Antenna Selection for Optimum Wireless LAN Performance

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PURPOSE

Overview of antenna properties and performance characteristics

Overview of RF propagation characteristics

Overview of how antenna properties affect wireless system performance

Establish antenna selection criteria for optimum system performance

Review current wireless antenna technologies

INTRODUCTION

System designers and operators should have knowledge of antenna performance

Properly selected antenna systems can improve performance and reduce cost

Tutorial will provide basic knowledge of antenna performance and selection criteria.

Other factors which affect antenna selection include size, appearance and

$$$$$$$$$$$

ANTENNAS

Antennas are passive devices that do not require supply power to operate

They do not amplify RF Energy

If 100% efficient, they will not radiate more power than is received at their input terminal

Basic performance characteristics: VSWR, radiation patterns, 3 dB beamwidth, gain, polarization and bandwidth

VSWR

Defines how closely antenna input impedance matches feed cable characteristic impedance.

Impedance mismatch will reduce system efficiency.

Table 1. Percent Reflected Power/Transmission Loss as a Function of VSWR.

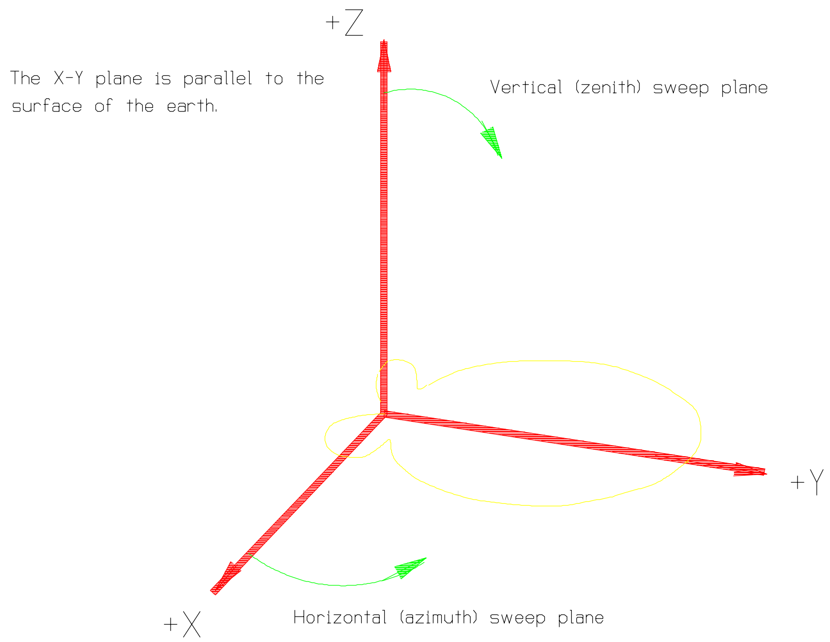
VSWR	Percent Reflected Power	Transmission Loss (dB)
1.0:1	0.0	0.0
1.25:1	1.14	0.05
1.5:1	4.06	0.18
1.75:1	7.53	0.34
2.0:1	11.07	0.51
2.25:1	14.89	0.70
2.5:1	18.24	0.88

