

ANTENNA BUYER'S GUIDE THE ESSENTIAL SPECS

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TABLE OF CONTENTS

INTRODUCTION4 - 5FREQUENCY6 - 7GAIN8PATTERN9FORM FACTOR10POWER HANDLING11CONCLUSION & EXAMPLE12 - 1



ANTENNA BUYER'S GUIDE: KNOWING WHAT TO KNOW

INTRODUCTION

In choosing an antenna for your next communications application, there are a number of different specifications to take into account. When first getting started, it can be difficult to know what you are looking for. This guide aims to help find the right antenna, by showing information you want to know, and what questions to ask. With the help of this guide, you will be able to approach a communications equipment retailer with the proper knowledge to have a useful, productive conversation—one that results in finding the perfect communications solution.

When choosing an antenna for your next RF application, several key specifications must be considered. It can be difficult to know where to start. Antennas are multi-parametered beasts. Even for professionals with years of experience, seeking out a new antenna solution typically requires the supplier to ask some questions of their own. Many important aspects are taken into consideration—because engineering details matter a great deal when seeking optimal performance.





So here are the Five Essential Specs to accelerate antenna selection!



1. FREQUENCY



Radio frequencies span 9 kHz to 275 GHz — that's 8 orders of magnitude! Without allocation and regulation of this spectrum, radio communication would be unreliable and conflicted. Governments around the world license slices of the spectrum for commercial use, usually via auctions, while reserving many slices for other civil, defense, industrial, scientific, medical and amateur use as seen in the chart above for US frequency allocations.

Frequency is the fundamental specification for all antennas. Frequency is defined as the **number of** cycles of a wave per second with units of Hertz (Hz)

Each antenna is designed to operate at certain frequencies. For example, a Wi-Fi router works at 2.4 to 2.5 GHz and an FM radio operates from 88 to 108 MHz. Each needs an appropriately tuned antenna.

For antennas, frequency is generally specified as a range: as a minimum and maximum frequency, or as the center frequency, with a percentage bandwidth. Either way of specifying works - the important part is knowing what range your equipment needs. You can search for your specific application online to see the general frequency range it falls into.

HERE ARE SOME OF THE APPLICATIONS AND THEIR FREQUENCIES:

FREQUENCY BAND	RANGE	WAVELENGTH (METERS)	APPLICATION(S)
Extremely Low Frequency (ELF)	3-30 Hz	100,000-10,000 km	Underwater Communication
Super Low Frequency (SLF)	30-300 Hz	10,000-1,000 km	AC Power
Ultra Low Frequency (ULF)	300-3000 Hz	1,000-100 km	Military Communications
Very Low Frequency (VLF)	3-30 kHz	100-10 km	Navigational Beacons
Low Frequency (LF)	30-300 kHz	10-1 km	AM Radio
Medium Frequency (MF)	300-3000 kHz	1,000-100 m	Aviation and AM Radio
High Frequency (HF)	3-30 MHz	100-10 m	Shortwave Radio
Very High Frequency (VHF)	30-300 MHz	10-1 m	Military Radio, FM Radio
Ultra High Frequency (UHF)	300-3000 MHz	100-10 cm	DTV, Mobile Phones, GPS
Super High Frequency (SHF)	3-30 GHz	10-1 cm	Satellite Links, Automobile Radar
Extremely High Frequency (EHF)	30-300 GHz	10-1 mm	Astronomy, Remote Sensing
Visible Spectrum	400-790 THz	750-380 nm (nanometers)	Human Eye

2. GAIN

Gain is a key parameter for antennas that is a product of radiation directivity and electrical efficiency. Antenna gain indicates how strong of a signal an antenna can send or receive in a specified direction. Normally stated in units of **dBi**, marketers usually use peak values, or state a range of gains that are typical.

Gain is a squishy number, because it attempts to boil down a complex 3D radiation pattern into just a few numbers. To better understand antenna gain, antenna designers utilize two-dimensional, and three-dimensional pattern graphs to aid in proper antenna



This visualization shows the simulated far-field radiation pattern of a Vivaldi tapered slot antenna radiating with high gain in a tight beam as indicated by the red region. Source: https://www.comsol.com/blogs/simulation-tools-for-solving-wave-electromagnetics-problems/

selection. These patterns provide system engineers a visual of how a specific antenna radiates in a specific plane or volume.

