MEASUREMENT OF RADIATION PATTERN

Objective: To measurement the radiation pattern (polar pattern) of a microwave antenna.

List of Equipment

1. Microwave source with square wave modulation
2. Isolator
3. Variable attenuator
4. Waveguide horns as a test and receiving antenna
5. Antenna test bench
6. Tunable Detector
7. VSWR meter
8. Means of measuring the angle θ

Theory

The radiation pattern is a graphical representation of the strength of radiation of an antenna as a function of direction. The strength of radiation is usually measured in terms of field strength although sometimes radiation intensity (power radiated per unit solid angle) is also used. For the purpose of radiation pattern, one considers the given antenna to be located at the origin of a spherical polar coordinates systems (r, θ, ϕ) and the variation in the field strength at different points on an imaginary concentric spherical surface of radius r is noted. For sufficiently larger r, as explained later on, the field variation or the pattern is independent or r and also the fields are tangential to the hypothetical spherical surface. In general, separate patterns are plotted for θ and ϕ polarization.

Usually the radiation pattern is shown in principal planes of interest, e.g., $\theta = 90^0$ and ϕ = constant planes. Further, for linearly polarized antennas, patterns may be plotted in E – plane or H – plane E- plane is defined as the plane passing through the antenna in the direction of beam maximum and parallel to the far field E – vector. One defines the H – plane similarly. It is quire common to plot the pattern by normalizing the field values with respect to the field strength in the direction of maximum radiation.

The radiation pattern of typical microwave antennas consists of a main lobe and a few minor or side-lobes. Beam-width of an antenna is defined as the angular separation between 3 dB points with respect to the maximum field strength. Side lobes represent a loss and leakage of information in the transmit mode. In the receive mode, sidelobes may cause an uncertainty in determining the angle of arrival of a signal. However, sidelobes are very sensitive to the surroundings in which the radiation pattern is measured.

The wavefronts in the vicinity of an antenna have a small radius or curvature but after traveling some distance the radius of curvature increases to such an extent as to make the wave front practically a plane wave. A receiving antenna is considered to be in the far-field of the test antenna if the wavefront across it is practically plane. Most measurements are carried out in the far field region since; otherwise, when the receiving antenna is kept in the region of curved wavefornt, there will be a phase difference across the receiving aperture. It can be shown that the phase variation over the receiving aperture is less than one sixteenth of a wavelength if it is at a distance R from the transmitting antenna, where

$$R = \frac{2D^2}{\lambda}$$

In which D = largest dimension of the larger of the receiver and transmitter antennas.

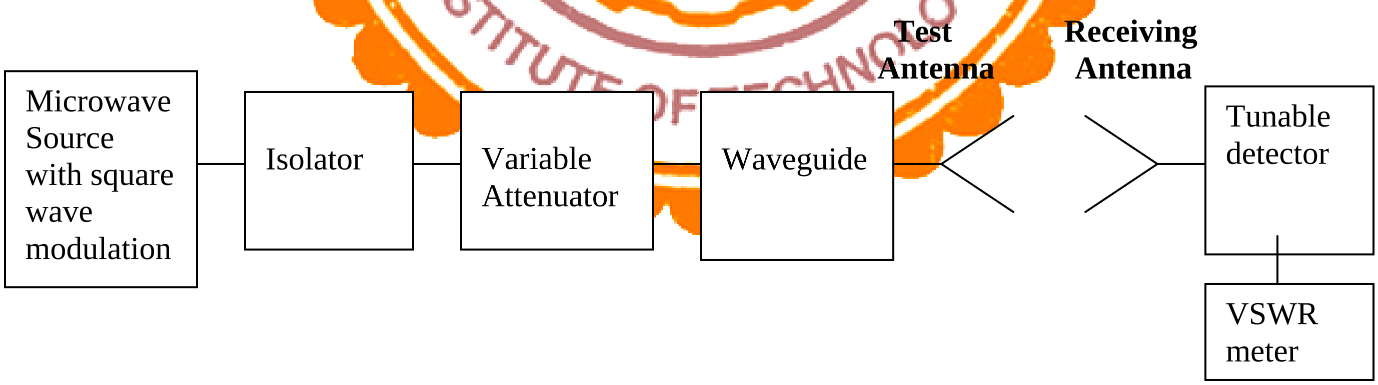

Fig 1. Experimental setup for the measurement of radiation pattern

PROCEDURE

1. Set up the apparatus as shown in Fig.1. Again the antenna for maximum meter reading and mark this position of the receiver antenna as O^0. Set the source at, say, 10 GHz. Use square-wave modulation if necessary, and tune the detector. Adjust the calibrated attenuator for a 30 dB attenuation and adjust the meter gain to produce half-scale deflection. Take care to kept the distance between the antennas sufficiently large so that they are in the far-field zone.
2. Rotate the receiving horn clockwise, in steps of 5 or 10^0, to cover the main lobe and atleast the first sidelobe. At each position, adjust the calibrated attenuator to restore the half scale deflection on the meter and record the attenuator setting.
3. Return to the O^0 position and repeat for half scale deflection when attenuation is 30 dB. Rotate in steps of 5 or 10^0 in the anticlockwise direction and record the attenuator setting at each step to restore half scale deflection.
4. Convert the attenuator readings to dB and plot the results.
5. Plot the radiation pattern in the above manner for both E- and H-plane. Determination the beamwidth and level of the first sidelobe with repeat to the main lobe.

Discussions

1. What are the different types of horn antennas?
2. What do you understand by far-field zone?
3. What is radiation pattern? What are the types of radiation patterns?
4. What are half power beam width and main lobe? Differentiate between Broadside pattern, End fire pattern and Omni directional pattern?

References

1. E.C. Jordan and K.G.Balmain, ‘Electromagnetic wave Radiating Systems’ 1968.
2. R.E. Collin, ‘Antennas and Radio Wave Propagation’, 1985.
3. C.A. Balanis, ‘Antenna Theory: Analysis and Design, 1982.
4. A.W. Cross, ‘Experimental Microwaves’, 1977.