Example Antenna Types

Developed by Kathryn L. Smith, PhD

Ansys

Sources

The material presented herein is from the following sources:

"Elements of Electromagnetics," by Matthew N.O Sadiku, 5th ed. (2010)
"Engineering Electromagnetics," by Nathan Ida, 3rd ed. (2015)
"Microwave Engineering," by David Pozar, 4th ed. (2012)
"Antenna Theory," by Constantine A. Balanis, 4th ed. (2016)
"Antenna Engineering Handbook," by John L. Volakis, 4th ed. (2007)

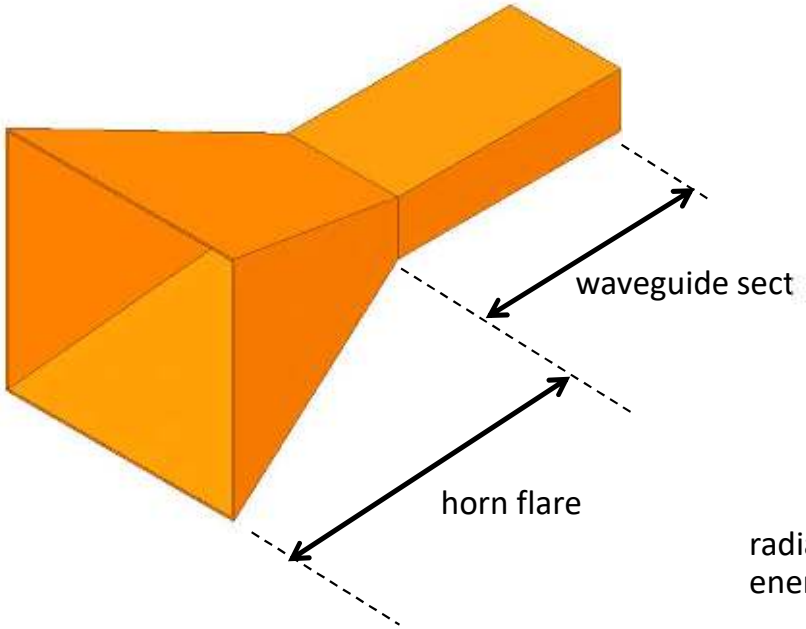
Agenda

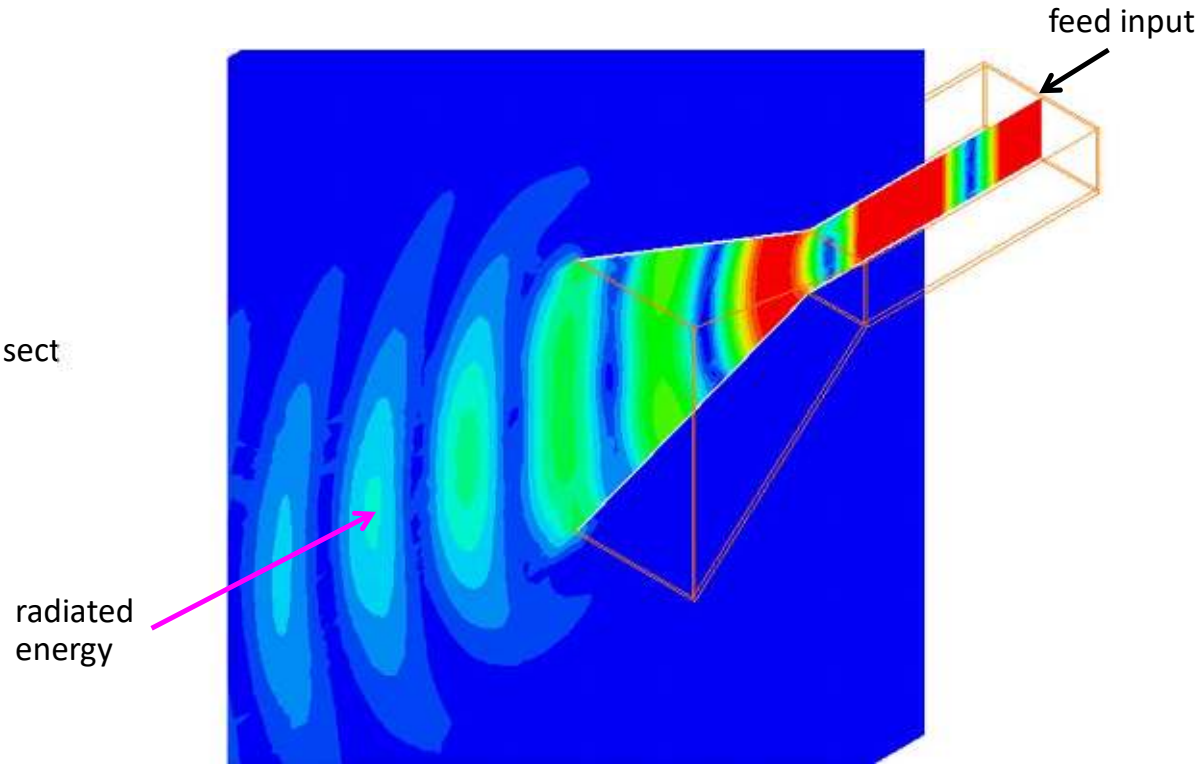
Antennas are engineered devices used to send and receive electromagnetic signals. Each antenna has a unique set of characteristics – frequency response, polarization, radiation pattern, etc. – which are set by its size and topology. It is important to know general characteristics of common antenna topologies, in order to choose the proper topology for any particular application. In this module, we will briefly introduce each of the following antenna topologies.

- Horn Antennas
- Yagi Antennas
- Slot Antennas
- Rectangular Patch Antennas

Horn Antennas

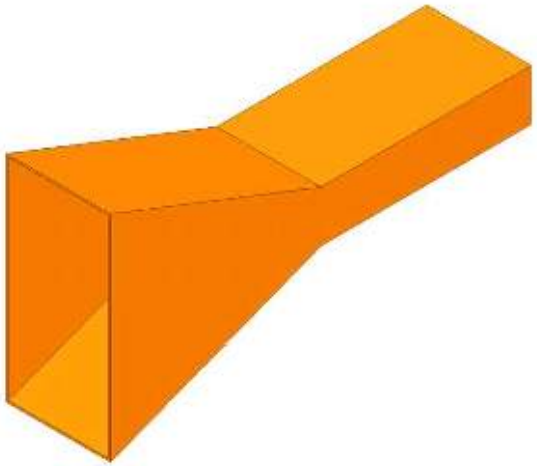
A horn antenna consists of a section of rectangular waveguide, which flares outward at the end and terminates in an open aperture. The transmitted wave is excited in the waveguide section, and radiates out the mouth of the horn.