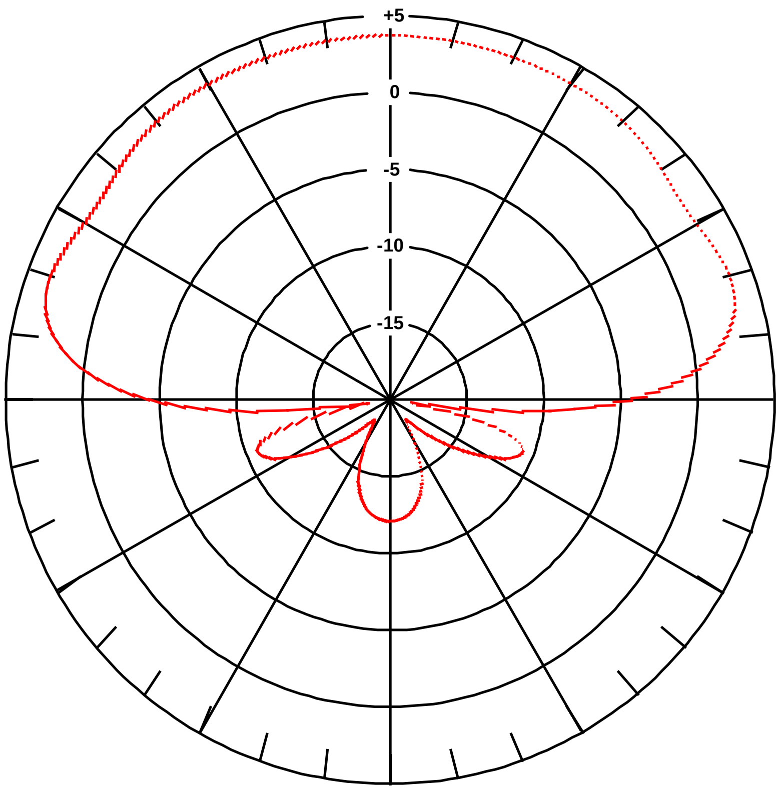
RADIATION PATTERNS

Provide information that describes how an antenna directs the energy it radiates

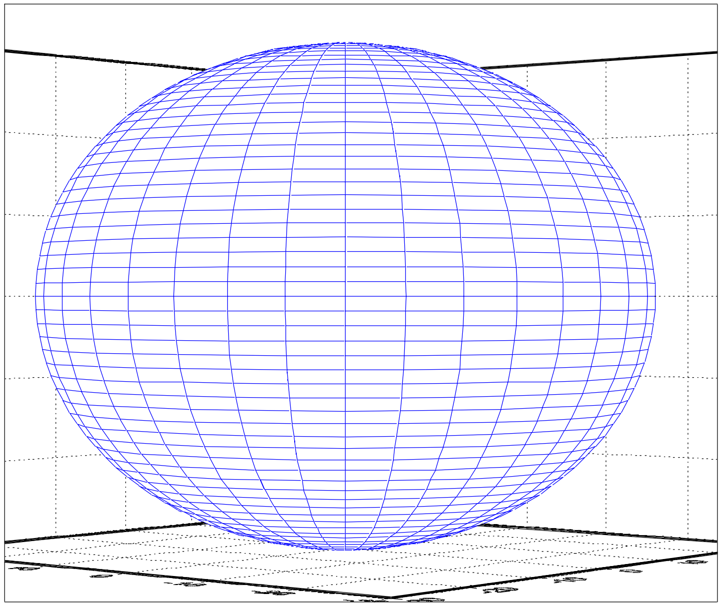
Information presented in the form of a polar plot for both horizontal (azimuth) and vertical (zenith or elevation) sweeps

Define quantitative aspects such as 3 dB beamwidth, directivity, side lobe levels and front to back ratio.



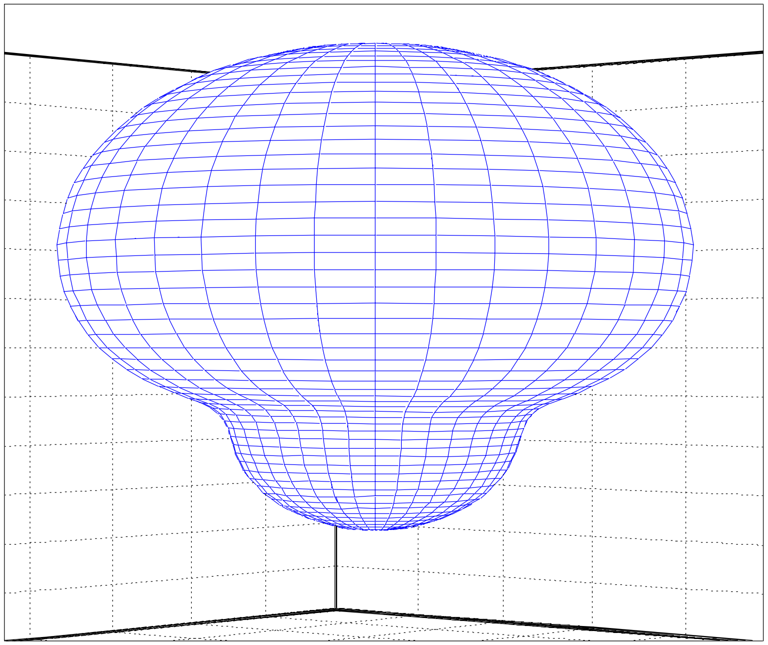


Description of Sweep Planes and Typical Radiation Pattern



Imaginary Point Source

Typical Antenna



GAIN

Accounts for overall efficiency of antenna.

