

Why Buy Cisco Antennas?

There are major advantages to buying antennas from Cisco. This paper describes Cisco's antenna technology from design to testing and how that guarantees customers get a great product.

Introduction

There are many antenna suppliers capable of delivering Wi-Fi antenna solutions. However, it can be difficult, if not impossible, to know which one will deliver a high-quality solution with products that meet their advertised specifications and one that will really work for your particular installation. It may be very difficult to verify performance. The tools needed for that are highly specialized, large, and expensive.

The solution to these challenges is simple: Cisco should be the antenna supplier for your Wi-Fi network. There are a variety of reasons for that choice.

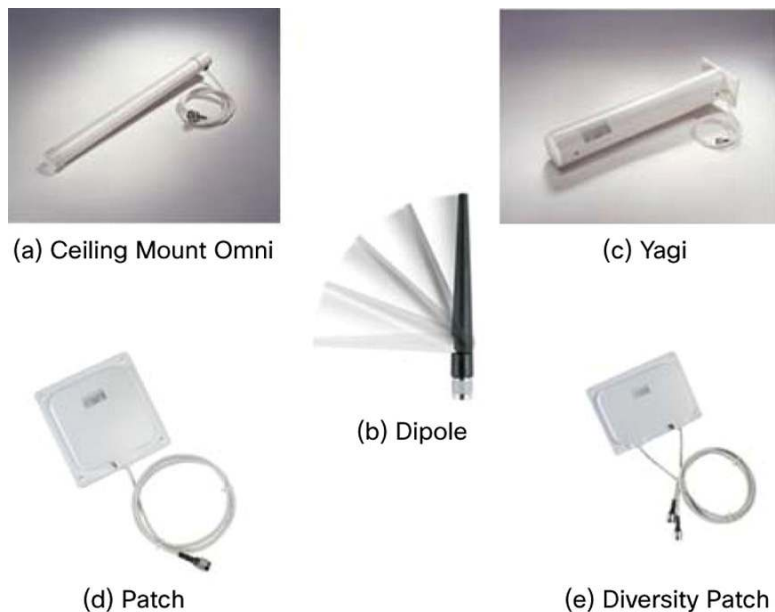
- Cisco[®] antennas go through complete electrical, mechanical, and environmental testing to ensure the specifications accurately reflect the product and that they meet requirements.
- Cisco has the experienced staff and tools to design, build, and test many of the antennas in the product line. We understand antennas.
- Cisco has long-standing relationships with other antenna suppliers who understand that Cisco customers require high-quality, high-performing antennas.
- All Cisco wireless network features like the Cisco Wireless Control System, radio resource management (RRM), rogue access point detection, and location services are all tested with Cisco antennas. These features demand the consistent, repeatable performance that Cisco antennas deliver.
- You get the full support of the Cisco Technical Assistance Center (TAC) when you use Cisco antennas.

This paper contains an in-depth look at Cisco's antenna-related capabilities. However, we begin by highlighting a couple basic antenna terms that will be crucial to demonstrations later in the paper. Gain and beamwidth are explained since they are the two most commonly discussed antenna parameters when it comes to Wi-Fi antennas. For a complete description of antenna parameters and what they mean, see the Cisco white paper entitled, "Antenna Patterns and Their Meaning". You can download it from:

http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/prod_white_paper0900aecd806a1a3e.html.

Since antenna measurements are crucial to understanding how an antenna might perform in your system, a full description of Cisco's antenna measurement system is included in this paper along with how its use fits into our overall plan for design verification or the qualification of third-party antennas. Next, a description of Cisco's antenna design capabilities demonstrates our serious commitment to providing high-quality antenna solutions. Finally, we discuss our complete line of antennas, a sampling of which are shown in Figure 1. We make some basic recommendations about the use of several Cisco antennas and provide a full description of the benefits of choosing Cisco as your antenna supplier.

