Lab #1 –Propagation Modes & Path Loss

In this lab you will use the Lab-Volt microwave equipment to verify Friis's equation for free-space path loss, and observe how path loss is affected in the presence of a reflector. After that, you will go into the field to test the range of a commercially wireless transceiver; using these measurements, you will model the path loss under different scenarios.

Section 1: Free Space Path Loss

As discussed in class, when an electromagnetic (EM) wave is radiated into free space, the power density decreases as one moves away from the radiation source. In other words, the power received by an antenna decreases as the antenna is moved further away from the transmitter. This power decrease is called the free-space path loss. In the ideal case where the transmitter and receiver are separated by a vacuum, with no other objects nearby, the path loss follows Friis's equation:

$$P_{RX} = P_{TX} G_{TX} G_{RX} \left(\frac{\lambda}{4\pi \cdot d} \right)^2$$

From Friis's equation, it follows that received power is inversely proportional to the square of the distance that separates the transmitter and receiver. In the first section of this lab, we will verify this square law relationship between path loss and distance.

We will be using the Lab-Volt microwave equipment. Both the transmitter and receiver use horn antennas operating at 10 GHz. Although we are not operating in free-space, the horn antenna provides sufficient directivity such that reflections off nearby objects are minimized, giving a good approximation to free space propagation.

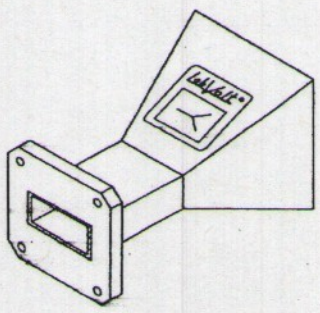


Fig. 1

Figure 1: Horn Antenna

Set up the components as shown in Figure 2 below. Use the long support rods for both the transmitter and receiver.

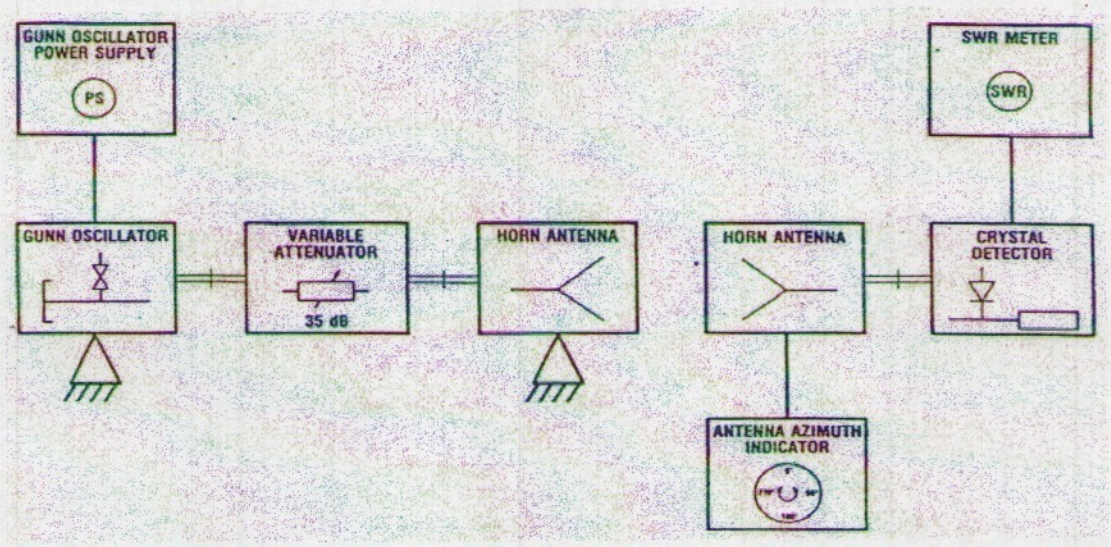


Figure 2: Setup for measuring free space path loss

Adjust the height of the support rods such that the center of each antenna is 30 cm above the working surface. Set the initial separation of the horn antennas at d = 50 cm.

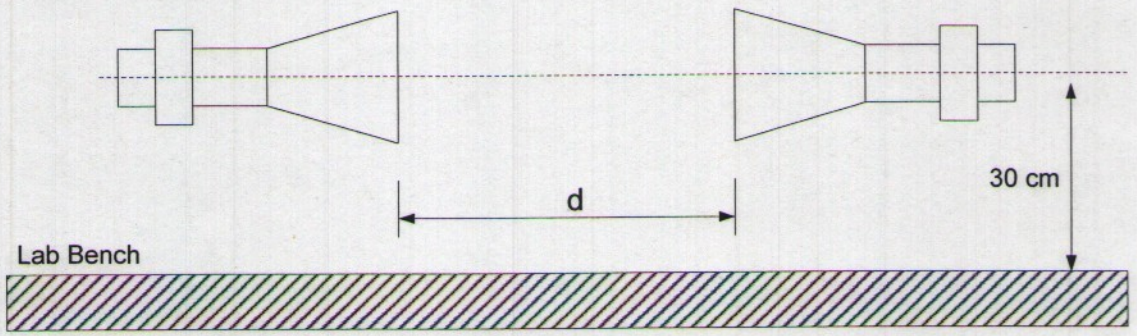


Figure 3: Side-view of horn antennas' separation and height

Power up the Gunn oscillator power supply and SWR meter. Allow a warm-up of 1 to 2 minutes. Adjust the Gunn oscillator supply voltage to 8V.

