Typical Antenna Selection Tips

Choosing the right antenna for your installation means considering several factors:

- Path
- Mounting
- Cabling
- Selecting the Antenna

1. Considering the Path

Equipment, walls, foliage and other things that obstruct the line of vision between the antennas in your system affect how much signal is conducted between them. When designing your system, make every attempt to eliminate obstructions between antennas. This can be done by mounting the antennas as high as possible (above obstructions) or moving the antennas out from behind an obstacle.

Although some signal may be lost if several feet of cable is required, that loss is much less than when the view is obstructed. Ultimately, antennas will be selected based upon whether the view is obstructed or unobstructed.

When considering the path, also consider whether the Master radio talks with multiple remotes. Antennas achieve “gain” by focusing the beam of energy. If the beam is focused, the antenna cannot communicate as well in all directions. Therefore, if a Master needs to talk with multiple Remotes, an antenna will have to be selected that has a “pattern” that can see all the Remotes.

2. Antenna Mounting

A second factor in choosing the antenna is the available mounting options. In general, it is best to mount the antenna as high as possible. Is there a mast that either antenna will be mounted to? Or is it only possible to mount the antenna directly to the radio?

3. Cabling to the Antenna

When considering where the antenna will be mounted, consider if the radio can be mounted close to the antenna and have the serial cable run from the radio down to the equipment. Keeping the RF cable as short as possible limits signal loss.

Cable Loss Chart

Cable Type	*dB loss per 10 ft*
RG-316	4.2
LMR195	1.8
LMR400	0.67
LMR600	0.44
LMR1200	0.23
LDF4	0.35
LDF5	0.20
LDF7	0.13

4. Choosing the Right Antenna

Once the considerations above have been determined, you can use the chart below to aid in choosing the correct antenna. First select the column marked ‘Unobstructed Distance’ or ‘Obstructed Distance’, whichever is appropriate. Second, find the row that corresponds to the distance between the antennas. Third, find the ‘Link Gain’ that you need in your system.

The ‘Link Gain’ is a composite of the gains of each of the antennas (the Master’s antenna and the Remote’s antenna) as well as any cable loss. For example, if you want to communicate over a 2 mile unobstructed distance, you should include at least 7 dB of Link Gain. This means you could select:

Master antenna gain:	8	dBi
Remote antenna gain:	8	dBi
Cable at the Master:	-2	dB
Cable at the Master:	-5	dB
Total Link Gain:	9	dBi

More gain will give you more distance. It doesn’t make any difference whether the gain is on the Master or the Remote radio. The gains of the two antennas add up.

Make the choice for each antenna pair (if you have a point–multipoint system).

4.1 Distance Chart

The chart below has been adjusted to allow for 10dB of “margin” in your system. The margin accounts for expected changes in the environment during operation.

Minimum dBi for Unobstructed Distances	
Distance (miles)	*Net dB*
1	4
2	7
3	10
5	15
7	20
10	25
12	30
15	35

4.2 Key Antenna Attributes

Radio antennas come is a variety of types, but all types are characterized by three important electrical characteristics: antenna *pattern*, *gain*, and *polarity*.

4.2.1 Antenna Pattern

Information between two radios is transferred via electromagnetic energy radiated by one antenna and received by the other. The radiated power of most antennas is not uniform in all directions, and the varying intensities of an antenna’s radiated power in various directions is called the *pattern* of the antenna. Each antenna should be mounted so that its direction of strongest radiation intensity points toward the other antenna or antennas with which it will exchange signals. Complete antenna patterns are three-dimensional, although often only a two-dimensional slice of the pattern is shown when all the antennas of interest are located in roughly the same horizontal plane, along the ground rather than above or below one another.