Figure 1. Various Antennas Commonly Found in WLAN Systems

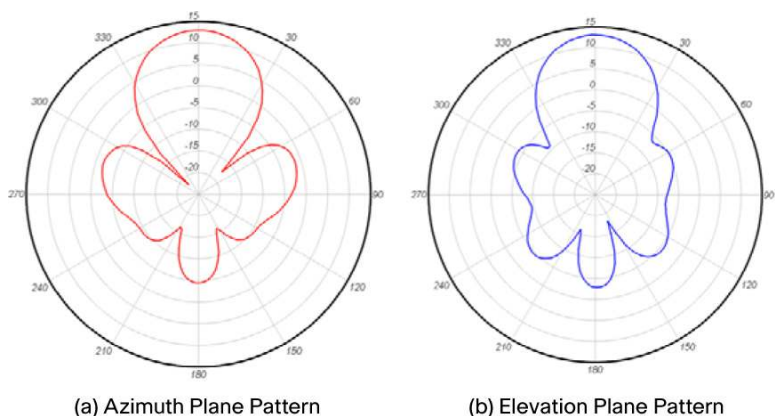


Antenna Parameter Descriptions

The two most commonly used antenna parameters are “gain” and “beamwidth.” Knowing these two parameters is often enough to describe the function of the antenna and make basic decisions about its use.

For the purposes of the discussion of gain and beamwidth, we will refer to the antenna patterns shown in Figure 2. These patterns are from a 2 x 2 patch array. These patterns show the raw data plotted on a 40-dB scale.

Figure 2. Antenna Patterns from Cisco Aironet 1310 Outdoor Access Point/Bridge, a 2 x 2 Patch Array



Gain

It is common to use the term “gain” when talking in particular about the “peak gain.” We always state the gain of an antenna as a single number and it should be understood as being the peak value of the gain.

Think of gain as a description of the distribution of the energy radiated by the antenna. It can't be stressed enough that antennas do not "create" power; they merely distribute it over a surface. In general, if the gain is high, the area over which the power is distributed will be low (at least in one plane). So high gain typically implies narrow beamwidth.

The gain of an antenna (in any given direction) is defined as the ratio of the power gain in a given direction to the power gain of a reference antenna in the same direction. It is standard practice to use an isotropic radiator as the reference antenna in this definition. Note that an isotropic radiator would be lossless and that it would radiate its energy equally in all directions. That means that the gain of an isotropic radiator is $G = 1$ (or 0 dB). It is customary to use the unit dBi (decibels relative to an isotropic radiator) for gain. Gain expressed in dBi is computed using the following formula:

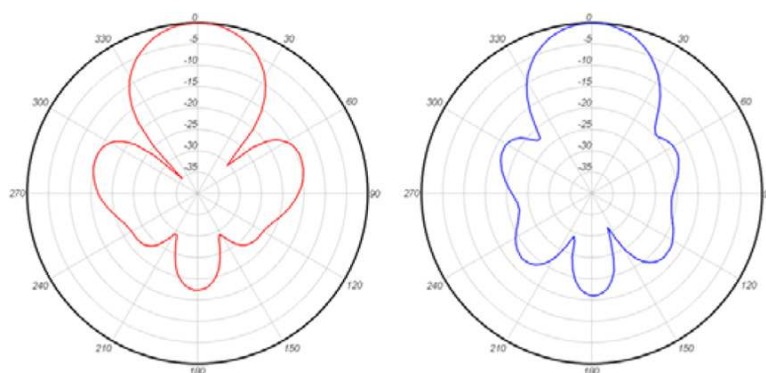
$$G_{dBi} = 10 \cdot \log(G_{\text{Numeric}}/G_{\text{Isotropic}}) = 10 \cdot \log(G_{\text{Numeric}})$$

Notice that this definition does not describe a peak value or the gain in any particular direction. The gain describes the distribution of power over all angles. It is a 3D concept. So a peak gain of 7 dBi indicates that this antenna directs 7 dB more of the available power in a single direction an isotropic radiator would as shown in Figure 2. This fictitious isotropic radiator would radiate all its available power equally in all directions and its 3D radiation pattern would be a sphere. Notice that an isotropic radiator would fit the definition of an omnidirectional antenna, but not all omnidirectional antennas would fit the definition of isotropic antennas. An isotropic antenna is a "concept" rather than a description of a real antenna.

