EBOOK

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ANTENNAS 101

Implications of Internal vs External Antenna Designs

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CONTENTS

ABOUT SYMMETRY ELECTRONICS

Established in 1998, Symmetry Electronics is a focused global distributor of wireless connectivity solutions, sensors, and audio-video technologies. Offering comprehensive design support and available-to-ship inventory, Symmetry is committed to helping engineers accelerate time to market, reduce costs, and offer modern solutions for their IoT designs. Acquired by the Berkshire Hathaway company TTI, Inc. in 2017, Symmetry Electronics is part of the Exponential Technology Group (XTG) – a supergroup of electronic component distributors and engineering services firms working together to accelerate the growth of the electronics industry.

SYMMETRY ELECTRONICS

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ANTENNAS 101: Implications of Internal vs External Antenna Designs

Wireless connectivity plays a major role in the Internet of Things (IoT). One crucial component of IoT product development is determining the ideal antenna to integrate into your design. Selecting the incorrect antenna in terms of addressing sizing on the PCB or needed range for the application could turn into a costly pitfall. The expert Applications Engineers at Symmetry Electronics are helping engineers and designers cut the guesswork out of antenna selection with our Antennas 101: Implications of Internal vs External Antenna Designs e-book. Follow along as we uncover the pros and cons of internal vs external antennas and key applications where these specific form factors are optimal. Working in positioning, short, or long-range applications? Be sure to browse our Antenna Selector Guide for a convenient way to narrow down the ideal solution for your unique use case.

Internal vs. External Antennas - Which Reigns Supreme?

	Abracon	AVX	EAD	Taoglas	TE Connectivity
Cellular (5G/LTE/3G)	▲	▲	▲	▲	▲
Bluetooth/Wi-Fi/Zigbee	▲	▲	▲	▲	▲
ISM/LoRa®/Sigfox	▲	▲	▲	▲	▲
GNSS	▲	▲	▲	▲	▲
Ultra-Wideband (UWB)		▲		▲	
Satellite Communications	▲			▲	▲

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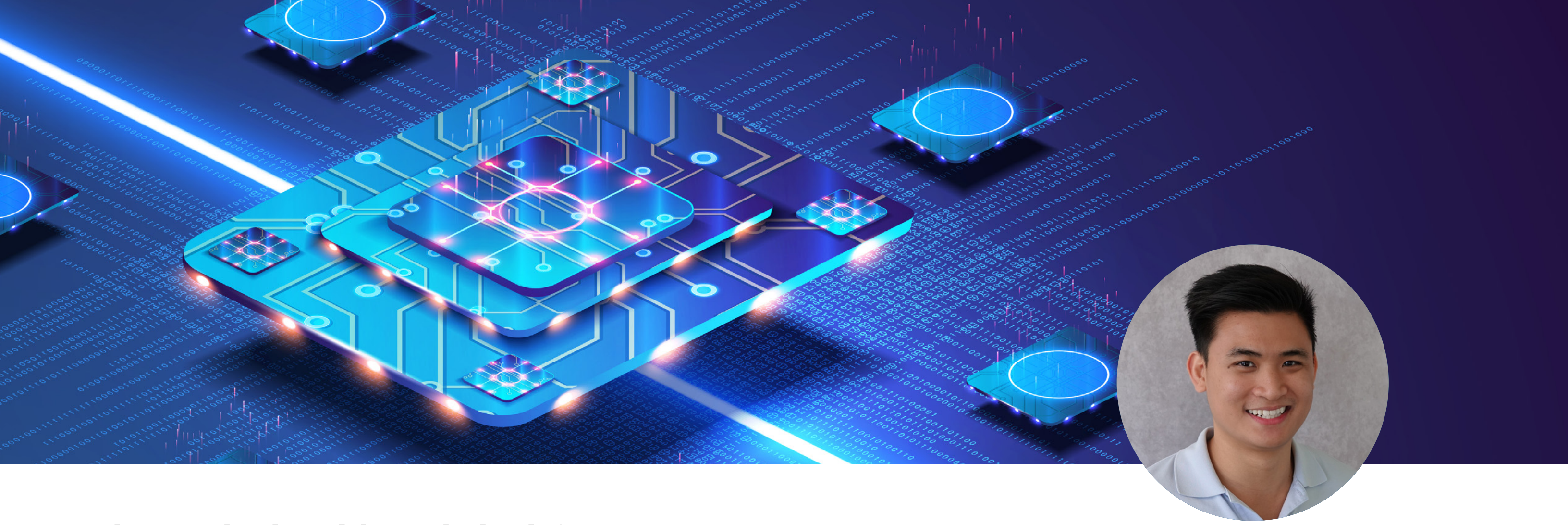
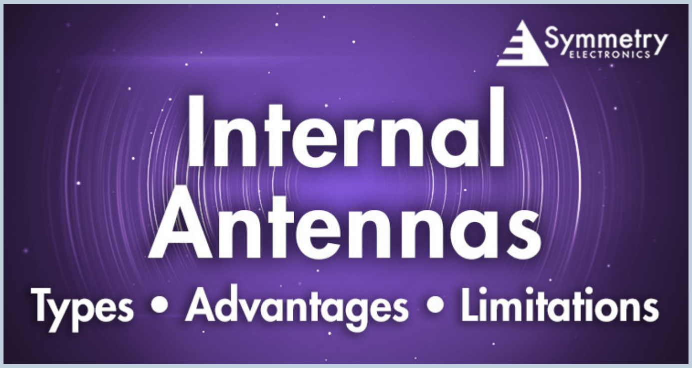


