Experiment 2 - Antenna Pattern

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Abstract

The student will learn to measure antenna patterns.

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1 Radiation Pattern - Theory

1.1 Antenna Radiation Pattern and Regions

Antenna radiation patterns are one of the most important parameters of an antenna and is generally representing the far field power produced by the

antenna as a function of the direction measured from the antenna center position. Other types of patterns are represented by phase, polarization or fields measured in near or far fields zones. The behavior of the electromagnetic fields changed with the distance from the antenna, and three regions are defined:

Reactive near-field region - The region in the space immediately surrounding the antenna in which occurs only a reactive field when $d \leq \lambda/(2\pi)$ where λ represents the wavelength.

Radiating near-field region - Beyond the former region and for which $\lambda/(2\pi) < d < 2D^2/\lambda$ where d is the distance from the antenna, D is the largest dimension of the antenna. This region is called also Fresnel region. In this region the radiating field begins to dominate.

Far-field region - Beyond this region, the reactive field become negligible and also the radial part of the fields. This region is called also Fraunhofer region.

Generally measurements are taken in the far field region. In case of large planar antennas it is more convenient to make near field measurements and to calculate the interesting far field parameters from the measured data, using Fourier transform techniques.

1.2 Antenna Radiation Pattern Lobes and nulls

A radiation lobe can be defined as a portion of a radiation pattern bounded by regions of relatively weak radiation intensity. The *main* lobe is a high radiating energy region. Other lobes are called *sidelobes*, and the lobe radiating in the counter direction to the desired radiation direction is called *back lobe*. Regions for which the radiation is very weak are called radiated nulls.

1.3 Antenna Beamwidth.

Antenna beamwidth is defined as the angle between half power points on the main beam. In case that we have a logarithm radiation power pattern in [dB] units, it means that we measure the angle between two 3dB points.

1.4 Antenna Directivity

Directivity is a parameter related to the far field power pattern. Defining radiation intensity U as the power radiated per unit solid angle (in

watts/m^2/unit solid angle), and suppose that $U = CF(\theta, \varphi)$, than

$$D = \frac{4\pi F_{\max}(\theta, \varphi)}{\int_0^{2\pi} \int_0^{\pi} F(\theta, \varphi) \sin\theta d\theta d\varphi} \tag{1}$$

where D is the directivity. Directivity measures the amount of radiated energy to a specific direction, usually the maximal energy. Generally $D > 1$, except in the case of an isotropic antenna for which $D = 1$. An antenna with directivity $D >> 1$ is called a directive antenna.

1.5 Antenna Radiation Power Density

The time averaged power density of the antenna's radiation is given by

$$\mathbf{W}_{av} = \frac{1}{2} \operatorname{Re}(\mathbf{E} \times \mathbf{H}^*) \quad (\mathrm{W/m^2}) \tag{2}$$

The general radiated power is given by

$$P_{rad} = \frac{1}{2} \iint_S \operatorname{Re}(\mathbf{E} \times \mathbf{H}^*) dS \tag{3}$$

1.6 Antenna Radiation Intensity

Radiation intensity of an antenna is defined as the time averaged power radiated per unit solid angle. Hence

$$U = r^2 W_{\text{rad}} \tag{4}$$

Then P_{rad} is given by

$$P_{rad} = \iint_S U d\Omega \tag{5}$$

2 Antenna Radiation Pattern - Measurement

2.1 Objective

Upon completion of the study, the student will become familiar with the following topics:

1. Applying a automatic system to measure radiation pattern of antennas.
2. Radiation pattern, cartesian and polar (amplitude and phase).
3. E-plane and H-plane diagrams.
4. Omni-directional pattern.
5. Main lobe, sidelobes, back lobe and radiation nulls, main and cross poarizations
6. Far field and near field.
7. Bandwidth.

2.2 Prelab Students Preparation and Report

1. Define a radiation pattern.
2. Explain the following antenna parameters:
   - E-plane and H-plane diagrams
   - Beamwidth
   - Main lobe, sidelobes and backlobe
   - Beam efficiency
   - Far-field region, near-field region and reactive near-field region
   - Bandwidth
   - Isotropic, omni-directional, and a directional patterns
   - Main and cross poarization
3. What is the mimimal distance between the transmitting and receiving antennas to obtain far field condiitons ?
4. Describe and explain how to measure E-plane and H-plane patterns of a dipole antenna.
5. Explain how to decrease the back lobe.
5. Describe the experiments you intend to perform.

2.3 Equipment Required

The following equipment needed to the pattern experiment:

Network analyzer Hp -8179D
Personal computer with Orbit Midas 2.01f
Antenna controller Alchut - 4902A
Antenna positioner.
Dipole antennas, microstrip antennas, a log - peridic antenna 1 - 10 GHz

Printer Hp - Laser 5p.
Printer Hp - 690

2.4 Measuring Antenna Pattern controlled by MiDAS software

1. Switch on the Network Analyzer.

2. Switch on the system controller (below the Network Analyzer).

3. When the PC computer is in work, double click on the icon midas2.01f.

4. Click on Acquisition (yellow icon). Wait until the clock disappeared. You get the screen "MiDAS Far-Field Antenna Measurement".