Generally, visualizations of this type show either the Azimuth (horizontal), or Elevation (vertical) radiation pattern for a particular antenna. Using these azimuth and elevation polar plots, you can determine where the antenna gets the best gain and select the most suitable antenna for your project.

Higher gain generally means that radiation is concentrated over a smaller beam width. This might be appropriate for some line of sight applications, such as those that need to isolate a specific signal and avoid interfering signals. A wider beam might be needed, for example, if there are many receiving units moving around that need to stay connected, as for tactical communications.

3. PATTERN

Pattern refers to the shape of the radiation around the antenna. "Omni" implies a donut pattern typical of a dipole antenna, "pencil beam" implies the pattern typical of a high-gain dish, and so on. An infinite variety of patterns are possible.

The radiation pattern or antenna pattern is the graphical representation of the radiation properties of the antenna as a function of space. That is, the antenna's pattern describes how the antenna radiates energy out into space (or how it receives energy). It is important to state that an antenna radiates energy in all directions,



Example of a principal plane cut for elevation pattern of a linearly polarized antenna with generally dipole-like characteristics. For vertical polarization, this means there are nulls to the zenith and nadir, and gain is maximum on bore (perpendicular to the face of the antenna) at the horizon.

at least to some extent, so the antenna pattern is actually three-dimensional.

It is common, however, to describe this 3D pattern with two planar pattern cuts along the elevation and azimuth axes, called the *principal plane patterns*. These principal plane patterns can be obtained by making two slices of the 3D pattern through the maximum value of the pattern or by direct measurement. It is these principal plane patterns that are commonly referred to as the antenna patterns.

Choosing an antenna with the right radiation pattern is just as important as choosing one with enough gain - it determines whether the power of the antenna is going to be able to cover the needed area.

4. FORM FACTOR



The size, weight and mounting details of antennas matter to determine their suitability to the use case. In general, receive only antennas are more compact than transmit antennas for the same frequency because amplifiers and receivers can compensate for low efficiency of electrically small antenna structures.

The old antenna adage about gain, bandwidth, and compactness applies here - you can only pick two!

The form factor defines (basically) the size and shape of the physical antenna. It may seem like a simple thing, but knowing the platform and size constraints for your antenna can seriously narrow the choices. Does it need to be portable? Mounted to a vehicle? Easily deployable? These all play a role in which antenna will serve you best. Consider the size, mounting needs, durability, and mobility for your specific application.

5. POWER HANDLING



For transmit antennas, the amount of power injected into them must be taken into account. Electronic attack platforms like the US Army's EW Tactical Vehicle pictured above possess myriad antennas that can handle lots of RF power. Source: https://www.army.mil/article/217284/newest_electronic_warfare_vehicle_tested_at_fort_irwin

Power handling, also referenced as "maximum input power," is an oft overlooked, but equally important specification when it comes to purchasing an antenna. Power handling is often stated in kW for high power transmit antennas—For receive-only antennas, the internal limiters (which protect against strong signals nearby) are specified in **dBmW**.

The maximum input power defines the maximum power of the signal that can be transmitted through one antenna port. Exceeding the power handling limits of your antenna may cause permanent damage or failure.

You'll want to have some idea of how much power handling your antenna will need, based on the use case, and the other components needed or already in use in the system.

That's it.

Five easy pieces.

If you have an idea of your needs - with regard to these specs, you'll be well on your way to selecting an effective antenna for your application.

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EXAMPLE



Close study of the above figure reveals that its graphics and descriptions cover all five of the essential specs to describe the <u>OMNI-C014-01</u> fractal wideband antenna. It has an impressive ten-to-one frequency coverage and is inherently frequency independent by its geometry - no matching network required.

So, if you can, when it comes time to chat about your antenna application, please give consideration to the five essential antenna specs; you'll have a much more efficient conversation.

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