A slice taken in a horizontal plane through the center (or looking down on the pattern) is called the *azimuth pattern.* A view from the side reveals a vertical plane slice called the *elevation pattern.*

An antenna pattern with equal or nearly equal intensity in all directions is *omni-directional.* In two dimensions, an omni-directional pattern appears as a circle. (In three dimensions, an omni-directional pattern would be a sphere, but no antenna has a true omni-directional pattern in three dimensions.) An antenna is considered omni-directional if one of its two-dimensional patterns—either the azimuth or elevation pattern—is omni-directional.

Beam width is an angular measurement of how strongly the power is concentrated in a particular direction. Beam width is a three-dimensional quantity but can be broken into two-dimensional slices just like the antenna pattern. The beam width of an omni-directional pattern is 360° since the power is equal in all directions.

4.2.2 Antenna Gain

Antenna gain is a measure of how strongly an antenna radiates in its direction of maximum radiation intensity, compared to how strong the radiation would be if the same power were distributed equally in all directions. An antenna's gain describes the distance to the furthest point on the pattern from the origin. For an omni-directional pattern, the gain is 1, or equivalently 0dB. The higher the antenna gain, the narrower the beam width, and vice versa. The amount of power that is received by the receiving antenna is proportional to:

Transmitter Power x Transmit Antenna Gain x Receive Antenna Gain

The antenna gains and transmit power can therefore be traded off. For example, doubling one antenna gain has the same effect as doubling the transmitter power. Doubling both antenna gains has the same effect as quadrupling the transmit power.

4.2.3 Antenna Polarity

Antenna polarization refers to the direction that the electromagnetic field lines point as energy radiates away from the antenna. In general, antenna polarization is elliptical. The simplest and most common form of this elliptical polarization is simply a straight line, or *linear polarization.* Of the transmitted power that reaches a receiving antenna, only the portion that has the same polarization as the receiving antenna polarization is actually received.

For example, if the transmit antenna polarization is linear pointed in the vertical direction (vertical polarization, for short), and the receive antenna also has vertical polarization, the maximum amount of power possible will be received. On the other hand, if the transmit antenna has vertical polarization and the receive antenna has horizontal polarization, theoretically, no power would be received. If the two antennas have linear polarizations orientated at 45° to each other, half of the possible maximum power will be received.

4.3 Antenna Types

The following antenna types are approved for use with OS2400 industrial radios:

- Whip Antenna
- Collinear Array Antenna
- Yagi Array Antenna
- Parabolic Reflector Antenna

4.3.1 Whip Antennas

Two types of whip antennas are approved for use with OS2400 industrial radios. These antenna type descriptions use the symbol λ to denote wavelength.

4.3.1.1 1/2λ Straight Whip or 1/2λ Articulating Whip (2dBi)

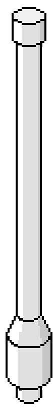
This is the most commonly used antenna type, and does not require a ground plane. About 5 inches long, this antenna is typically connected to a remote radio (connected directly to the radio enclosure).

An *articulating* antenna bends at the connection, as shown here, and functions the same as a non-articulating antenna.

4.3.1.2 1/4λ Whip Antenna (2dBi)

The 1/4λ whip antenna, at about 2.5 inches long, is shorter than the 1/2λ whip, and does require a ground plane mounted below the antenna and over the top surface of the radio. The 1/4λ whip works well with belt-mounted remote radios, but does not radiate well out the top of the antenna, so must remain vertical.

4.3.2 Collinear Array Antenna



A collinear array antenna is typically composed of several linear antennas (like the 1/2λ wave whip) stacked on top of each other. The more stacked elements within the collinear array, the longer the antenna, and the more gain it has.

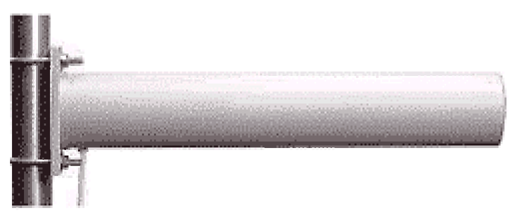
The antenna pattern is toroidal; its azimuthal beam width is 360° (omni-directional); its vertical beam width depends on its length (the number of stacked elements), such that more elements produce a narrower beam width.