5. Click on RCV in order to set the needed frequency, according the antenna measured. You get the frequency screen. On the left screen choose SWEEP and # of frequencies 3. Set the frequencies in the middle of the antenna band and in the upper and lower edges of the band.

6. Click Auto-fill on the green icon at the lower-right part of the screen. If there is a red message on the lower row of the screen, set the source frequency to entirely include the frequency range you have chosen.

7. Click Overview. If there are no red message, the system is ready to work.

8. If antennas are mounted on the positioners, click RUN. The measurement goes on. Wait until you get the subscreen message:
"The ascii file c\... has been created". Then press OK.

9. Wait until the positioner goes to its starting point.

10. Press the icon 'analysis'. Wait until you see the frequencies you have chosen. Press shift and simultanuously click on the frequencies you want to see their pattern. Click 'cartesian' or 'polar' pattern type. Then press icon 'plot now' on the lower-right side of the screen. You will see the patterns of the relevant frequencies, including some details as beamwidth, nulls position etc.

11. Press 'file' and 'print'.

12. Press 'file' and 'close' to return to main screen.

2.5 Experiment Procedure

Before you measure antenna pattern, check the bandwidth of the antenna and calculate the far-field distance of the antennas.

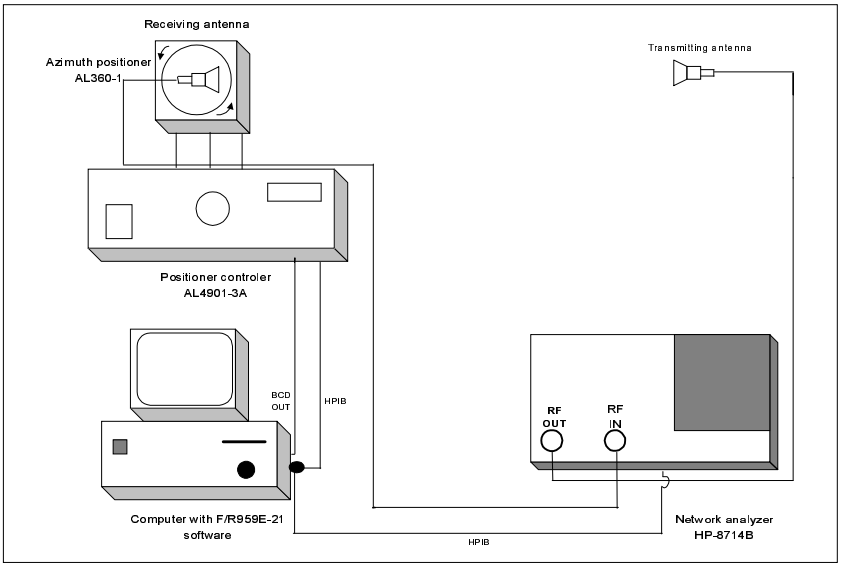


Figure 1:

1. Get E-plane, H-plane, E-plane cross-pol and H-plane cross-pol for two microstrip antennas.

2. Repeat 2 where the ground plane of the measured antenna is larger. Compare the patterns you get in 2 and 3.

2.6 Final Report Requirements

Please perform the following requirements

1. Describe and explain each of your measurement results.Describe the type of antennas, bandwidths, beamwidth, abtenna lobes, far-field distance. All your measured results must be included in your final report.

2. Plot the maximum of the main lobe as a function of frequency.

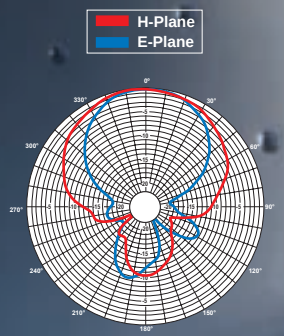
3. Compare your results with the theoretical results.

PRODUCT DATA SHEET

CUSHCRAFT CORPORATION

2.4 GHz ANTENNA

- Small, easy to disguise package aesthetically neutral
- Wall and ceiling mount
- UV stabile indoor/outdoor housing



S2406P

S2406P

2.4 GHz Panel Antenna

The S2406P antenna has been designed to provide users of 2.4 GHz. systems with an antenna offering 6+ dBi of directional gain in a package that can be easily hidden or disguised.

The antenna can either be wall mounted to provide directional coverage or ceiling mounted if there is a desire to direct or focus signal into a coverage area from a ceiling mount location.

There is an articulating mount available for the antenna. The articulating mount allows the antenna to be oriented both in azimuth and elevation.

The antenna's most compelling feature is its total size. The antenna is only 5.2" X 3.8" X 1/2" deep in total. As such the antenna can be conveniently mounted in very confined spaces and disguised if need be.

SPECIFICATION CHART

Model	Freq. MHz	Gain dBi	VSWR	Polarization	-3dB bmwidth E-Plane	-3dB bmwidth H-Plane	Weight lb (kg)	RF Connector (f)	Dimensions in. (cm)	Power (Watts)	Mount Style
S2406P	2400-2500	6	1.8:1	Linear	65°	70°	.5 (.23)	N	5.2 x 3.8 x 1/2 (13.2 x 9.7 x 1.4)	10	Wall/Surface

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