Efficiency reduction occurs from:

- **VSWR mismatch**
- **Ohmic losses (energy lost as heat)**
- **Radome losses.**

POLARIZATION

Describes the orientation of the radiated wave's electric field

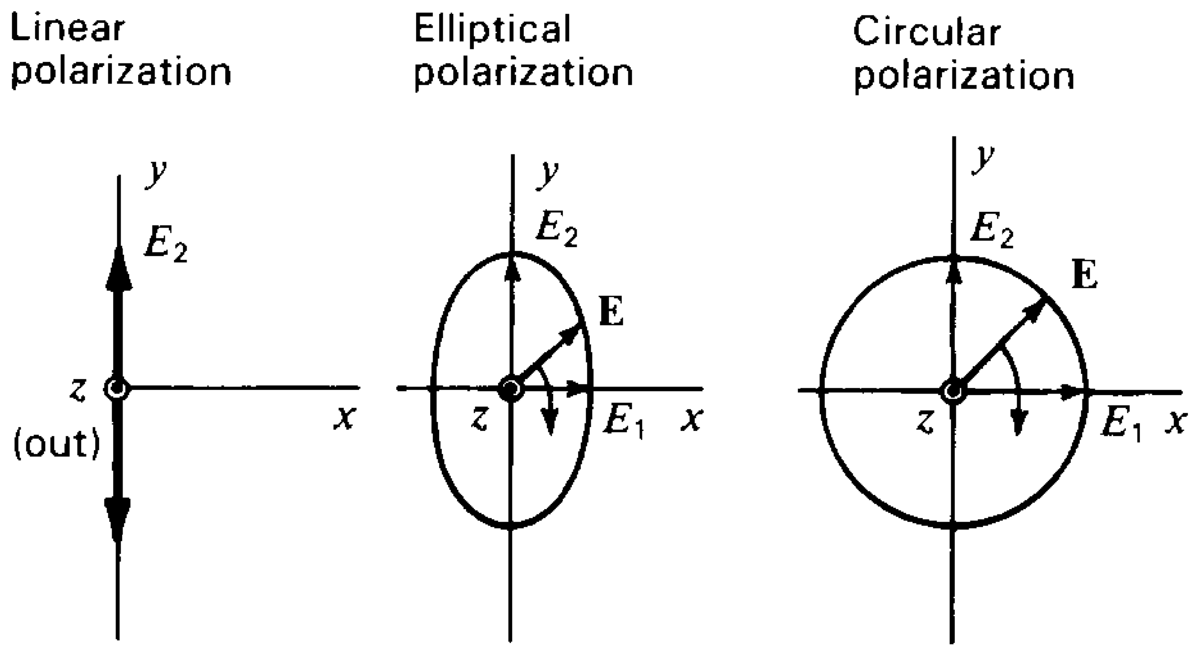


Table 2. Polarization Mismatch Between Two Linearly Polarized Waves as a Function of Angular Orientation.

Orientation Angle	Polarization Mismatch (dB)
0.0	0.0
15.0	0.3
30.0	1.25
45.0	3.01
60.0	6.02
75.0	11.74
90.0	∞

Table 3. Polarization Mismatch Between a Linearly and Circularly Polarized Wave as a Function of the Circularly Polarized Wave's Axial Ratio.

Axial Ratio	Minimum Polarization Loss (dB)	Maximum Polarization Loss (dB)
0.00	3.01	3.01
0.25	2.89	3.14
0.50	2.77	3.27
0.75	2.65	3.40
1.00	2.54	3.54
1.50	2.33	3.83
2.00	2.12	4.12
3.00	1.77	4.77
4.00	1.46	5.46
5.00	1.19	6.19
10.00	0.41	10.41

RF PROPAGATION

Path Loss

Multipath Fading

Interference and Noise

Polarization Distortion

Effects of earth and surrounding objects

PATH LOSS

Path Loss (dB) = 20 log10 (4 pi r/lambda)

Table 4. Typical Free Space Path Loss Values (dB) for Various Wireless Frequencies

Distance/Frequency	915 MHz	1920 MHz	2.450 GHz	5.7875 GHz
100 meters	71.68	78.11	80.23	87.70
200 meters	77.69	84.13	86.25	93.72
500 meters	85.66	92.09	94.21	101.68
1,000 meters	91.68	98.11	100.23	107.70
2,000 meters	97.69	104.13	106.25	113.72
5,000 meters	105.66	112.09	114.21	121.68
10,000 meters	111.67	118.11	120.23	127.70

MULTIPATH FADING

Result of multiple signals from the same RF source arriving at the receive site via many paths.

The RF signal is time delayed, attenuated, reflected or diffracted and arrives at the receive site at a different amplitude, phase and perhaps time sequence than the direct signal.

The total received signal is vector sum of direct and all multipath signals which may result in complete cancelation of direct signal.