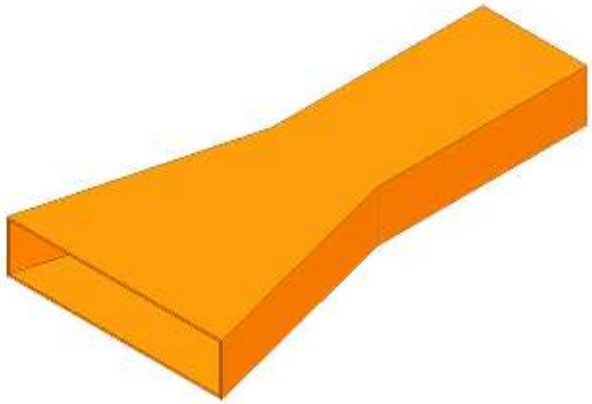


Horn Antennas

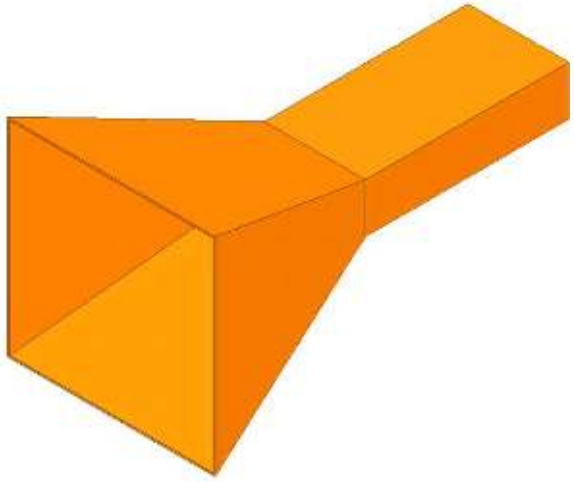
To form the horn of the antenna, horn antennas may be flared only in the direction of the electric field (an E-plane sectoral horn), only in the direction of the magnetic field (an H-plane sectoral horn) or in both directions (a pyramidal horn).



E-plane Sectoral Horn



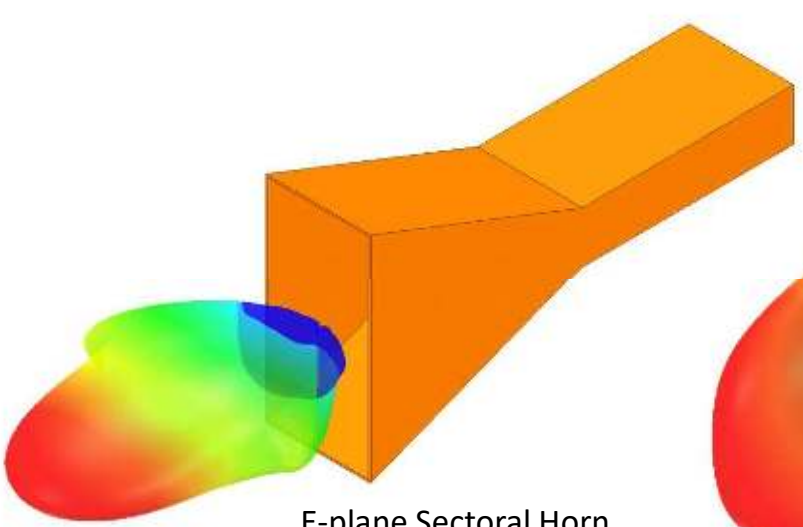
H-plane Sectoral Horn



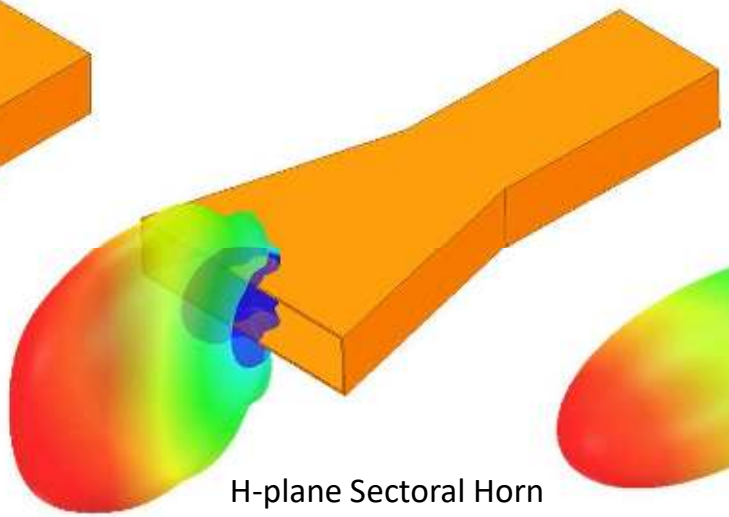
Pyramidal Horn

Horn Antennas

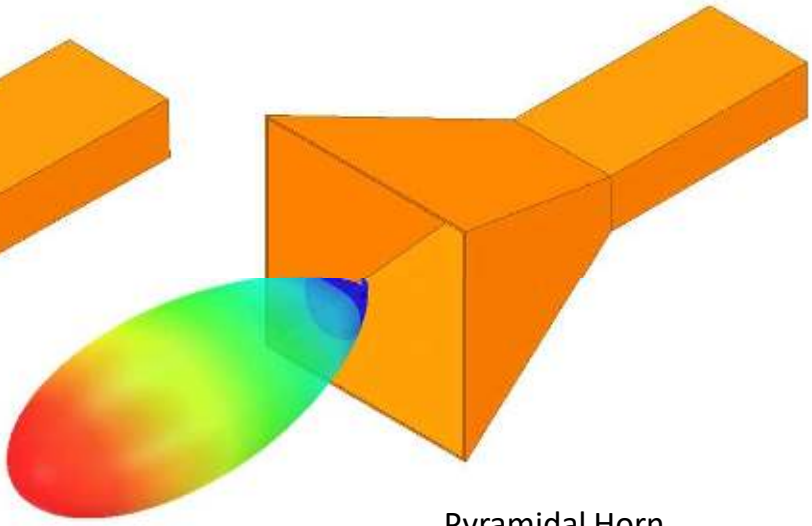
The purpose of the flare is to increase the directivity of the antenna and narrow the beamwidth in the plane of the flare.