Occasionally, a theoretical dipole is used as the reference; in this case, the unit dBd (decibels relative to a dipole) is used to describe the gain. This unit tends to be used when referring to the gain of omnidirectional antennas of higher gain, especially in land-mobile-radio and amateur radio circles. In the case of these higher gain omnidirectional antennas, their gain in dBd would be an expression of their gain above 2.2 dBi. So if an antenna has a gain of 3 dBd, it also has a gain of 5.2 dBi.

If you look at Figure 2 again, you'll see that the "gain" of that antenna is about 13 dBi, judging from the peak of the pattern. Frequently, patterns are shown normalized to the peak gain. This normalization often makes it easier to determine side lobe levels, front-to-back ratios, and other antenna parameters by inspection from the normalized patterns. If the antenna patterns from Figure 2 are normalized to the peak gain, the patterns shown in Figure 3 are the result. The patterns look the same and are shown on a 40-dB scale as before, but the value of the side lobe levels and other parameters are more obvious.

Figure 3. Normalized Antenna Patterns from Cisco Aironet 1310 Outdoor Access Point/Bridge, a 2 x 2 Array

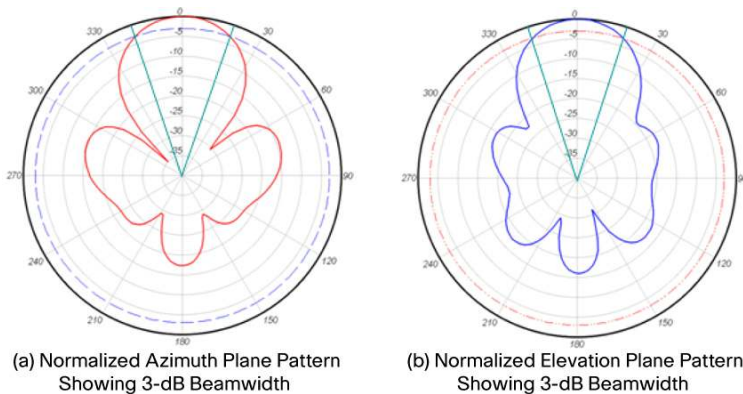


(a) Normalized Azimuth Plane Pattern (b) Normalized Elevation Plane Pattern

3-dB Beamwidth

The 3-dB beamwidth (or half-power beamwidth or just beamwidth) of an antenna is typically defined for each of the principal planes. As Figure 4 illustrates, the 3-dB beamwidth in each plane is defined as the angle between the points in the main lobe that are down from the maximum gain by 3 dB (the power is reduced by one-half at these points).

Figure 4. Normalized Antenna Patterns for the Cisco Aironet 1310 Outdoor Access Point/Bridge Showing the 3-dB Beamwidth



The dashed circles in each antenna pattern represent a normalized gain of -3 dB. The points where these circles cross the patterns represent the -3 dB points and are used to determine the 3-dB beamwidth. The 3-dB beamwidth is the angle between these two points. In the azimuth plane, the -3 dB points are 341 degrees and 19 degrees, yielding a 3-dB beamwidth of 38 degrees. In the elevation plane, the -3 dB points are 342 degrees and 18 degrees yielding a 3-dB beamwidth of 36 degrees.

Antennas with wide beamwidths typically have low gain and antennas with narrow beamwidths tend to have higher gain. Remember that gain is a measure of how much of the power is radiated in a given direction. So an antenna that directs most of its energy into a narrow beam (at least in one plane) will have a higher gain.

Cisco's Test and Measurement Capabilities

All antenna data sheets contain gain and beamwidth specs. Cisco is unique in the WLAN business in that we make all our own antenna measurements so that all the antenna specifications can be verified before a design is approved for use with Cisco Wi-Fi products. Cisco can produce not only conducted measurements like voltage standing wave ratio (VSWR) with a network analyzer, but also antenna patterns in an anechoic chamber that has been designed and built to accommodate the types of antennas that we use and sell.