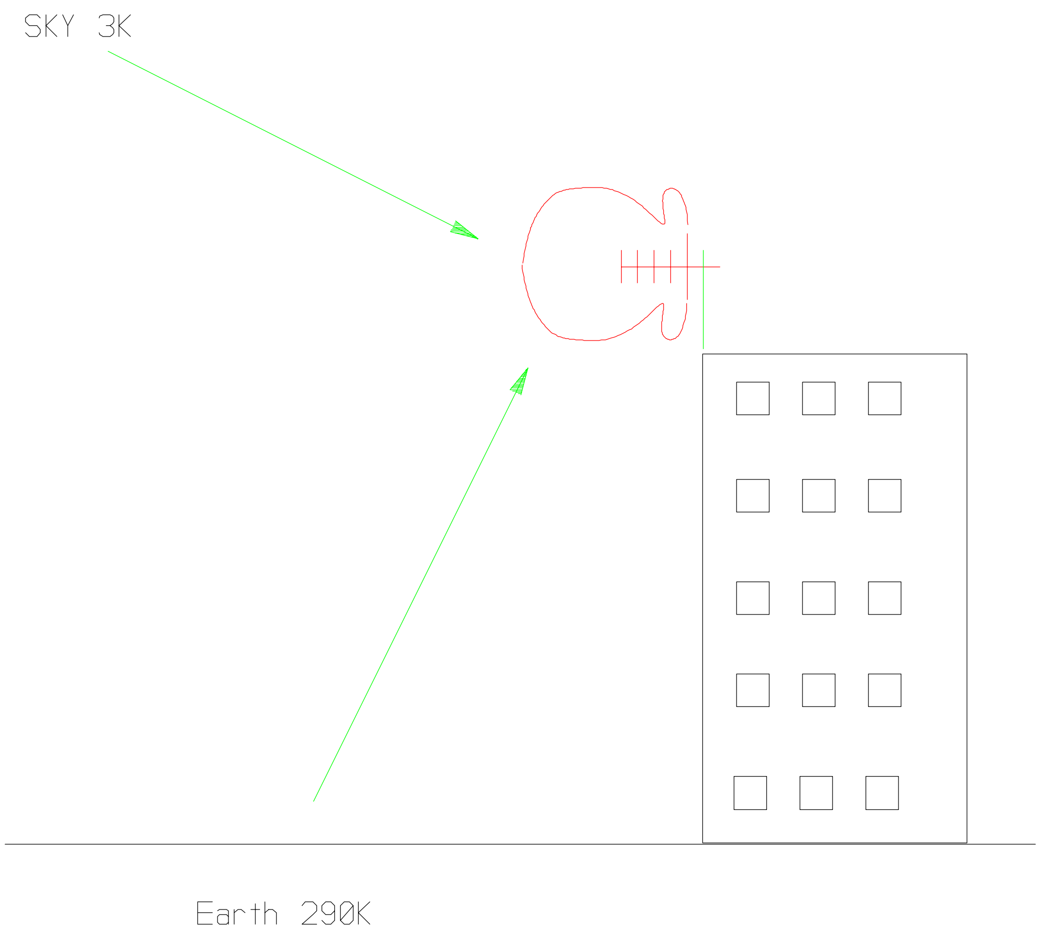
INTERFERENCE AND NOISE

Interference to wireless systems can occur from many sources:

Atmospheric noise
Galactic noise
Man-made noise
Radio noise
Receiver noise

In signal to noise calculations, noise is typically expressed as a temperature. The antenna will introduce noise as a function of the temperature of the objects it "sees".

INTERFERENCE AND NOISE



POLARIZATION DISTORTION

As RF waves reflect and diffract off of various objects, the orientation and sense of polarization may change.

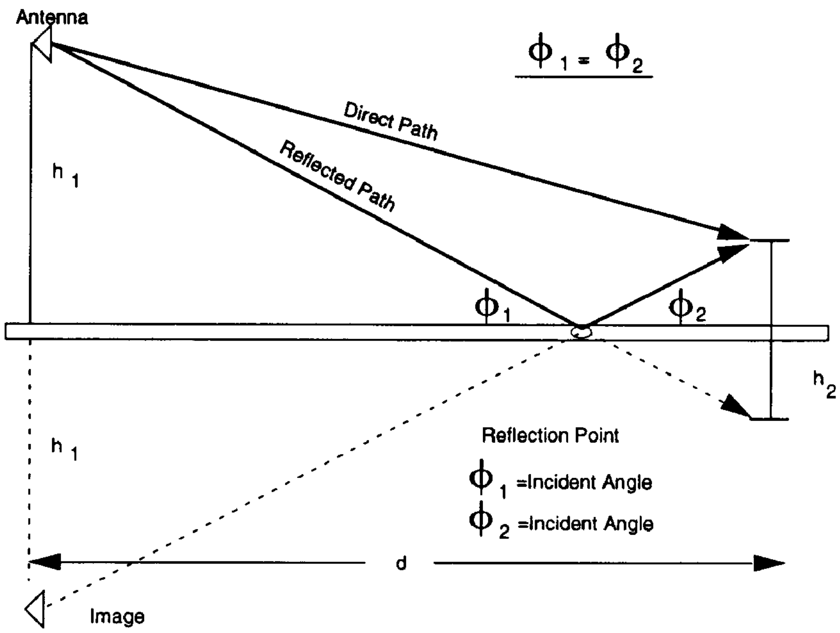
EFFECTS OF EARTH AND SURROUNDING OBJECTS