E-plane Sectoral Horn



H-plane Sectoral Horn



Pyramidal Horn

Horn Antennas

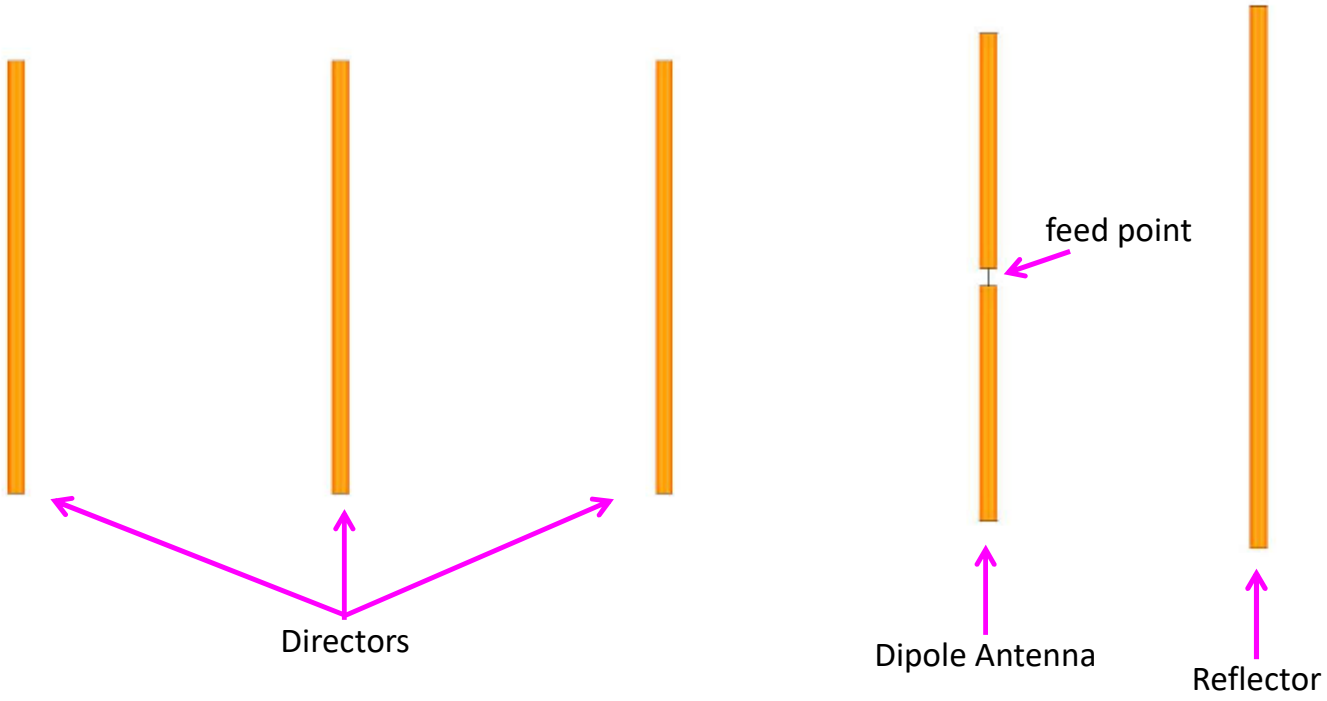
Horn antennas are typically **very broadband**, operating above the cutoff frequency of the waveguide, and radiate a **linearly polarized** wave, oriented in the same direction as the electric field in the waveguide.

They are often used in applications that need very high directivity.

A special kind of horn antenna called a **standard gain horn**, which has constant gain over a broad bandwidth, is often used in testing environments to measure other antennas, because its behavior is so well known.

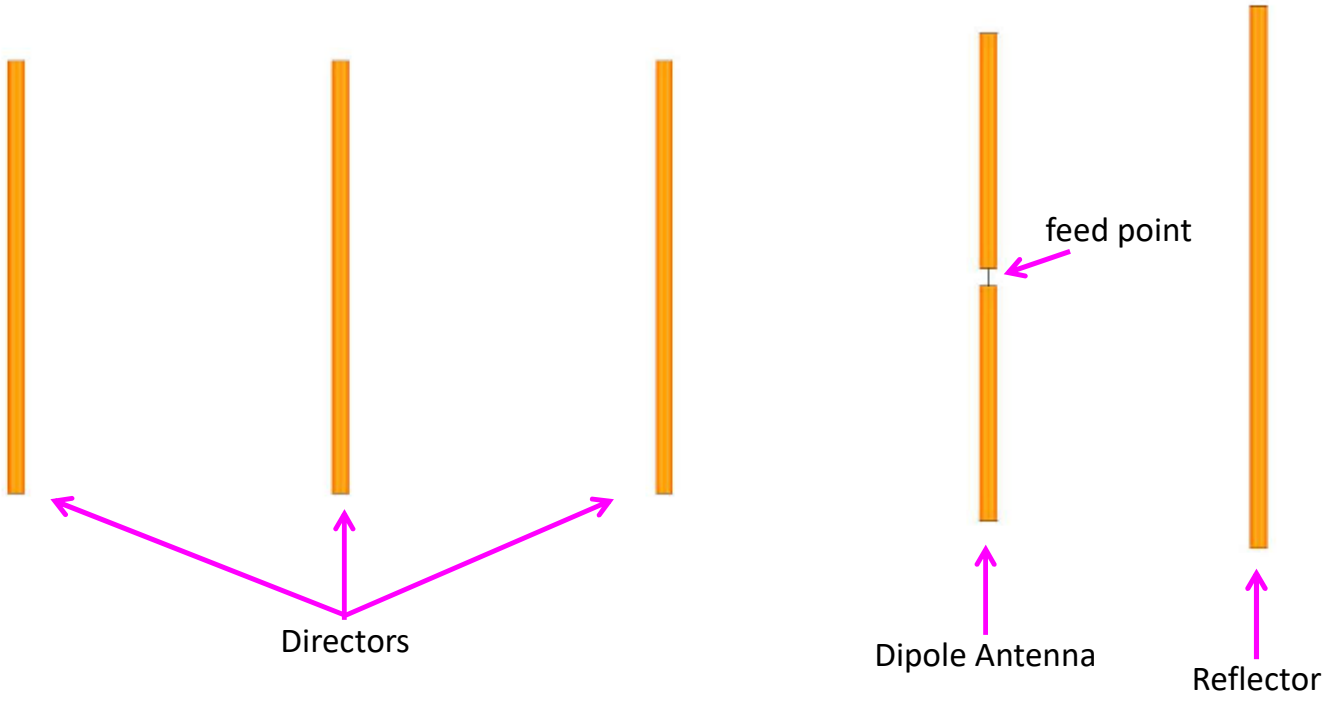
Yagi-Uda Antennas

Sometimes referred to as simply “Yagi” antennas, Yagi-Uda antennas consist of a single dipole antenna which is operated within an array of other (non-driven) linear conducting elements.