The antenna gain—typically 5-10dBi—also depends on the length (number of stacked elements), such that more elements produce higher gain.

The antenna polarity is linear, parallel to the length of the antenna.

4.3.3 Yagi Array Antenna

A yagi antenna is composed of an array of linear elements, parallel to one another and attached perpendicular to and along the length of a metal boom. The feed is attached to only one of the elements. Elements on one side of the feed element are longer and act as reflectors; elements on the other side are shorter and act as directors. This causes the antenna to radiate in a beam out of the end with the shorter elements. The actual pattern depends on the overall geometry, including the number of elements, element spacing, element length, etc. Sometimes the antenna is enclosed in a protective tube that hides the actual antenna geometry, as shown here:



The antenna pattern is a beam pointed along the boom toward the end with the shorter elements. The beam width varies with antenna geometry but generally is proportional to the length (where longer length produces a narrower beam).

The antenna gain—typically 6 to 15dBi—also varies with antenna geometry, but generally is proportional to the length (where longer length produces higher gain).

The antenna polarity is linear (parallel to the elements, perpendicular to the boom).

4.3.4 Parabolic Reflector Antenna

A parabolic reflector antenna consists of a parabolic shaped dish and a feed antenna located in front of the dish. Power is radiated from the feed antenna toward the reflector. Due to the parabolic shape, the reflector concentrates the radiation into a narrow pattern, producing a high-gain beam.

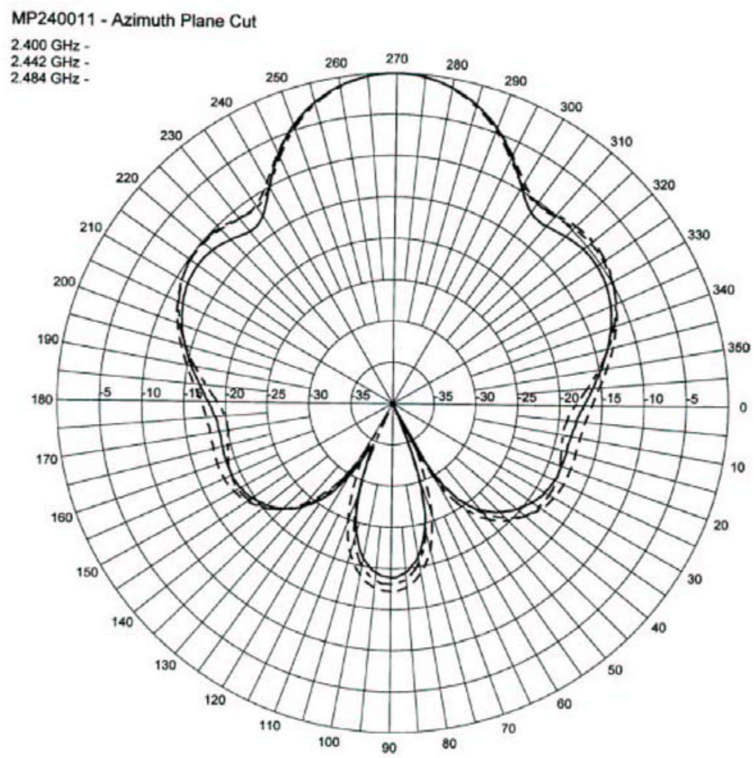
The antenna pattern is a beam pointed away from the concave side of the dish (beam width varies with the size of the reflector and the antenna construction).

The antenna gain varies with the size of the reflector and the antenna construction. Typical values are 15 to 30dBi.

The antenna polarity depends on the feed antenna polarization.

