

ANTENNA POLARIZATION CONTROL

Polarization is a fundamental attribute of microwave signals. It describes the orientation of the signal's electric field. Linear and circular polarizations are in wide use and are sub sets of the general case of elliptical polarization. Linear polarization is specified by its spatial orientation and by its cross-polarization. Circular polarization is specified by its sense (left- or right-hand) and by its axial ratio (AR). Cross-polarization is expressed in dB with respect to the desired (co-polarized) signal. Axial ratio is the ratio of the maximum to minimum response to a linear signal of any orientation and may be expressed either as a voltage ratio (VAR) or in dB. These parameters are related by the following expressions:

$$AR \text{ (dB)} = 20 \text{ LOG (VAR)}$$
$$\text{cross-polarization (dB)} = 20 \text{ LOG} \left(\frac{VAR-1}{VAR+1} \right)$$

Two signals can be transmitted at a single frequency with orthogonal linear or circular polarization ("Frequency reuse"), thus doubling the capacity of a communications system. Cross-polarization and axial ratio effects can degrade the isolation between the two signals. Therefore careful specification of these parameters is vital. In addition, for maximum efficiency, transmission of signals must be between antennas having the same polarizations.

In steerable antennas, particularly for satellite work, polarization control is a virtual "third-axis" of the antenna together with the elevation and azimuth axes. With the proliferation of frequency reuse satellites, more attention is now paid to improvements in antenna polarization specifications and control.

In general, it is possible to create an antenna with any elliptical polarization by using an orthogonal linear polarized antenna, a power divider and a variable phase shifter. The antenna might be a crossed dipole, turnstile or an orthogonal linear horn. The power divider could be a quadrature hybrid, for example. In that case, both senses of elliptical polarization would be available at the two hybrid ports.

In a waveguide system, this general function can be achieved by the use of an orthomode transducer (OMT) and a pair of rotatable quarter-wave plates constructed in circular waveguide. This device, which becomes complex if the plates must be remotely controlled, can handle significant RF power levels and has great polarization flexibility. See sketch below of generalized elliptical polarizers.

Most antenna systems do not require all possible elliptical polarizations and are restricted to providing either linear or circular, often with orthogonal ports. This function can be designed in waveguide by the use of an OMT and a single quarter-wave plate, which is oriented 45° to the electric field when circular polarization is desired. The sense is determined by inspection: considering the antenna as a transmitter and looking outward in the direction of propagation, the polarization is right-hand sensed if the slow axis of the quarter-wave plate lies clockwise to the plane of the incident electric field. For prime focus antennas, system polarization sense is the opposite of the feed sense.

In coaxial systems, a quadrature hybrid is connected to turnstile-type antennas for circular polarization with the hybrid bypassed for linear operation.

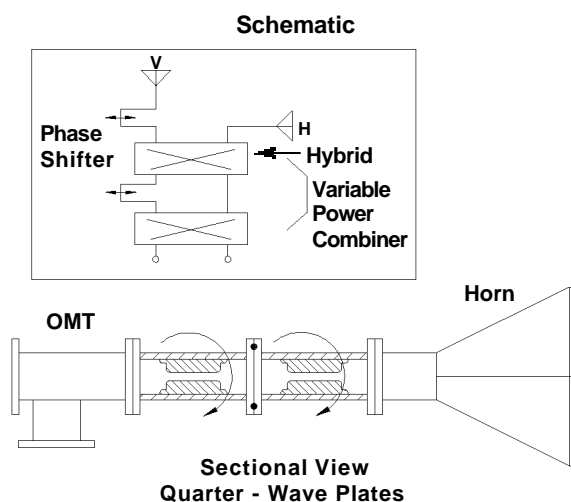
Another requirement is to provide remote control of the angle of linear polarization; this is the case with an Earth Station antenna where the satellite's local polarization angle changes depending on the relative positions of the satellite and the Station.

In some cases, the entire antenna can be physically rotated for polarization alignment. In other cases, such as with feeds for large reflectors, the feed itself may rotate. Many techniques have been developed for polarization rotation by using motorized "probes" inside circular waveguide cavities forming part of the feed. These result in efficient operation and have very small moving parts with tiny actuators, thus eliminating the need to rotate low-noise amplifiers and associated waveguide, etc.

Another technique uses a remotely-rotated circular waveguide half-wave plate. This device, when connected between the OMT and the feedhorn, rotates both orthogonal polarizations through an angle twice that of its own angle while providing good cross-polarization. It can be used to advantage in transmit/receive systems operating over modest bandwidths.

Combinations of the above devices are available from Seavey Engineering. For example, waveguide feeds are produced having a probe system to select linear and circular with the entire feed then rotated remotely for linear polarization alignment.

Remote switching between any fixed polarization and another can be done through standard waveguide or coaxial switching arrangements.



General Elliptical Polarizers