Laboratory Exercise:
Simple Radar Systems

Wireless Networking Systems Laboratory
Tennessee Technological University

28 March 2011

1 Introduction

Radar, or radio detection and ranging, is a term first coined by the United States Navy in 1940. As the name implies, it is the use of electromagnetic waves (radio waves) to detect and determine the range to some arbitrary target. A radar system does this by transmitting some waveform then waiting for echos of that waveform to return. When a target is present, the waves reaching it will become scattered with some of the reflections/refractions being directed back towards the radar system. These echos are gathered and, based on the time between transmission and reception, the distance to the target is determined [1].

1.1 Bistatic Radar

Until now we have assumed that the transmitter and the receiver shared a common antenna. This setup is what is called Monostatic Radar. There are however, circumstances in which the transmitter and receiver may be placed in the different locations so as to make use of the forward scattering characteristics of the target. This is what is called Bistatic Radar . Such a setup can be useful for detecting stealth aircraft. Some stealth aircraft are designed to minimize the backscatter of radar signals by directing the energy in other directions. By seperating the transmitter and receiver it is possible to instead use the forward scattering for detection making an otherwise invisible aircraft visible again [2].

2 Objectives

To familiarize the student with:

- the basic operation of a radar system
- some of the available equipment in the Wireless Networking Systems Laboratory

3 Required Equipment

1. Tektronix CSA8000B Communications Signal Analyzer/Digital Sampling Oscilloscope (DSO)
2. Agilent-33220A 20MHz Function / Arbitrary Waveform Generator
3. Picosecond Pulse Labs Model 3600 Impulse Generator
4. 2 Horn Antennas and stands
5. 20 dB attenuator

6. 10 dB attenuator
7. Metal object to serve as target
8. Assorted cables and connectors as needed

If the equipment you are using differs from that listed here be sure to take the time to understand the equivalent setup for your equipment.

3.1 Warnings

Notice: When connecting the cables to the test equipment be sure to turn only the outer nut and **not** the cable itself! The pin which acts as the connection between the cable and the test equipment is gold plated to ensure a good connection. Rotating this pin within the port could result in premature wear to this plating and degraded performance.

Notice: When connecting cables to the DSO be sure to wear the grounding strap so as to avoid damage to the equipment [3].

3.2 Picosecond Pulse Generator

The pulse generator we will be using is the Model 3600 Impulse Generator made by Picosecond Pulse Labs. This device will produce 7.5 volt pulses at a rate determined by the clock input. This device also features a TTL gate input which is fed to the input of an AND gate along with the clock input. This allows the user to disable/enable the pulse generator through the use of another digital signal. For this experiment we will not need to disable the output so we will connect the our clock signal to the TTL gate as well [4]. Take some time to look over the product specification sheet for this piece of equipment and be sure to follow the directions of this assignment closely so as to avoid damaging it or any other equipment you are using.

4 Procedure

Much of the equipment you will use in this exercise is very sensitive and it is important to carefully observe all notices given in Section 3.1 for both the safety of the equipment and yourself. We will begin with the physical setup of the equipment.

1. Since this experiment is an example of a simple monostatic radar system the antennas will be collocated. Position the two horn antennas side by side facing the same direction with all of the test equipment positioned behind them.
2. Before powering on any equipment, make all connections as shown in Fig 1.
3. Turn on the DSO
4. Set the following parameters for the Agilent-33220A Function / Arbitrary Waveform Generator.
   - SQUARE WAVE
   - Frequency - 2.000,000,0 MHz
   - Amplitude - 5.000 Vpp
   - Offset - +2.5000 Vdc
   - Duty Cycle - 50
5. Turn on the Pulse Generator
6. Press Output on the Function Generator. The button should now be glowing.