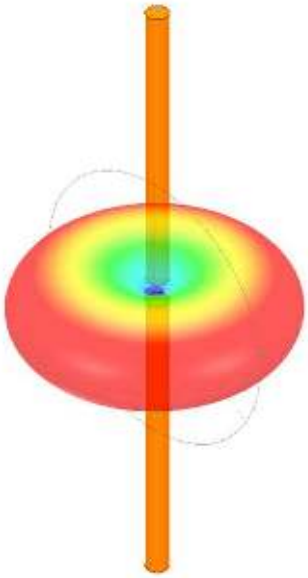
Yagi-Uda Antennas

The exact number of reflectors and directors in a Yagi-Uda antenna varies, but a typical design is shown below, with a single “reflector” element and three “director” elements. Notice that the reflector element is slightly *longer* than the dipole, while the director elements are slightly *shorter* than the dipole.

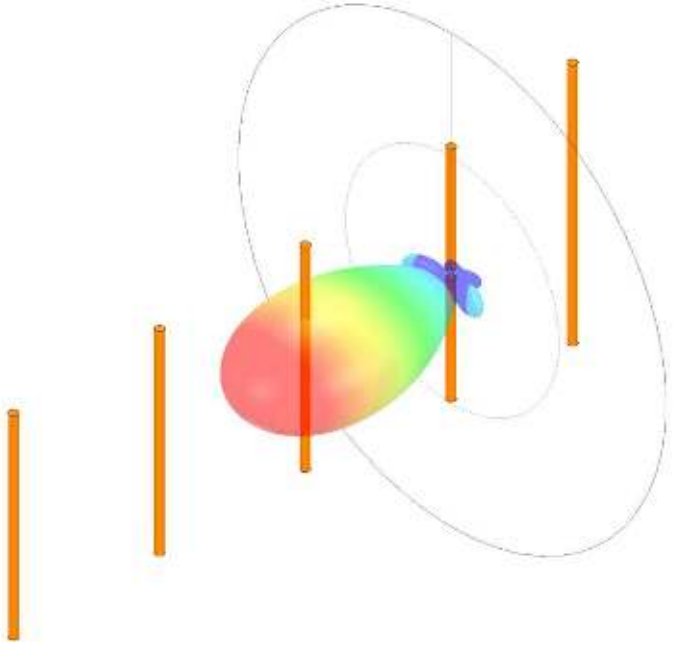


Yagi-Uda Antennas

Unlike an isolated dipole, which has a rotationally symmetric radiation pattern, the Yagi-Uda antenna is highly directive, with its maximum radiation directed toward the directors, and away from the reflector, as shown below.



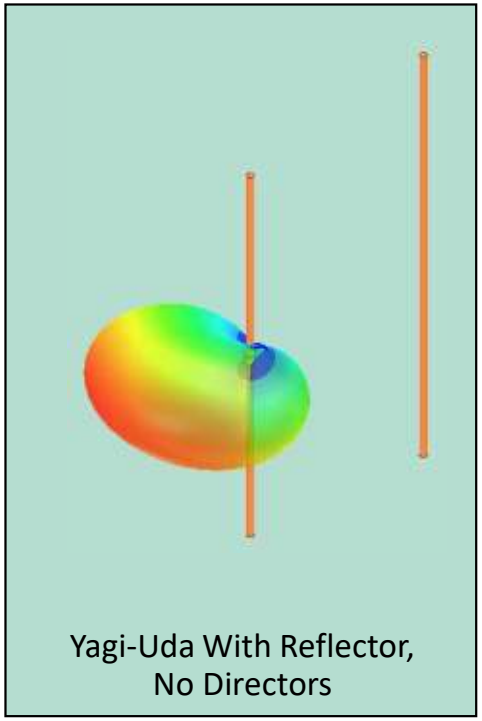
A Typical Dipole Radiation Pattern



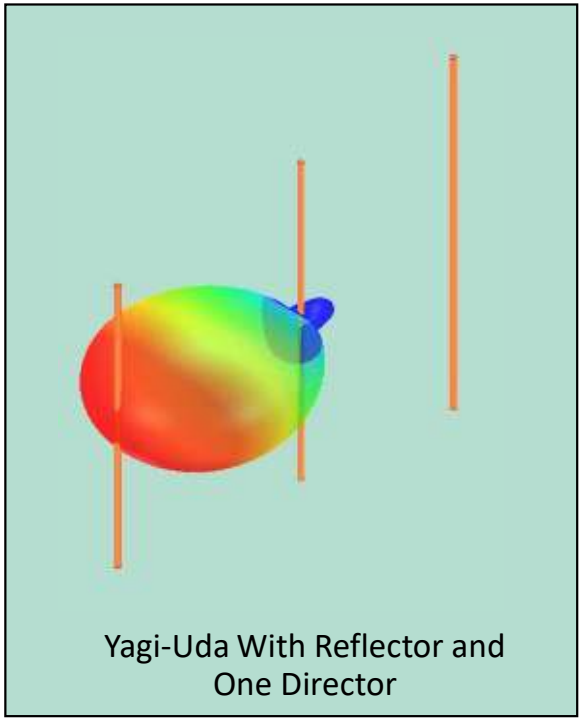
The Yagi-Uda Radiation Pattern

Yagi-Uda Antennas

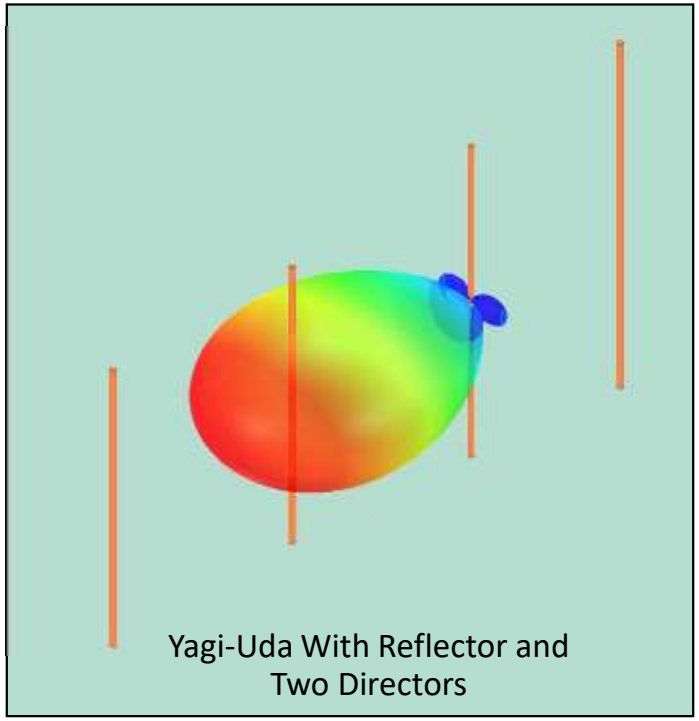
A single dipole element radiates symmetrically broadside from the dipole. Addition of a "reflector" behind the dipole pushes the radiation in the opposite direction, and addition of "directors" in front of the dipole increases the directivity in the forward direction, as shown below.