An anechoic chamber is a specially built room that is used to mimic "free space" so that antenna measurements can be made accurately and without interference. The word "anechoic" means "without echo," implying that there are no stray signals bouncing around on the inside of the chamber corrupting the measurements. The idea is to produce an accurate description of an antenna's radiation pattern. This means suppressing unwanted signals coming from outside the chamber as well as keeping energy from the measurements being made from bouncing around (echoing) on the inside of the chamber. As shown in Figure 5, the Cisco anechoic chamber is built with all metal walls and is a completely shielded enclosure. With this shielding, stray signals from outside the anechoic chamber do not corrupt the measurements on the inside of the chamber.

Figure 5. The Outside of the Cisco Anechoic Chamber



But an anechoic chamber is not just a big metal room. The inside of the Cisco anechoic chamber is lined with pyramidal shaped absorber material, as shown in Figure 6. Any reflections of energy generated on the inside of the chamber are suppressed by the absorber so that the probe antenna (the horn in the back) receives only the direct energy from the antenna under test. The absorber is a foam material that is somewhat fragile (the chamber is not really designed to accommodate people. There are little lights and only a small space for the operator to walk in and mount the antenna. That area is covered in a “walkable” absorber and that is the only place to move around inside the chamber. The operator exits the chamber and the door is closed for any testing. Most absorber material tends to work well when the energy strikes it at angles close to 90 degrees. The pyramidal shape extends the usefulness of the absorber by presenting several possible angles of incidence. Smaller or larger cones are required depending on the frequency range of the chamber. The Cisco chamber has been designed to provide accurate results up to and beyond 6 GHz. Styrofoam is used to provide support to the antenna under test since it has a very low dielectric constant and thus produces only very small reflections.

Figure 6. The Inside of the Cisco Anechoic Chamber



The anechoic chamber plays a large role in the design and qualification of any antenna product. In order to verify a third-party antenna, measurements are made in the Cisco anechoic chamber to check gain, beamwidth, front-to-back ratio, side lobes, and so on. We work hard to maintain good correlation with our antenna suppliers and to ensure that our results are accurate. From early prototypes to production antennas, the anechoic chamber is used to check all the specs along the way. As an example, consider the Cisco Aironet 2-dBi Diversity Omnidirectional Ceiling-Mount Antenna, product ID AIR-ANT24020V-R, shown in Figure 7. This very popular 2.4-GHz antenna performs well and is easy to mount to a ceiling grid system.

Figure 7. Cisco Aironet 2-dBi Diversity Omnidirectional Ceiling-Mount Antenna (AIR-ANT24020V-R)



Figure 8 shows the patterns that Cisco reports in the Antenna Reference Guide (see http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/product_data_sheet09186a008008883b.html for all Cisco's antenna products). These are the patterns assuming the antenna is pointing down toward the floor. Note that the azimuth plane patterns are somewhat noncircular. This is due to the presence of the second antenna in the package. There will always be some effect from the surrounding antennas. Any patterns that are "too ideal" should be greeted with some skepticism.

Figure 8. Azimuth and Elevation Plane Patterns from Cisco Aironet 2-dBi Diversity Omnidirectional Ceiling-Mount Antenna

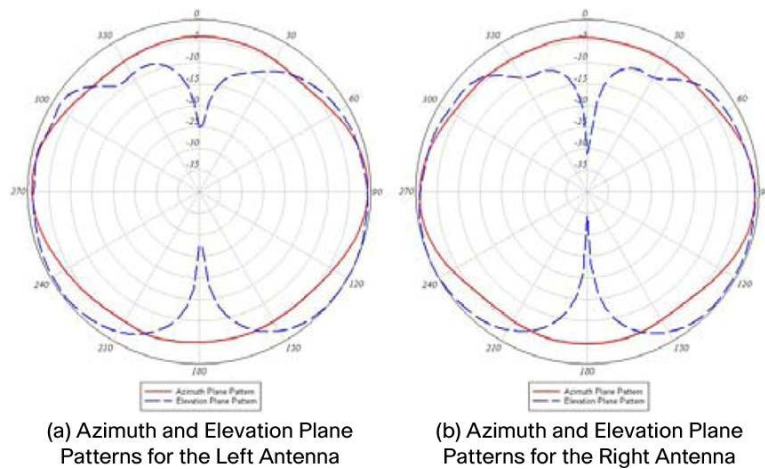
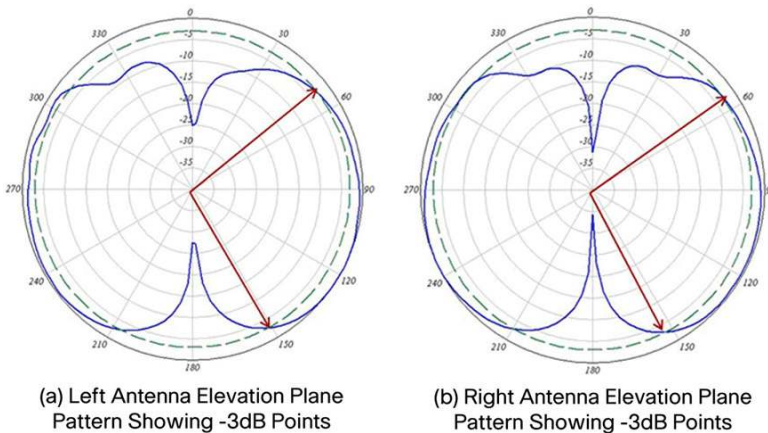