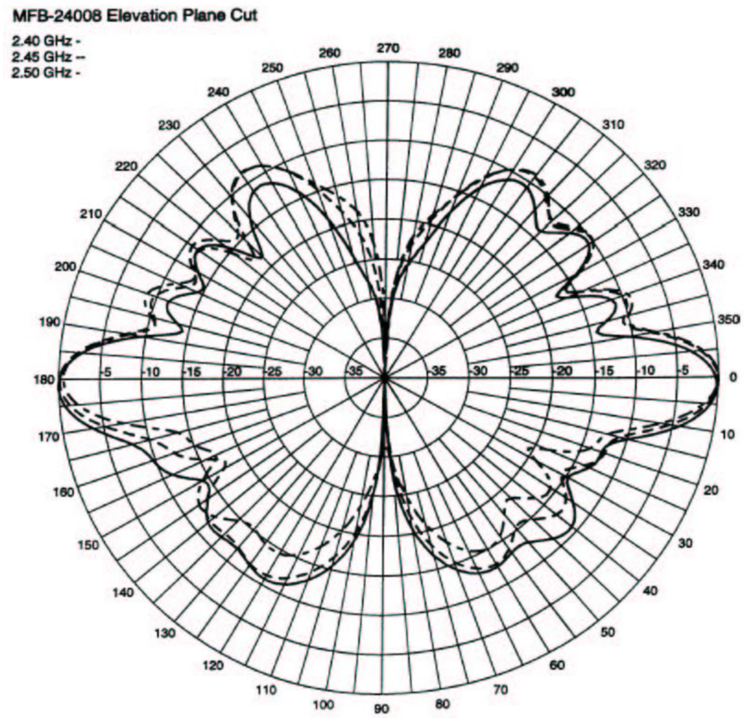
5 Example Antennas

Patch Antenna 8 dBi Directional



Patch Antenna 11 dBi Directional

Omni Directional 8 dBi Antenna

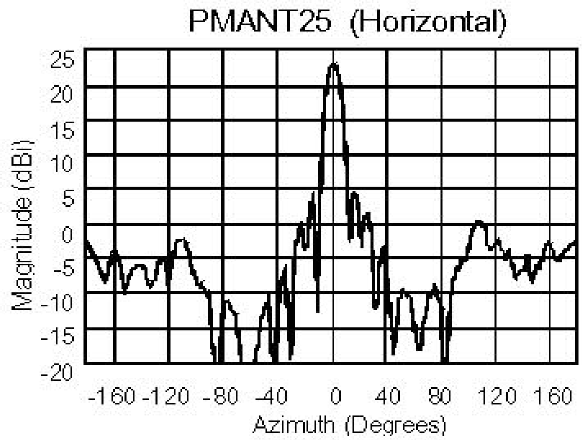


MFB-24008 Elevation Pattern - 8 dBi Fiberglass Omni-directional Base Station Antenna

