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Experiment No:

Title: To study the radiation pattern and gain of horn antenna.

Components required: ATS 20/ATS 40 antenna trainer kit, connecting probes (Teflon), PC with Printer and Horn antenna.

Theory:

A horn antenna is used to transmit radio waves from a waveguide (a metal pipe used to carry radio waves) out into space, or collect radio waves into a waveguide for reception. It typically consists of a short length of rectangular or cylindrical metal tube (the waveguide), closed at one end, flaring into an open-ended conical or pyramidal shaped horn on the other end. The radio waves are usually introduced into the waveguide by a coaxial cable attached to the side, with the central conductor projecting into the waveguide to form a quarter-wave monopole antenna. The waves then radiate out the horn end in a narrow beam. However in some equipment the radio waves are conducted between the transmitter or receiver and the antenna by a waveguide, and in this case the horn is just attached to the end of the waveguide. In horns installed outdoors, suchas the feed horns of satellite dishes, the open mouth of the horn is often covered by a plastic sheet which is transparent to the radio waves, to keep out moisture.

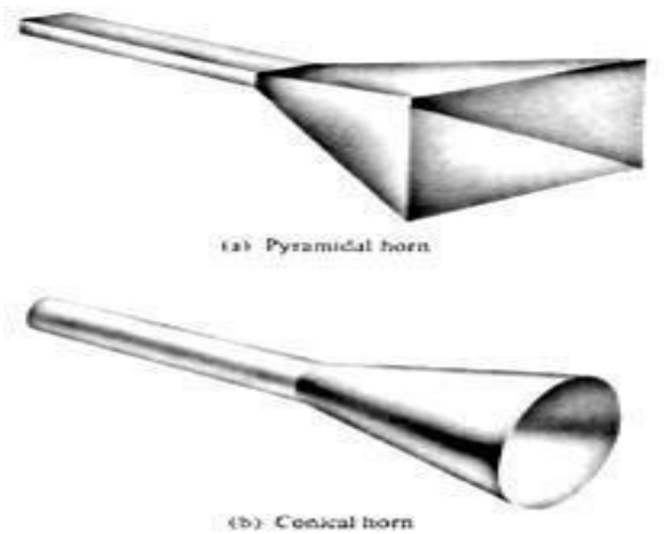

Figure 1: Aperture antenna configuration a) Pyramidal Horn b) Conical horn

A horn antenna serves the same function for electromagnetic waves that an acoustical horn does for sound waves in a musical instrument such as a trumpet. It provides a gradual transition structure to match the impedance of a tube to the impedance of free space, enabling thewaves from the tube to radiate efficiently into space. If a simple open-ended waveguide is used as an antenna, without the horn, the sudden end of the conductive walls causes an abrupt impedance change at the aperture, from the wave impedance in the waveguide to the impedance of free space, (about 377 ohms). When radio waves travelling through the waveguide hit the opening, this impedance-step reflects a significant fraction of the wave energy back down the guide toward the source, so that not all of the power is radiated. This is similar to the reflection atan open-ended transmission line or a boundary between optical mediums with a low and high index of refraction, like at a glass surface. The reflected waves cause standing waves in the waveguide, increasing the SWR, wasting energy and possibly overheating the transmitter. In addition, the small aperture of the waveguide (less than one wavelength) causes significant diffraction of the waves issuing from it, resulting in a wide radiation pattern without much directivity.
To improve these poor characteristics, the ends of the waveguide are flared out to form a horn. The taper of the horn changes the impedance gradually along the horn's length. This acts like an impedance matching transformer, allowing most of the wave energy to radiate out the endof the horn into space, with minimal reflection. The taper functions similarly to a tapered transmission line, or an optical medium with a smoothly-varying refractive index. In addition,the wide aperture of the horn projects the waves in a narrow beam.
The horn shape that gives minimum reflected power is an exponential taper. Exponential horns are used in special applications that require minimum signal loss, such as satellite antennasand radio telescopes. However conical and pyramidal horns are most widely used, because they have straight sides and are easier to design and fabricate.

Radiation Pattern:

The waves travel down a horn as spherical wave fronts, with their origin at the apex of the horn. The pattern of electric and magnetic fields at the aperture plane at the mouth of the horn, which determines the radiation pattern, is a scaled-up reproduction of the fields in the waveguide. However, because the wave fronts are spherical, the phase increases smoothly from the edges of the aperture plane to the center, because of the difference in length of the center point and the edge points from the apex point. The difference in phase between the center point and the edgesis called the phase error. This phase error, which increases with the flare angle, reduces the gain and increases the beam width, giving horns wider beam widths than similar-sized plane-wave antennas such as parabolic dishes. At the flare angle, the radiation of the beam lobe is down about -20 dB from its maximum value. As the size of a horn in wavelengths is increased, the phase error increases, giving the horn a wider radiation pattern. Keeping the beam width narrow requires a longer horn (smaller flare angle) to keep the phase error constant. The increasing phase error limits the aperture size of practical horns to about 15 wavelengths; larger apertures would require impractically long horns. This limits the gain of practical horns to about 1000 (30 dBi) and the corresponding minimum beam width to about 5 - 10°.

Procedure:

A. **Transmitter section:**
1) Set the control to manual (M) of the transmitter section.
2) Set the count to memory location 0001.
3) Set the desired frequency of the transmitter (fr) using front panel controls of transmitter.
4) Press Enter this will save the transmitting frequency.
5) Mount the LPDA on the stand provided and connect it to RF OUT of transmitter.

B. **Receiver section:**
1) Now set the control to manual (M) of the receiver section.
2) Set the count to memory location 0001.
3) Set the frequency of the Receiver same as that of transmitter using front panel controls.
4) Press Enter, this will save the Receiving frequency.
5) Connect Horn antenna to RF IN of receiver section.

C. **Stepper Unit:**
1) Connect Trigger output of stepper unit to input STEPPER of receiving section.
2) Set the control to manual (M) of the stepper unit section.
3) Set the step size of stepper motor to 5° using front panel controls.

D. **Transferring readings:**
1) Now set the control to Auto (A) of the receiver section.
2) Note down the memory location on receiver section.
3) Now set the control to Auto (A) of the stepper unit section.
4) Readings of the received power will be automatically gets store in receiver section.
5) Now connect RS232 cable of PC to receiver section.
6) Open antenna software on PC and select comport 1/comport 2.
7) Press MENU button of receiver section till a SERIAL MODE YES.
8) Now press ENTER of receiver section so that readings will be uploaded to PC.

E. **Taking readings:**
1) Press ENTER on keyboard radiation pattern will be generated.
2) Note down the maximum gain displayed on the screen.
3) Take printout of radiation pattern and locate -3dB gain from the max gain both on each side of 0 dB reference line and calculate the angle difference as HPBW.

Conclusion:

Questions:

1. List the merits, demerits, and applications of horn antenna.
2. Define Radiation pattern and Half Power Beamwidth of Antenna.