Yagi-Uda With Reflector, No Directors



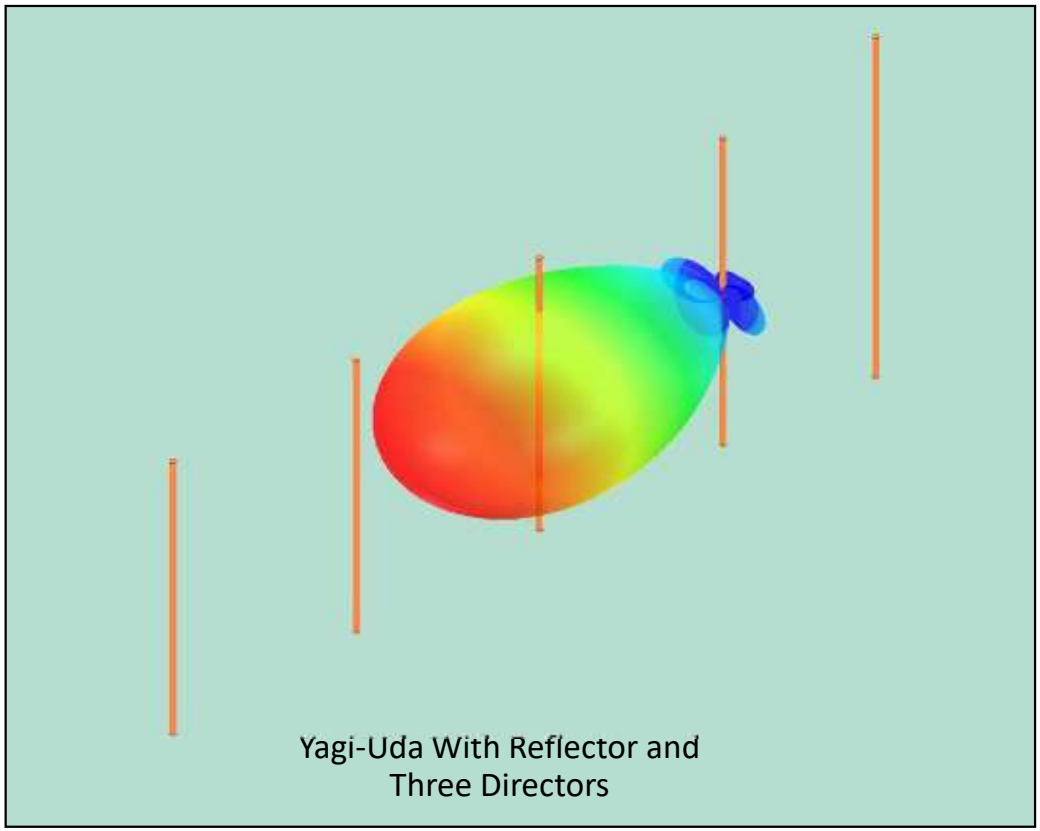
Yagi-Uda With Reflector and One Director



Yagi-Uda With Reflector and Two Directors

Yagi-Uda Antennas

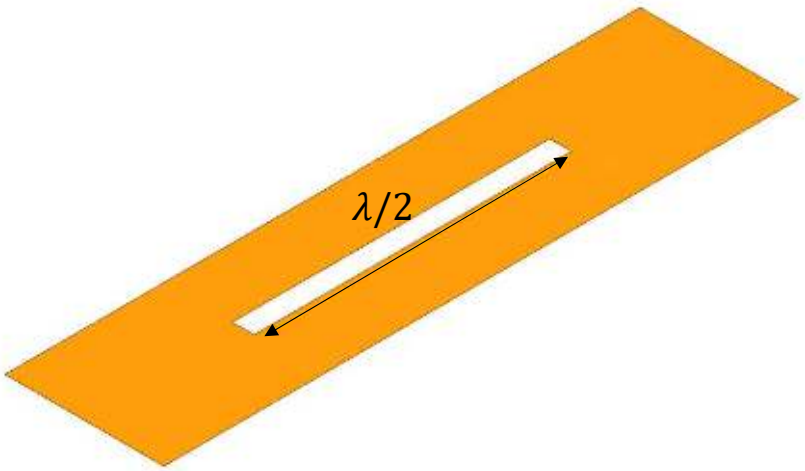
Like a dipole, a Yagi-Uda antenna is **narrowband**, and has **linear polarization**, with the electric field oriented in alignment with the dipole. These are used in applications where high directivity is critical.



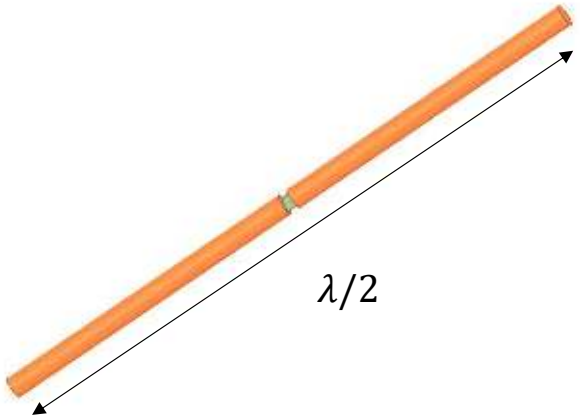
Yagi-Uda With Reflector and
Three Directors

Slot Antennas

Slot antennas consist of a rectangular half-wavelength-long “slot” in an otherwise planar conductor. Operation, by Babinet’s Principle, is analogous to that of a half-wave dipole antenna.