Figure 9 shows normalized patterns, as is the custom to make the examination of the patterns simpler. Considering now only the elevation plane patterns, the beamwidth can be read directly from the graphs. Figure 9 shows only the elevation plane patterns of both antennas in the AIR-ANT24020V-R; the 3-dB beamwidth is shown as the angle between the red arrows. The beamwidths are about 97°, just as listed in the data sheet. The chamber is used to verify the manufacturer's specs as well as to ensure that our advertised specs are accurate. The chamber is an invaluable tool for working with antennas.

Figure 9. Elevation Plane Patterns from the Cisco Aironet 2-dBi Diversity Omnidirectional Ceiling-Mount Antenna Showing the 3-dB Beamwidth



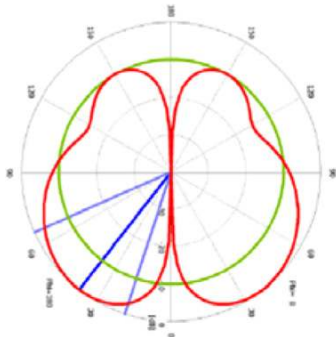
As an example of how things might be wrong, a portion of another antenna vendor's data sheet is shown below in Figure 10. The specs are shown along with the patterns from the antenna in question. Note that the data sheet shows that the vertical (elevation plane) beamwidth should be 80°. Even a casual glance at the patterns shows that the elevation plane beamwidth is not 80°. It appears to be closer to 50°.

Another potential problem with these patterns is that they are obviously simulations. This output is not measured data. These are two very common problems that are encountered when looking at antenna data sheets. The data must be measured data and the data must match the data sheet. Measured data is typically distinguishable from a simulation by less-than-ideal features in the patterns. Sometimes these less-than-ideal features are subtle, but more often they are fairly obvious. Small "bumps" or "dips" - like blemishes in an unretouched photo - will be visible. As for the antenna shown in Figure 10, no one knows how this antenna behaves because nothing about these specs is believable. The specs and the patterns do not match. It may be that neither is correct.

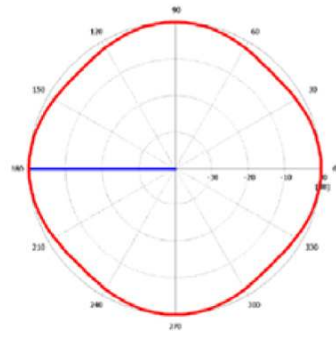
These types of data sheet inaccuracies are all too common as antenna suppliers try to keep up with one another or come out with the same products for a given market. In the best case, these problems are typos but often they are not. Cisco antenna products go through a detailed qualification process that always includes measuring the patterns in the anechoic chamber with several samples. The data sheets match the patterns and the patterns are always measured data, so they can be trusted. Cisco suppliers also go through a detailed audit process to ensure that their quality standards and test methods are state-of-the-art. Everything is done to make sure that our antennas perform as advertised.

