antenna.

Receiver

After the signal leaves the antenna, the signal will be delivered to the receiver. The receiver, more than likely a spectrum analyzer, will output the signal. With the spectrum analyzer, the student and advisor will be able to observe what power loses were obtained in the systems. The power loses shall be small enough so that the input signal shall be close to the same as the received signal.

Requirements and Performance Specifications

The antenna's radiation pattern shall be Omni-directional. Omni-directional means that the signal waves passing through antenna shall be able to travel in all directions. The antenna shall be small in size and be printed on a high frequency circuit board. Along with the small size of the antenna, the antenna shall be low in cost. The VSWR, Voltage Standing Wave Ratio, shall be less than 2. If the VSWR would be equal to 1, then the antenna would be perfectly matched. The gain in dB of the antenna shall be less than 5 and relatively constant over UWB frequencies. The impedance of the antenna shall be matched and be a value that is easy to create on a high frequency circuit board. The UWB signal cannot be distorted after traveling through the antenna.

There are many types of antennas to use to make the UWB antenna. A small list of antennas is given in the Additional Information section of this document. The exact limit on the size of the antenna is not given because the definition of small is interpreted differently for person to person. An example is a monopole antenna found in the UWB Research Papers on the CD received from Dr. Shastry. The antenna's dimensions were 50 millimeters by 50 millimeters by 0.8 millimeters. Dr. Shastry said this would be a good size for the UWB antenna for this project. As long as the antenna fits easily on a desktop, the size of the antenna size will be reasonable.

Standards

Standards are used by about every company, so this project will have standards too. Agilent has standards for UWB, and these standards will be used for the UWB Antenna. UWB, in North America, must have a frequency range of 3.17 GHz to 10.56 GHz. The channel spacing for UWB is 528 MHz, and the symbol/chip rate is 3.2 MHz. The sub carrier spacing for UWB is 4.125 MHz. According to Agilent, the primary services of UWB are low mobility streaming video and data, and certified wireless USB next generation, Bluetooth. UWB is packet switched; not circuit switched. The Agilent peak single user data rate is 480 Mbps. The modulation of UWB is 200 Mbps and slower for QPSK, 320 for DCM, and 400 Mbps and 480 Mbps in general. The filter type depends on the format. UWB will either by shaped pulse or frequency switched OFDM. UWB is used worldwide.

Patents

As expected, any new design or creation has to have a patent. There are many patents for different UWB antennas. One patent is for the Dual Sphere UWB Antenna. Waldemar Kunysz created this antenna. The antenna has two conducting spheres with a gap of air inbetween them. This antenna has consistent performance in the azimuth plane and works across the whole UWB frequency range.

Another patent for a UWB antenna is the Electrically small planar UWB antenna apparatus and related system. The inventor of this antenna is John W. McCorkle. "The antenna has a conductive outer ground area that encompasses a tapered non-conducting clearance area, which surrounds a conductive inner driven area." The VSWR of the antenna is very small in the whole UWB frequency range. Amplifiers can be placed on the antenna and be used as a feed.

A third patent found on the Internet is the Contoured triangular dipole antenna. Alan Stigliani and Daniel H. Schaubert invented this antenna. The antenna is small in size and uses UWB radio communications. The curvature of the antenna helps it work over the whole UWB frequency range. The Contoured triangular dipole antenna can be a balanced dipole and an unbalanced dipole. There are many other UWB antennas with patents, but they are not listed to save time in reading the document.

Datasheet

The datasheet for the UWB Antenna has similar values seen in the Requirements and Performance Specifications section. The UWB Antenna will be Omni-directional, and small in size so it can easily fit on a desktop. The UWB Antenna will also be printed on a high frequency circuit board. The antenna will also work over the whole UWB frequency range and will almost have an impedance match. The VSWR will be less than or equal to 2 over the UWB frequency range. The UWB frequency range is 3.2 GHz to 10.6 GHz. There will be little to no distortion in processing the signal. When all of these specifications are met, the UWB Antenna is considered to be functioning properly.

Experimental Work, Simulations, and Design Equations

Up until now, all that has been done for the project is researching. No experimental work, simulations, or design equations have been created yet. Dr. Shastry believed that it would be better to read many documents on UWB, antennas, and watch EE 550 lecture tapes. All of the documents and lecture tapes helped the student learn more about UWB and antennas; so next semester, the student can start doing experimental work, simulations, and creating design equations. When these accomplishments will be completed can be seen in the schedule.

Schedule

The schedule for the project can be seen in Appendix B. A 3-day period was created in the schedule for possible design changes. Just in case problems occur with the original design, this 3-day period was created to give time to make the changes, and still have time to test and collect data.

Equipment List

The equipment that will be used for designing and testing the UWB Antenna can mainly be found in the RF Lab. A network analyzer, HP8722C or HP8410C, and a spectrum analyzer, HP8593E or HP8559A, will be used to test the output of the antenna. The signal generator with digital modulation, HPE4433B, will be used to generate the UWB signal entering the antenna. The MIC Fabrication Lab uses computer aided design to help design the shape, size, and test the antenna to make sure it works as specified. The software program Agilent Advanced Design System (Ver 2004A) will also be used to design the antenna. This program can be used on Windows and Unix. Sonnet 10.52 is another program that does the computer-aided design. The Anechoic Chamber is where the antenna will be tested so that all extra noise around the antenna can be eliminated. The Data Acquisition Facilities, Agilent VEE pro, will help gather all the data received in the Anechoic Chamber. As stated earlier, all equipment is located in the RF Lab and should be easy to access.

Appendix A – References

"Contoured triangular dipole antenna." FreshPatents. 4 December 2007 http://www.freshpatents.com/Contoured-triangular-dipole-antenna-dt20071018ptan20070241982.php.

Dr. Shastry, Bradley University, Professor and Advisor, 4 December 2007.

"Dual Sphere UWB Antenna." freepatentsonline. 4 December 2007 http://www.freepatentsonline.com/20070247371.html.

"Electrically small planar UWB antenna apparatus and related system." Patent Storm. 4 December 2007 http://www.patentstorm.us/patents/6590545.html.

Fundamentals of Applied Electromagnetics, EE 381 Text Book, Fawwaz T. Ulaby

Microwave and Wireless Engineering Program, Bradley University, Department of Electrical and Computer Engineering. Brochure

UWB Research Papers, CD from Dr. Shastry, Received: 2 October 2007

Appendix B – Schedule

Schedule for UWB Antenna Senior Project		
Week	**Date**	**Objective**
1	24-Jan-08	Computer Designing (Sonnet)
2	31-Jan-08	Computer Designing (Sonnet)
3	7-Feb-08	Designing Antenna
4	14-Feb-08	Designing Antenna
5	21-Feb-08	Designing Antenna
6	28-Feb-08	Build Antenna
7	6-Mar-08	Build Antenna
8	13-Mar-08	Build Antenna
9	27-Mar-08	Possible Design Changing
10	3-Apr-08	Possible Design Changing
11	10-Apr-08	Possible Design Changing
12	17-Apr-08	Testing and Recording (Anechoic Chamber)
13	24-Apr-08	Testing and Recording (Anechoic Chamber)
14	1-May-08	Final Report and Presentation
15	8-May-08	Final Report and Presentation