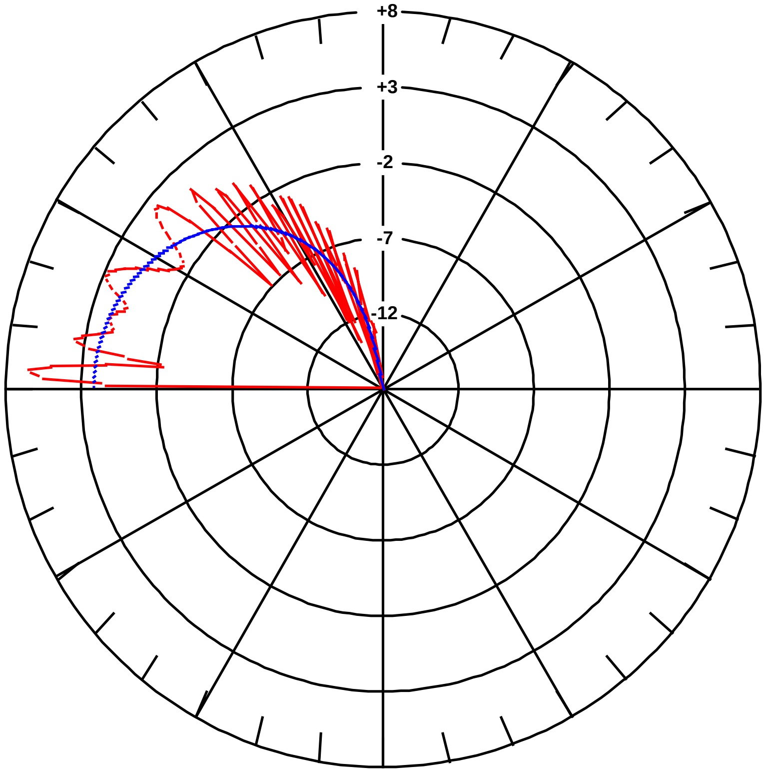
The earth is a dielectric body with varying conductivity and dielectric constant.

It impacts antenna impedance such that $R_a = R_r + R_l + R_g$

Energy dissipated in R_l and R_g is lost as heat and not radiated.

EFFECTS OF EARTH AND SURROUNDING OBJECTS





OPTIMIZING PERFORMANCE THROUGH ANTENNA SELECTION

Performance Issues:

- VSWR
- Radiation patterns
- Gain
- Polarization

Propagation Issues:

- Path loss
- Multipath
- Interference
- Polarization distortion
- Effects of earth and surrounding objects

Other Issues:

* Antenna cost *

Antenna size

Antenna appearance

ANTENNA TECHNOLOGY IN WIRELESS SYSTEMS

Default omni antenna

Higher gain omni antenna

Directional yagi antenna

Microstrip patch antenna

DEFAULT OMNI ANTENNA

Mounts directly to station connector

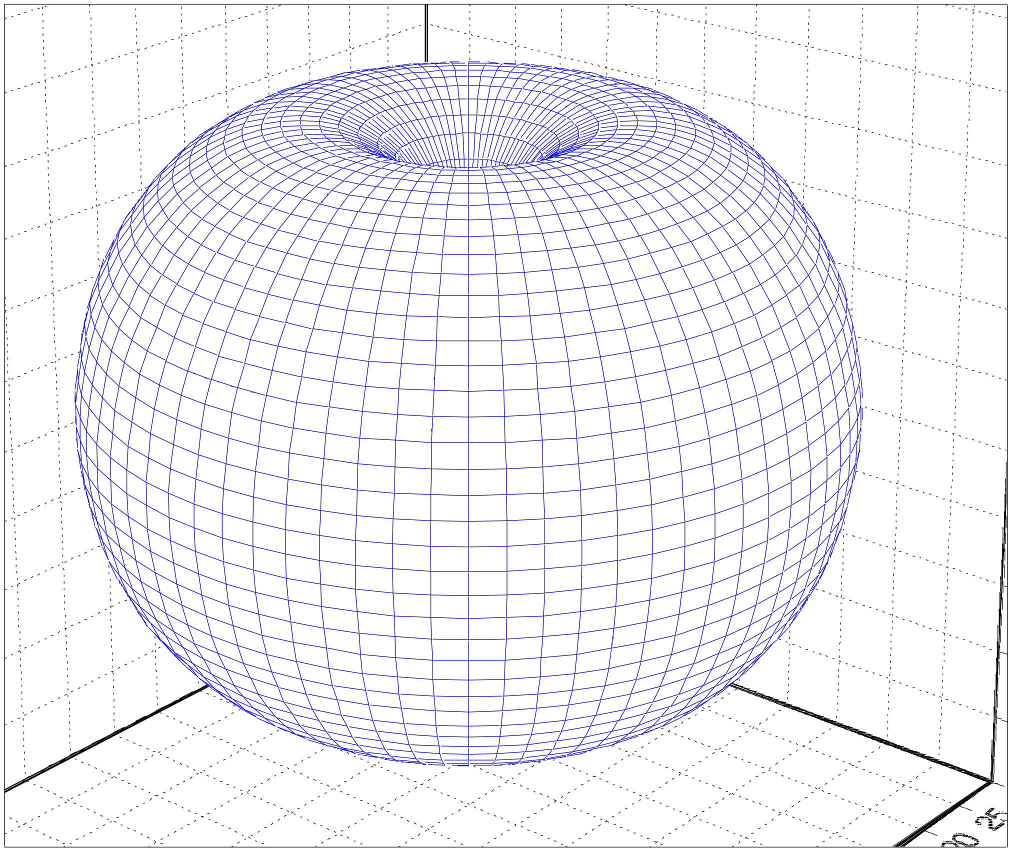
Omnidirectional

Low gain (2 dBi typical)