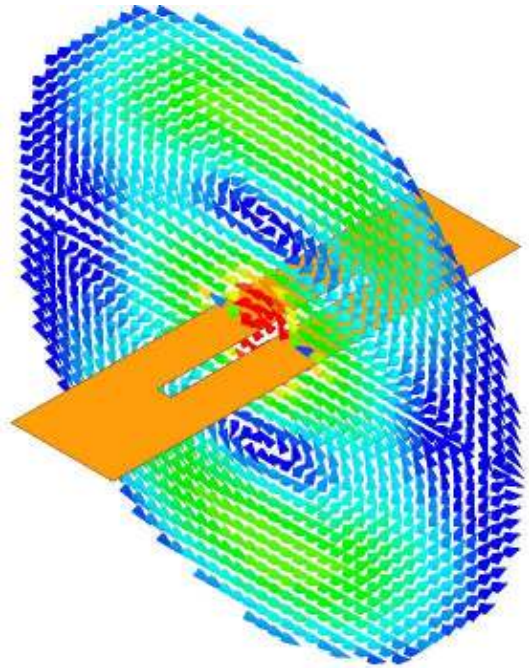
Slot Antenna



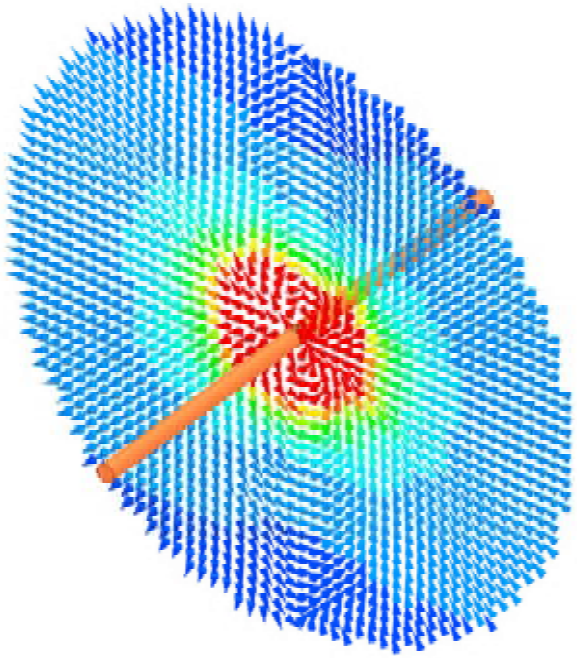
Dipole Antenna

Slot Antennas

The radiated fields are also roughly analogous to those of a half-wave dipole antenna, but with the polarizations of the electric and magnetic fields approximately transposed.



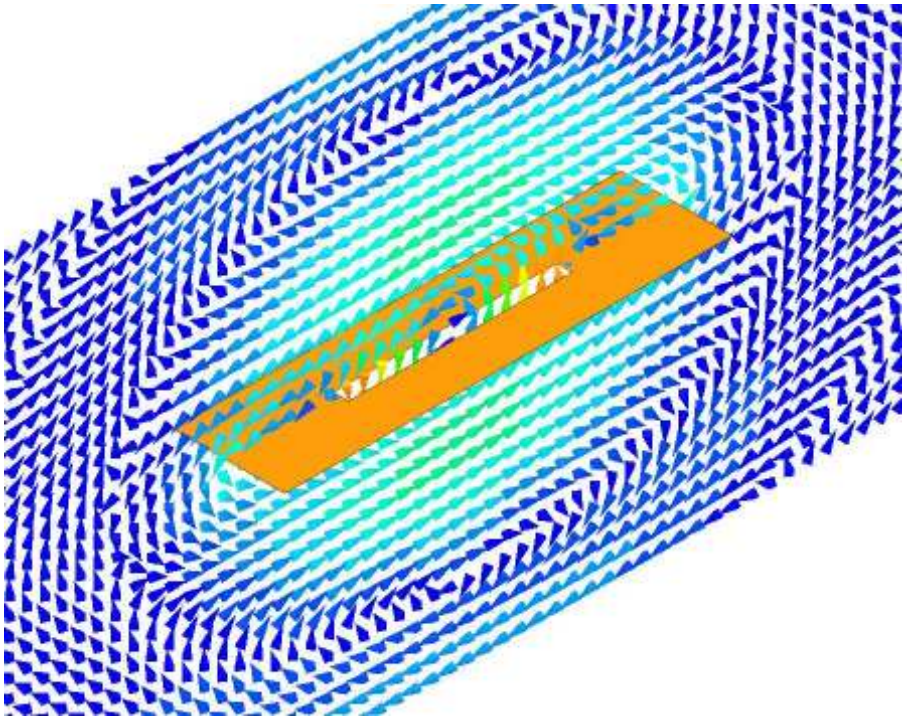
Electric Field around Slot Antenna



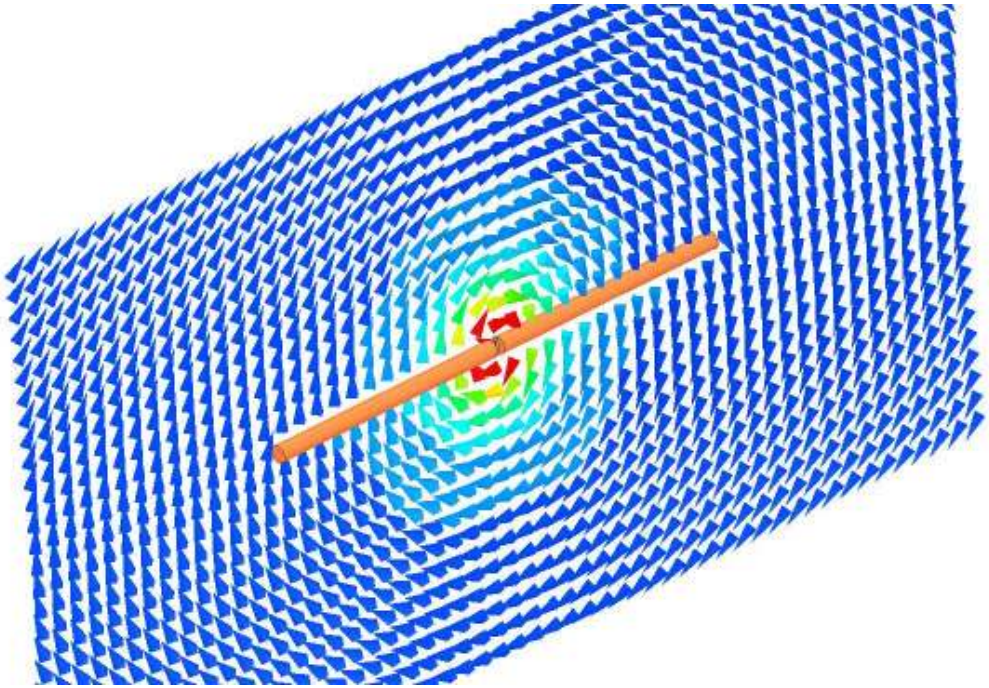
Magnetic Field around Dipole Antenna

Slot Antennas

The radiated fields are also analogous to those of a half-wave dipole antenna, but with the polarizations of the electric and magnetic fields approximately transposed.



