RADIATION CHARACTERISTICS OF DIPOLE, YAGI AND MICROSTRIP PATCH ANTENNA (AP1)

OBJECTIVES

For a group of antennas,
- Measure the radiation pattern,
- Estimate the 3dB (half-power) beamwidth.

APPARATUS

Microwave Source
Rotating Antenna Platform
Measurement Interface
Transmitting Horn Antenna
Dipole, Microstrip and Yagi Antenna Set
Coax Cables

INTRODUCTION
Antennas are devices designed to focus the radiation energy in some directions and suppress it in others. Antennas come in various shapes, sizes and materials. An antenna’s characteristics or performance can be grouped into two category, electrical performance and mechanical characteristics. The shape, build, weight, material and thickness are some of the mechanical characteristics. The radiation pattern, gain, directivity, bandwidth and beamwidth are among some of the electrical characteristics.

The most simple and yet popular type of antenna is the dipole. Figure 1 shows the picture of the dipole used in this experiment. It’s basically $\lambda/2$ wire which is fed at the centre. The radiated waves are linearly polarized, in the same direction as the wire dipole. If the dipole wire runs along the z-axis, the radiation is directed in the radial direction on the x-y plane. The magnetic field vectors lay on this plane of propagation and thus referred to as the H-plane. The radiation pattern is often described in terms of its principle E- and H- plane patterns, instead of a 3D spatial distribution of radiated energy as a function of the observer’s position along a constant radius sphere. The E-plane pattern is defined as the “plane containing the electric field vector and the direction of maximum radiation”, and the H-plane as “the plane containing the magnetic-field vector and the direction of maximum radiation”.

Yagi-Uda antenna (Figure 2), named after its developers, is widely used for TV reception. A dipole (or folded dipole) is used as the only active element to intercept radio waves and transfer the electromagnetic energy to a transmission line in the form of electric current and voltage. All other elements are considered as parasitic radiators without any feedline or matching network; thus making the realization considerably cheaper. The parasitic elements influence both the input impedance of the active element as well as the radiation pattern of the overall antenna system. An element longer than $\lambda/2$ behind the active element will act as a reflector, which reflects the approaching waves in the major lobe.
toward the dipole. Conversely, a shorter element in front of the active element will act as a director, which concentrates the received waves in the major lobe and reradiates toward the dipole. The directivity of the antenna system is greater with an increased number of parasitic elements, particularly the directors.

The microstrip antenna used in this experiment is a planar array antenna produced by arranging linear array antennas in a parallel configuration (Figure 4). Each rectangular patch of conductors on the dielectric substrate acts as a radiator. The array is made of 16 elements arranged in a 4 by 4 fashion. The elements are fed by a transmission line. Microstrip antenna is basically a metallic patch on top of a dielectric substrate, with a ground plane in the bottom.
PROCEDURE

I - RADIATION PATTERN MEASUREMENTS

Initial setting
1) An antenna measurement set-up is prepared on the experiment table. Observe the connection and familiarise with the test antennas. Identify the transmitter antenna, the receiver antenna, transmitting source and receiver.
2) Switch on the computer and run the antenna measurement software. Briefly, step through the various options and commands in the software.
3) Rotate the transmitting horn antenna to produce the required wave polarization for E-plane and H-plane pattern measurements.

Dipole antenna
1) A set of dipole antenna is provided with the experiment set.
2) Set-up the dipole for the E-plane measurement. Verify the set-up with the instructor.
3) Measure the E-plane pattern for the $\lambda/2$ dipole. Note that the transmitted waves must be horizontally polarized.
4) Determine the arrangement of the antenna for H-plane measurement. Verify the set-up with the instructor.
5) Determine the direction of transmitting horn antenna to produce the vertically polarized wave. Measure the H-plane patterns for the $\lambda/2$ dipole.
6) Plot the E- and H-plane radiation pattern of the dipole antenna. Compare the measured pattern with theoretical pattern and explain the similarities and differences.

Yagi-Uda antenna
1) Construct a Yagi antenna using the dipole antenna kit provided with the experiment set.
2) Measure the the E-plane patterns for a Yagi with one reflector, one director, one director plus one reflector, and four directors plus one reflector. The transmitted waves must be horizontally polarized. Note that directors are the shorter of the two wires, with reflector the longer.
3) Arrange the set to produce vertically polarized waves. Measure the H-plane patterns for the configuration with one reflector, one director, one director plus one reflector, and four directors plus one reflector.
4) Plot the E- and H-plane radiation pattern of the all the Yagi antenna. Compare the measured pattern with theoretical pattern and explain the similarities and differences.