Figure 10. Sample Antenna Data Sheet for Another Vendor's 5-GHz Ceiling Mount, Diversity Omnidirectional Antenna

| Specifications | |
|-----------------------------|-------------------------|
| Model | |
| Frequency Rang | 5150- 5850 MHz |
| Bandwidth | 700 MHz |
| Gain | 4.5 dBi |
| Vertical Beamwidth | 80° |
| Horizontal Beamwidth | 360° |
| VSWR | -/± 1.5 |
| Nominal Impedance | 50 Ohms |
| Polarization | Vertical |
| Max Power | 50 Watts |
| Connector | RPTNC Plug with Pigtail |
| Dimensions | 7.5" x 4.3" x 0.9" |
| Weight | 0.88 lbs |
| Rated Wind Velocity | 135 mph |
| Operating Temperature Range | -22°F to + 158°F |
| Mounting Way | Ceiling Tile Clips |



Vertical Radiation Pattern



Horizontal Radiation Pattern

Cisco's Antenna Design Capability

Cisco uses its anechoic chamber not only as a qualification tool, but also as a design tool. Several of Cisco's antennas have been designed in-house. We use state of the art 3D electromagnetics modeling software to design wireless LAN antennas for use with our access points, as well as to design the antennas that are integrated into certain access points like the Cisco Aironet 1131 and the Aironet 1140 Series and the Cisco Aironet 1310 Outdoor Access Point/Bridge. This ensures that our RF systems all work together in an optimal way and that we maintain compliance with the regulatory bodies around the world.

Cisco owns various prototyping tools for antenna construction, such as circuit board processing equipment and various mechanical tools like lathes, saws, drills and grinders. Our software and our prototyping tools allow us to build very accurate prototypes and to get an excellent idea about how the final product will behave. Prototypes are tested in our anechoic chamber as soon as they are complete. The electrical performance is checked every step of the way through the design process.

An antenna design goes through a concept phase and then into a prototype stage where all the performance parameters are measured over multiple units to make sure that we get the results we need. The anechoic chamber plays a key role in this testing. Final design verification takes place with units that have been built in our production facility in a pilot run of the product. Electrical design verification includes testing every electrical parameter in the data sheet as well as a few more to make sure that the performance is as expected. Mechanical design verification includes things like mechanical shock testing and thermal testing as well as any environmental tests required (for example, water tightness or resistance to salt fog). Cisco uses independent labs to perform environmental tests, as these generally require highly specialized equipment.

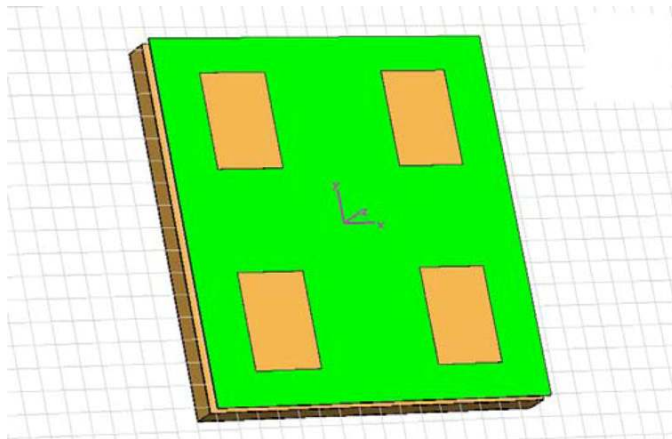
As an example, consider the Cisco Aironet 1310 Outdoor Access Point/Bridge, 2.4-GHz bridge product shown in Figure 11. That antenna was designed in-house at Cisco. The antenna is a 2 x 2 (4-element), 13-dBi patch array and is integrated into the front panel of the Cisco Aironet 1310 bridge.

Figure 11. Cisco Aironet 1310 Outdoor Access Point/Bridge (BR1310)



The design of this antenna started out as a simulation using our 3D electromagnetics modeling software. The design is modeled as closely as possible to the way in which it will be built, shown in Figure 12. The model is then divided into very small blocks in a fine grid (not related to the workspace grid shown) and the electric and magnetic fields are determined over the entire workspace. From those fields, all the antenna parameters are extracted and displayed.