Directional Yagi 13 dBi Antenna

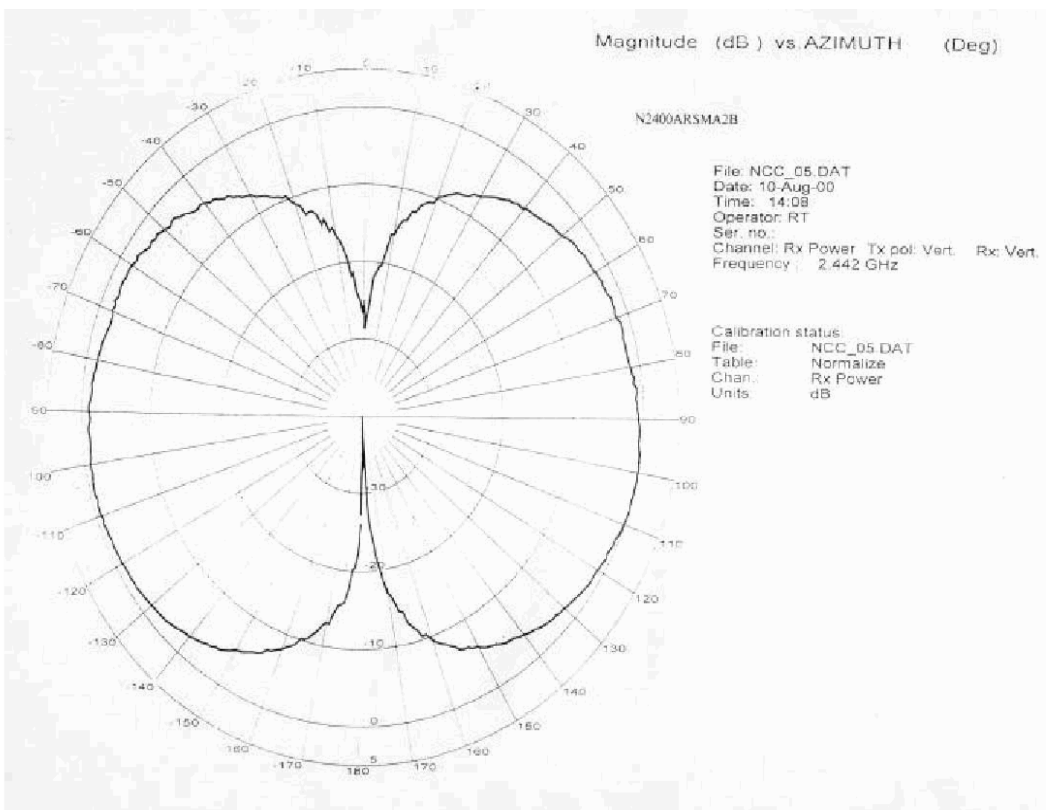
Electrical Specifications 2.4 GHz ISM - Yagi Antenna Series						
Model #	**Frequency Range**	**VSWR**	**Front-to-Back Ratio**	**Gain**	**Vertical Beam width @ 1/2 Power**	**Horizontal Beam width @ 1/2 Power**
MYP24013	2400-2483.5 MHz	<2:1, 1.5:1 nominal	>20 dB	13.5 dBi (11.3 dBd) nominal	30°	28°

Directional 24 dBi Parabolic Grid Antenna

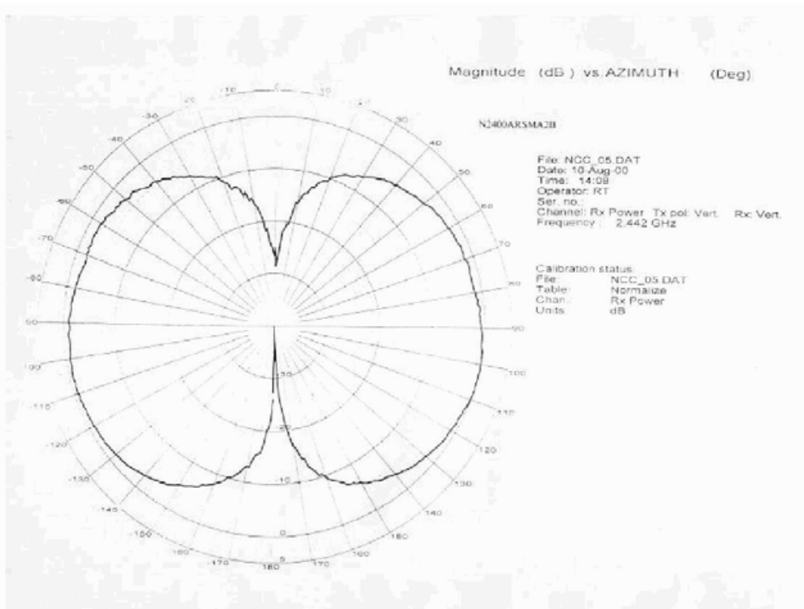


Omni Directional 2 dBi Antenna

2 dBi Omni straight



Omni Directional Articulating 2 dBi Antenna



Omni Directional Articulating 5 dBi Antenna