Microstrip antenna
1) Set up the microstrip antenna on the rotating platform.
2) Measure the E-plane and H-plane patterns of the microstrip antenna.
3) Plot the E- and H-plane radiation pattern of the microstrip antenna. Compare the measured pattern with theoretical pattern and explain the similarities and differences.
II – HALF POWER BEAMWIDTH ESTIMATES

1) From the dipole pattern plot of part I, deduce the angle with maximum pattern. This will be identified as peak of beam.
2) Measure the angle to the left where the radiation pattern reduces to 3dB (or half-power) from peak of beam.
3) Measure the angle to the right where the radiation pattern reduces to 3dB (or half-power) from peak of beam.
4) Deduce the 3dB beamwidth of the antenna. Compare the measured beamwidth with theoretical beamwidth and explain the similarities and differences.
5) Repeat steps (1) to (4) for each of the Yagi antennas and the microstrip patch antenna from plot part I.
**AP1 ANSWER SHEET:**

**RADIATION CHARACTERISTICS OF DIPOLE, YAGI AND MICROSTRIP PATCH ANTENNA**

Briefly describe the surrounding area where the antenna is being measured. Keep your observation limit to a 2 meter radius from the antennas.

Comment on the distance between the transmitting antenna and receiving antenna. Is the distance sufficient for the entire antenna being measured?
Sketch the radiation pattern that is measured for all the antennas.

Dipole (E-plane)
Beamwidth:

Dipole (H-plane)
Beamwidth:

Yagi (one reflector)
(E-plane)
Beamwidth:

Yagi (one reflector)
(H-plane)
Beamwidth:
Yagi (one director) (E-plane)
Beamwidth:

Yagi (one director) (H-plane)
Beamwidth:

Yagi (one director and one reflector) (E-plane)
Beamwidth:

Yagi (one director and one reflector) (H-plane)
Beamwidth:
Yagi (one reflector and four directors) (E-plane)
Beamwidth:

Yagi (one reflector and four directors) (H-plane)
Beamwidth:

Microstrip (E-plane)
Beamwidth:

Microstrip (H-plane)
Beamwidth:
Conclude the experiment by comparing the antennas with their theoretical characteristics.
### Radiation Pattern Measurement of Various Types of Antennas

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1 (Needs Improvement)</th>
<th>2 (Satisfactory)</th>
<th>3 (Good)</th>
<th>4 (Excellent)</th>
<th>Rating Awarded by Assessor</th>
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<tbody>
<tr>
<td>1</td>
<td>Abiluty to set-up the measurement space for an antenna.</td>
<td>Unable to prepare a reasonable measurement space.</td>
<td>Able to align transmitter and receiver antenna in the measurement set-up.</td>
<td>Able to remove obstacles from the direct line-of-sight in the measurement set-up.</td>
<td>Capable of preparing the measurement space for antenna, taking into account the obstacles and its effect.</td>
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<td>2</td>
<td>Ability to measure in E-plane and H-plane for antennas.</td>
<td>Unable to set-up E-plane or H-plane measurements</td>
<td>Able to identify E-plane and H-plane measurement set-up.</td>
<td>Able to prepare the source antenna and set-up the receiver antenna for both the planes.</td>
<td>Capable of preparing and executing the antenna measurement in both the planes.</td>
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<td>3</td>
<td>Estimation of beamwidth.</td>
<td>Unable to estimate the beamwidth.</td>
<td>Capable of locating the 3dB difference in the pattern.</td>
<td>Capable of estimating the beamwidth of the antennas.</td>
<td>Capable of estimating the beamwidth of the antennas, and compare is with theory.</td>
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<td>4</td>
<td>The ability to write lab report neatly without grammatical and spelling errors</td>
<td>Report is below average with many grammatical and spelling errors.</td>
<td>Report is patchy.</td>
<td>Report is somewhat neat with minimal grammatical and spelling errors.</td>
<td>Report is neat with no grammatical and spelling errors.</td>
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**Presentation of Report**

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**AVERAGE MARK (total/number of criteria)**

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**INSTRUCTOR NAME:**

**INSTRUCTOR SIGNATURE:**