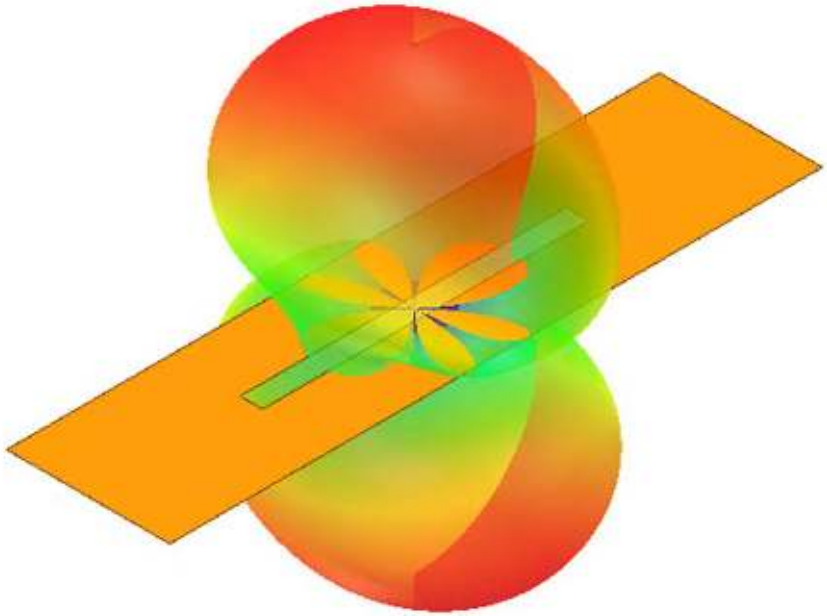
Magnetic Field around Slot Antenna



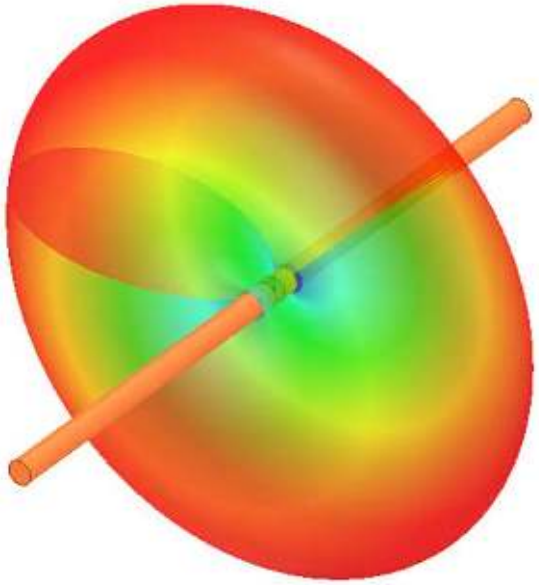
Electric Field around Dipole Antenna

Slot Antennas

The radiation pattern of a slot antenna approximates that of a dipole antenna, but with slight asymmetry introduced by the truncation of the ground plane. Slot antennas have a **bandwidth** that is **variable** with the width of the slot, and are **linearly polarized**, with the electric field oriented perpendicularly to the length of the slot.



Slot Antenna Radiation Pattern



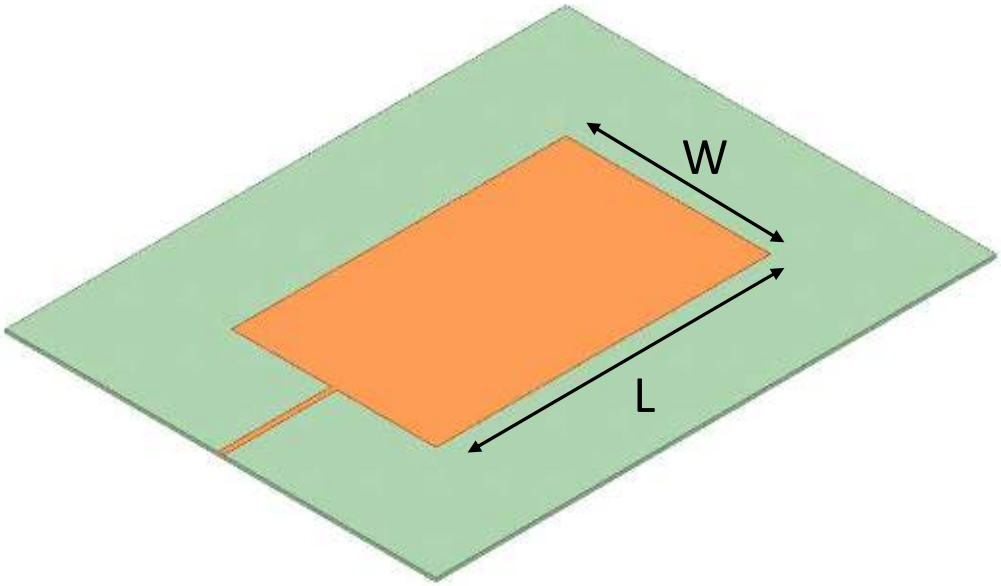
Dipole Antenna Radiation Pattern

Rectangular Patch Antennas

Rectangular patch antennas consist of a rectangular conductive element of width W and length L, which rests on the surface of a dielectric slab of thickness d and relative permittivity ϵ_r, with conductive backing.

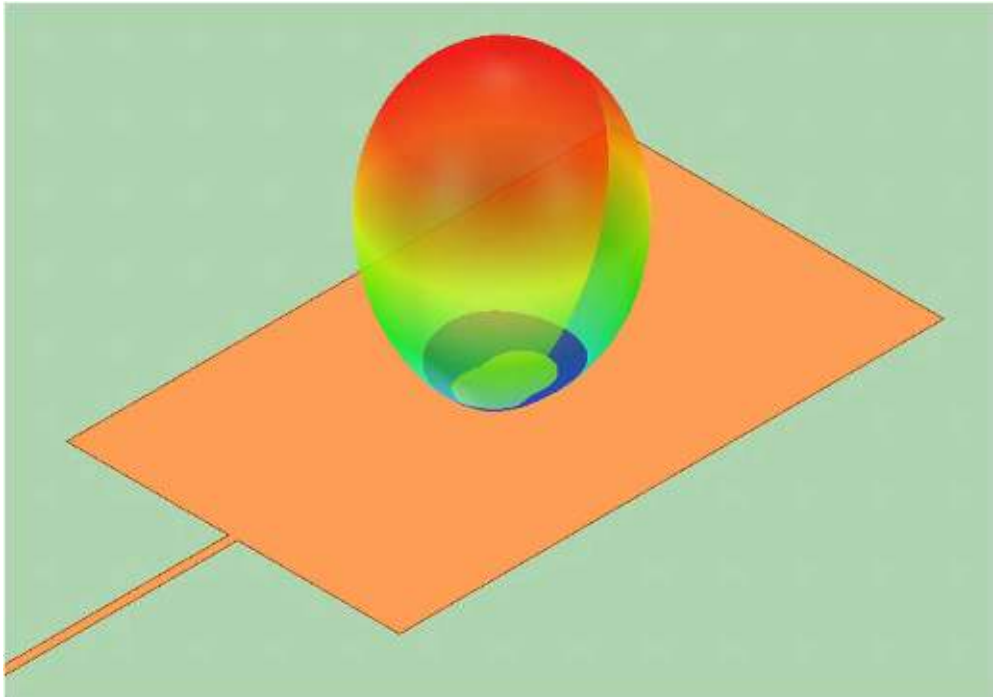
The radiation of the patch antenna occurs due to resonance of the fields in the cavity under the patch.