Linear polarized

Low Cost

TYPICAL DIPOLE ANTENNA PATTERN



HIGHER GAIN OMNI ANTENNA

Local or remote mounting

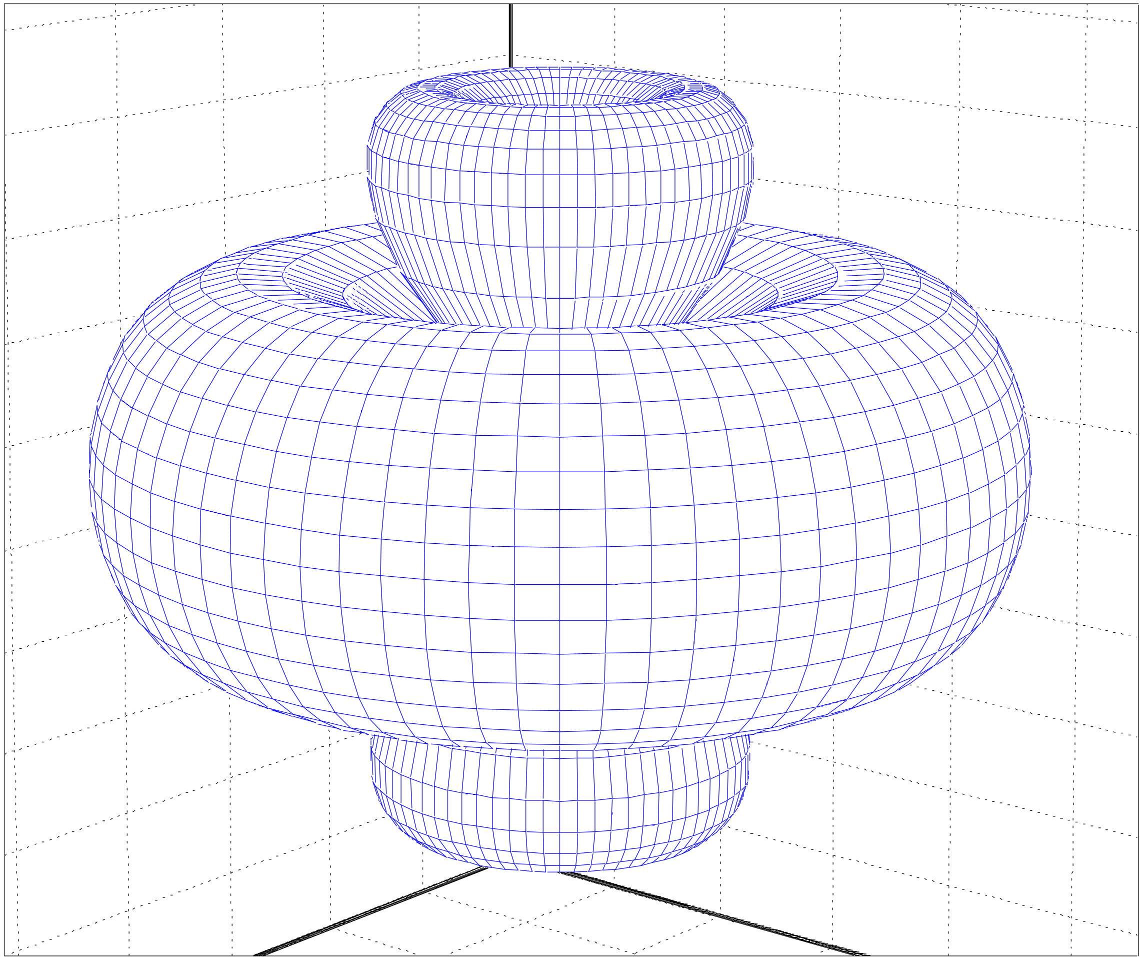
Omnidirectional

Higher gain (5 - 8 dBi possible)

Linear polarized

Low to moderate cost

TYPICAL 2-ELEMENT DIPOLE ANTENNA PATTERN



DIRECTIONAL YAGI ANTENNA

Local or remote mounting

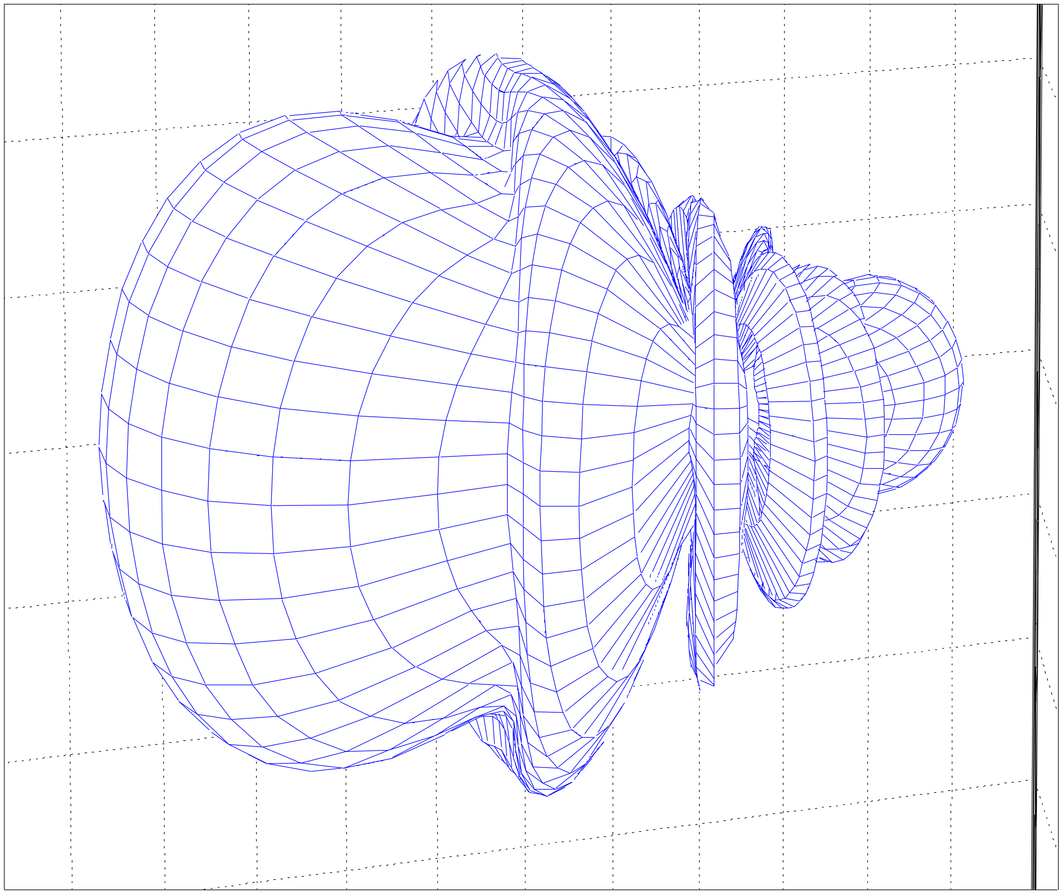
Directional

High gain (12 - 15 dBi or higher)