Figure 12. Cisco Aironet 1310 Antenna Model Ready for Simulation



If the simulated results look good and a number of other simulated checks look good (to investigate tolerances in board thickness, physical dimensions, and so on), a prototype is built. The first prototype of the Aironet 1310 antenna is shown in Figure 13. There are some minor differences from the simulation because some things had to be built “on-the-fly” (as in many lab experiments). The circuit boards and the metal backing were built here in the Cisco facility in a matter of hours. The next step is to do some measurements in the chamber.

Figure 13. First Lab-built Prototype Model of the Cisco Aironet 1310 Antenna.

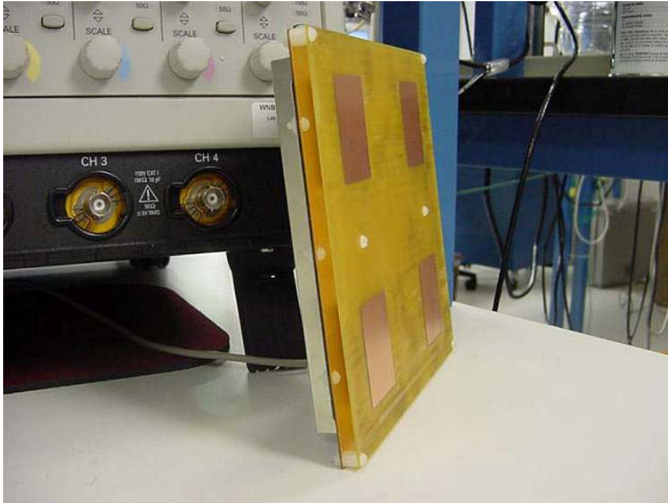
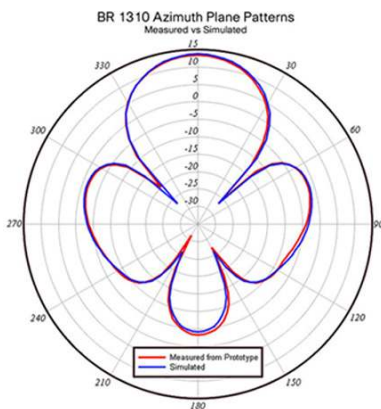


Figure 14 shows a plot of the azimuth plane pattern of the simulation as well as the measurement. Note the close correlation in the data. The simulation software is absolutely essential to getting things right and making sure that the antenna will perform before it is even built. In this case, the patch elements were positioned to maximize gain and keep the side lobes relatively low at the same time. This trade-off exercise was done with the simulation software so that several prototyping steps were not required. Cisco invests in the proper technology to do the proper job. Whether it is the qualification of a third-party antenna or the in-house design of an antenna, Cisco has the tools, the experience, and the expertise to develop high-quality, high-performance products.

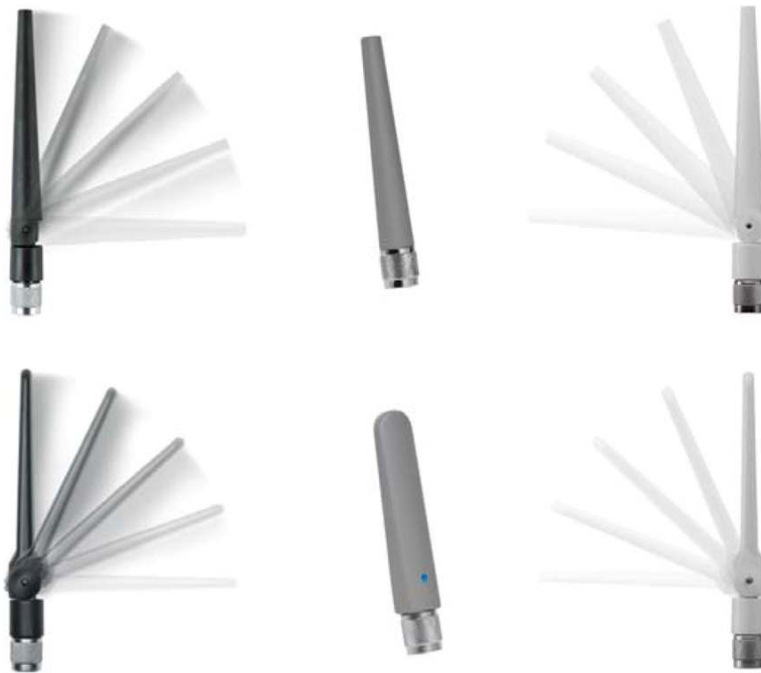
Figure 14. Simulated and Measured Azimuth Plane Pattern of the Cisco Aironet 1310 Prototype Antenna