This resonance occurs when the length L of the antenna is slightly less than half the length of the guided wave, because field fringing at the ends of the patch makes the patch “appear” longer than it physically is.



Rectangular Patch Antennas

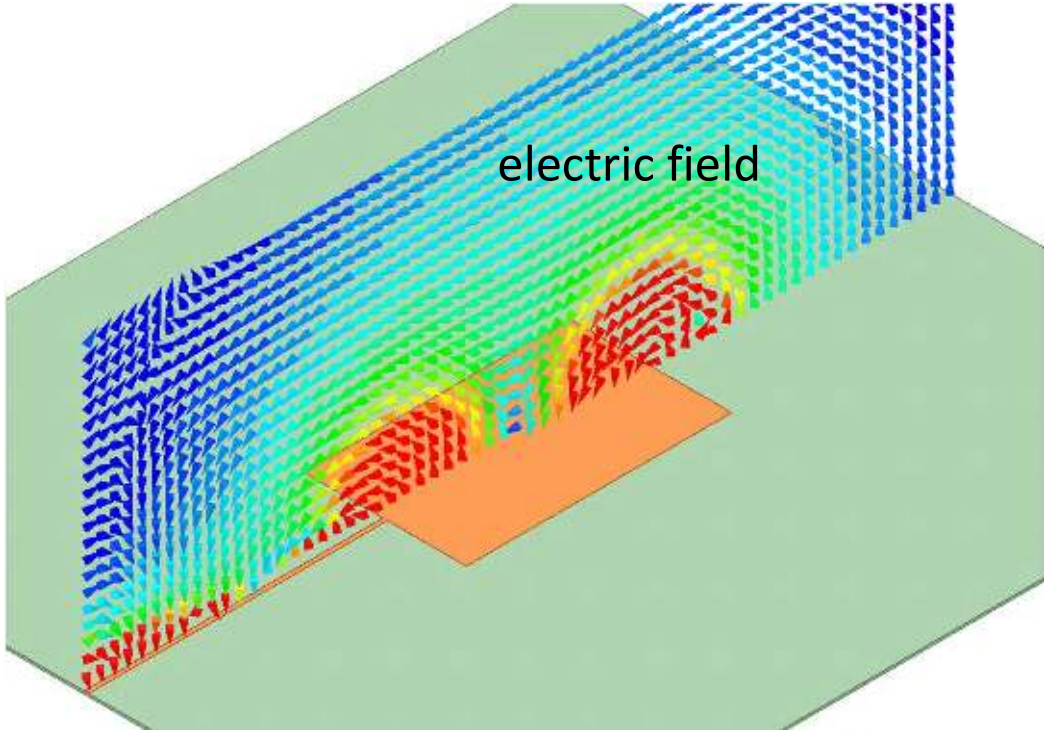
Rectangular Patch antennas radiate broadside, normal to the plane of the patch.



Rectangular Patch Antennas

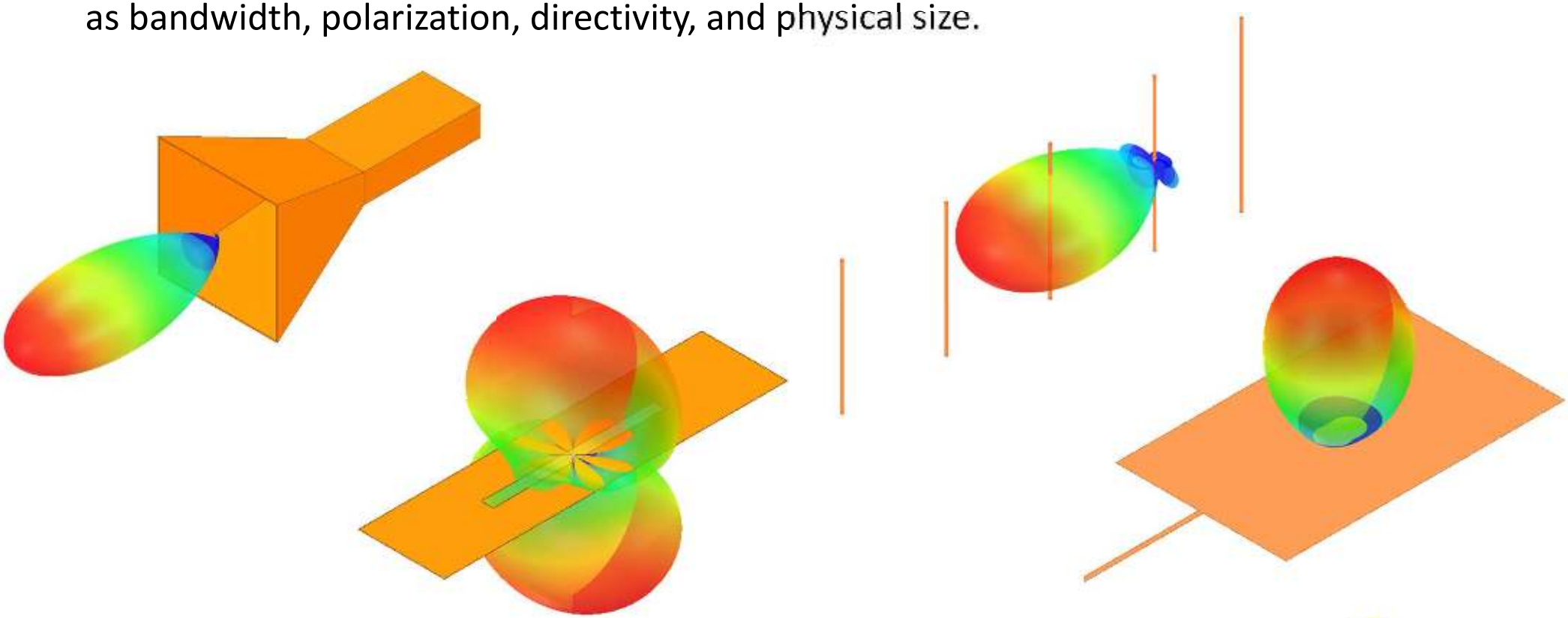
The polarization of an unmodified rectangular patch antenna is **linear**, with electric field oriented in the direction of the L dimension.

Rectangular patch antennas are commonly fed by **microstrip** (as shown here), or by a **coaxial probe** coming up through the dielectric, or by **coupling** with a resonant cavity or other proximate resonator.



Example Antenna Types

The selection of one antenna over another will depend on the desired application. The choice will involve judging the merit of each topology based on a variety of factors such as bandwidth, polarization, directivity, and physical size.

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