Linear polarized

Low to moderate cost

TYPICAL YAGI ANTENNA PATTERN



MICROSTRIP PATCH ANTENNA

Local or remote mounting

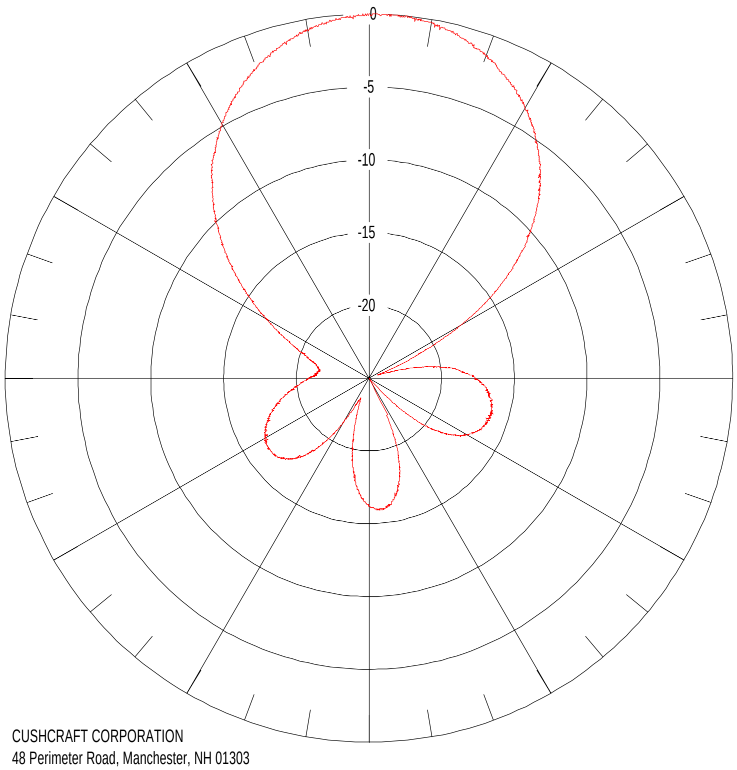
Directional

Moderate to high gain (6 - 15 dBi or higher)

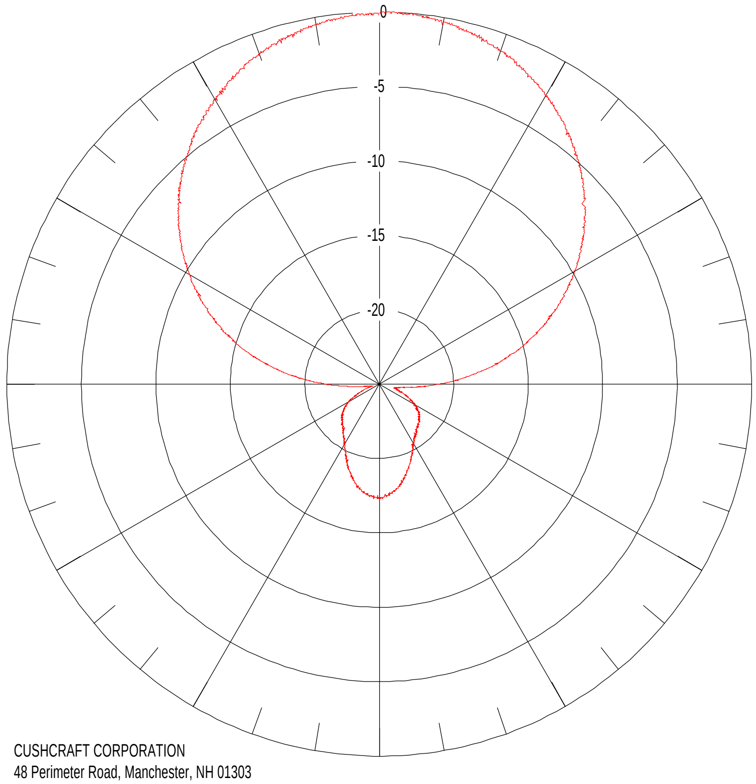
Linear, dual linear or circular polarized

Low to moderate cost

MICROSTRIP PATCH ANTENNA PATTERN



E-PLANE



H-PLANE

Table 5. Relative Comparison of Typical Wireless Antennas.

Performance/ Antenna	Default Omni	Higher Gain Omni	Yagi	Microstrip Patch
VSWR	1.5 - 2.0:1	1.5:1	1.5:1	1.5:1
Beamwidth Azimuth Zenith	 360 70	 360 <70	 20 - 60 30 - 50	 <100 <100
Gain	2 dBi	2 - 12 dBi	12 - 15 dBi	6 - 20 dBi
Polarization	Linear	Linear	Linear	Linear, dual linear, circular
Cost	Low	Low/moderate	Low/moderate	Low/moderate