A Full Line of Antennas

With Cisco's long history in the WLAN arena, it makes sense that we supply a wide range of antennas that cover every type of installation plan. We have a complete line of dipole antennas that can be attached directly to the access point (see Figure 15). There are black and white articulating dipoles for both bands, as well as shorter, nonarticulating gray dipoles designed to match the Cisco Aironet 1250 Series, and future access points with antenna connectors on the top of the housing. These antennas all provide the same coverage but allow for a different look for specific environments. Cisco 5-GHz dipole antennas are distinguished by a blue dot on the body of the antenna. The 2.4-GHz dipole antennas have no identifying mark.

Figure 15. Cisco Dipole Antennas for Indoor Access Points



As Figure 16 shows, Cisco also offers an array of omnidirectional antenna products for both the 2.4- and 5-GHz bands. Some are “stick” omnidirectional antennas offering a classic omnidirectional pattern, with the peak gain at the horizon, and some are low-profile omnidirectional antennas that give a more down-tilted pattern. There are omnidirectional antennas to mount on masts as well as plenty of solutions for the ceiling grid. Two of these antennas are actually diversity antenna packages, meaning they contain two antennas inside the same enclosure. This simplifies the mounting scheme and provides a single, unobtrusive look without the loss of performance. The indoor antenna solutions are provided with plenum-rated cable to meet the fire codes in many areas.

Several patch antennas are available for each band as well (see Figure 17). Patch antennas are really designed to be wall-mounted and cover areas out in front of the antenna. While these antennas are capable of being deployed outdoors, they all come equipped with plenum-rated cables for indoor deployments where this is required.

Figure 16. Cisco's Omnidirectional Family of Antennas for Indoor Access Points



Figure 17. Cisco Patch Antennas



There are also antennas specifically designed for use with our multiple-input multiple-output (MIMO) access points, such as the Cisco Aironet 1252 Access Point. These antennas are built for each band, and they each contain three antennas, again simplifying installation and providing a clean look when a large number of antennas are deployed. Cisco's MIMO antennas are ceiling-mount, omnidirectional antennas designed to mount to standard grid ceiling systems. Figure 18 shows the [Cisco Aironet 3-dBi Omnidirectional Antenna \(AIR-ANT2430V-R\)](#) and the [Cisco Aironet 4-dBi Omnidirectional Antenna \(AIR-ANT5140V-R\)](#). All Cisco 5-GHz antennas can be identified by their blue marker on the cables or by the blue heat shrink on the connectors, whereas the 2.4 GHz antennas have no marker on the cable and use standard black heat shrink.

Figure 18. Cisco MIMO Ceiling-Mount, Omnidirectional Antennas



With this family of antennas, and the rest of our antenna products (see all your options at http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/product_data_sheet09186a008008883b.html), Cisco offers an antenna that will meet your needs.

Cisco Should Be Your WLAN Antenna Supplier

Cisco has a full line of antennas, each of which is subjected to a range of tests to help ensure high-performance. Cisco has the experience and the engineering expertise in this area where others may not. Our antennas have been fully integrated and tested with the Cisco Wireless Control System (WCS). All the features you rely on, such as rogue access point detection, location services, and radio resource management (RRM), have been fully qualified using Cisco antennas. These features demand consistent antenna performance, which is what we deliver. With Cisco antennas, you also get full support from the Cisco Technical Assistance Center (TAC). Cisco's own FCC Part 15 product approvals are based on the use of Cisco antennas, not unknown, third-party products. In contrast to antennas from many other vendors, with Cisco antennas, you get accurate data sheets, performance descriptions, and products made with high-quality materials. We deliver the type of performance that you demand.



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