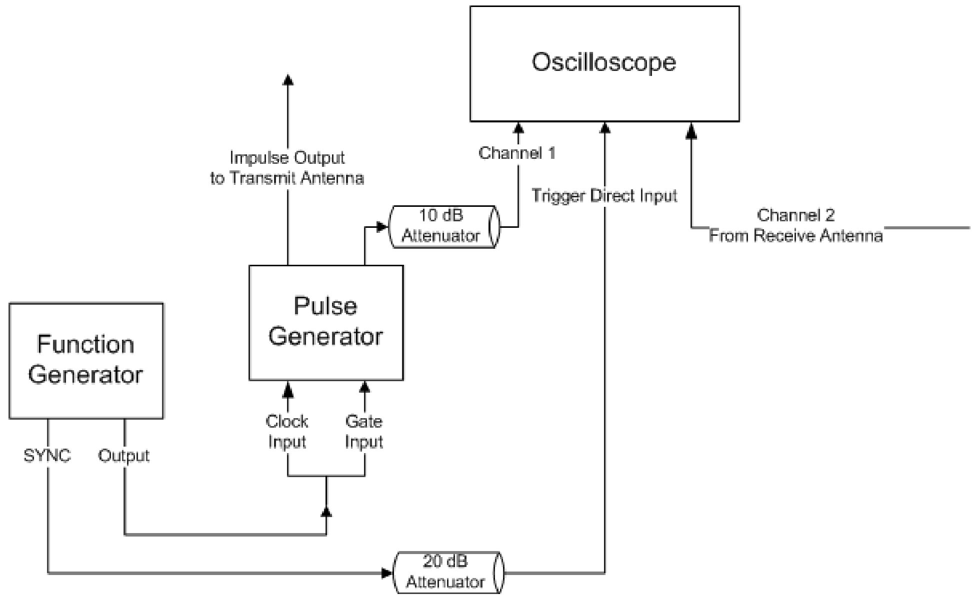

Figure 1: Exercise Equipment Setup

4.1 Monostatic Radar

Before we begin our measurements we should take note that generally, in monostatic systems, the transmitter and recevier actually share an antenna through the use of a duplexer [1]. For the sake of simplicity we will instead use two antennas, one for the transmitter and another for the receiver.

1. Place a metallic object some distance from the antennas. This will serve as our target.
2. Adjust the setting of the oscilloscope until you have a good picture of the received pulses.
3. Using the cursor function measure the time difference between the two pulses. What does this time difference represent?
4. Try moving the target away from then back towards the antennas while observing the change in the pulses on the oscilloscope.
5. Try angling the target to reflect the waves away from the antennas. What do you notice?

4.2 Bistatic Radar

We will now take a look at an example of bistatic radar.

1. Carefully disconnect the cable to the receive antenna and move the antenna approximately 10 feet away from the transmit antenna. Position the horns so that they are facing as shown in Fig. 2 then reconnect the receiver to the oscilloscope.
2. You should be able to observe a weak pulse on the receiver channel.
3. Observe the pulse without the target present.
4. Move the target into the position described in Fig. 2. What effect does this have on the received pulse?

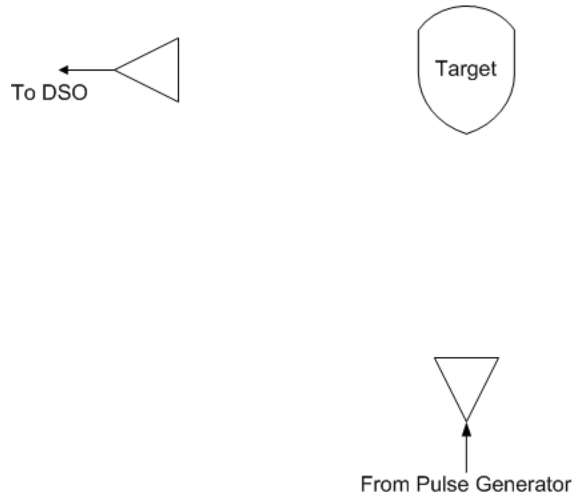

Figure 2: Antenna/Target Setup for Bistatic Case

4.3 Cleanup

1. Push the Output button on the Function Generator. It should no longer be glowing.
2. Turn off the Pulse Generator.
3. Shut down the DSO.
4. Carefully disconnect all the equipment and return it to its proper place.

References

[1] J. Eaves and E. Reedy, *Principles of Modern Radar*. Van Nostrand Reinhold, 1987.

[2] C. Wolff. (2008) radartutorial.eu. [Online]. Available: http://www.radartutorial.eu/

[3] *CSA8000B Communications Signal Analyzer TDS8000B Digital Sampling Oscilloscope User Manual*, Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077.

[4] *Model 3600 Impluse Generator Product Specification*, Picosecond Pulse Labs, P.O. Box 44, Boulder, CO 80306, June 2005.