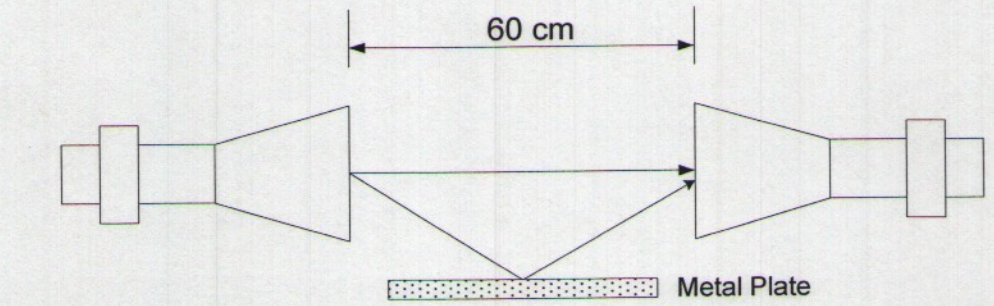
Adjust the variable attenuator to obtain a reference reading of -30 dB on the SWR meter. The SWR meter will be used to make relative power measurements. The SWR meter reading at d = 50 cm will serve as the reference point for all subsequent measurements.

Obtain readings from the SWR meter at d = 60, 70, 80, 90, and 100 cm. Compare your measurements to theory and comment.

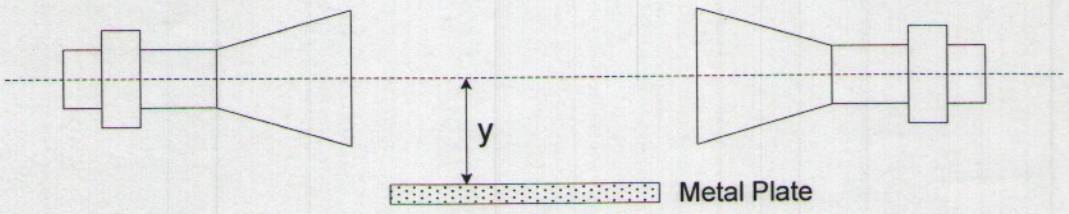
Section 2: Path Loss with Single-Ray Reflection

In this section of the lab we will set up a single reflector to observe its effect on path loss. Shown below is an overhead view of the arrangement, where the two horn antennas are separated by 60 cm, and a metal plate is placed at a distance y from the antenna center line.

Assuming there is only a Line of Sight (LOS) path and a single reflection, there will be constructive and destructive interference at the receiver as the distance y is varied. Analyze this situation and **predict** the distances y at which constructive and destructive interference will occur.



(a) Overhead View of LOS Path and Reflected Path



(b) Definition of Distance to Reflector

Figure 4: Overhead-view of horn antennas and metal reflector

Using the setup from Section 1, adjust the antenna separation to 60 cm. Adjust the variable attenuator until the SWR meter reads approximately -33 dB.

Find the metal plate from the Lab-Volt equipment kit, and set the metal plate into a stand. Place the metal plate at a distance y from the antenna center line. Adjust this distance and observe the SWR meter reading increasing and decreasing. Measure and record the distances at which constructive interference and destructive interference occur. Compare your measurements to prediction and comment.

Section 3: Range Testing with Wireless Transceivers

Your group will be assigned one pair of wireless transceivers from the following list:

CC1110 – 869 MHz transceiver

CC2510 – 2.4 GHz transceiver

Information for these ICs can be found on the Texas Instrument website (www.ti.com). It is suggested that you download the datasheet for these devices and look up the relevant specifications needed for this lab. You will be given ready-to-use circuit boards with one of these ICs mounted. Upon power-up, the ICs have been preprogrammed to run a link test using GFSK modulation at 2.4 kbps.

Test the range of the transceivers in a variety of environments, including at least **one** outdoor test with a direct line of sight, and at least **two** indoor tests where you do not have a line of sight. Document the distance measured, and the layout of the test environment (eg. sketches, etc). Create a model for the path loss, and compare your predicted link budget with the measured link budget. Do further research as needed to further refine your models.

Hand in a lab report by no later than the beginning of the next lab.