INTERNAL ANTENNAS:
Different Types and Advantages

BY AUGUSTINE NGUYEN
APPLICATIONS ENGINEER

The continuing evolution of IoT applications has introduced a demand for wireless devices to become smaller with each iteration. As devices continue to decrease in size, their antennas must become smaller along with them, thus making internal antennas increasingly more prevalent in today's market. Compact devices require internal antennas that are capable of meeting stringent size requirements while meeting high-performance standards. However, the smaller the antenna, the more difficult it is to meet these standards. Additionally, internal antennas present a new set of challenges for designers in comparison to their external antenna counterparts, as they are much more sensitive to product design factors such as ground plane size, enclosure material, and components that are in close proximity on the PCB. The purpose of this article is to outline the different types of internal antennas, their key performance parameters, and their specific design advantages.



Internal Antennas:
Different Types and Advantages

INTERNAL VS. EXTERNAL ANTENNAS

In comparison to internal antennas, external antennas are much more performance stable and easy to integrate. This is because external antennas are generally designed to be ground plane independent, meaning that the size of the PCB area to which it is connected does not play as big of a factor when it comes to performance. Conversely, internal antennas tend to have poorer efficiency, Voltage Standing Wave Ratio (VSWR), and gain (dBi) figures overall, especially in the lower frequencies, such as LTE bands 12 and 13 that cover the 700MHz spectrum. Due to all of the design considerations associated with internal antennas, engineers often opt for an external solution if they are not limited to size and form factor constraints for their project. For a more detailed analysis into key antenna performance parameters and comparisons between internal versus external antennas, please refer to our External Antennas: Different Types and Advantages blog.

Not sure which type of antenna is optimal for your design? Reference our FREE comprehensive Antenna Selector Guide.

TYPES OF INTERNAL ANTENNAS

EMBEDDED PCB/TRACE ANTENNAS

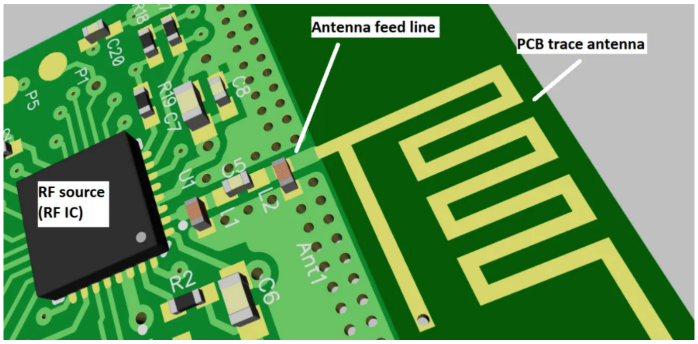


Figure 1: Example of a PCB/Trace Antenna design.

An embedded PCB antenna is a custom solution that is typically a metal trace printed onto the top layer of the PCB. Other types of PCB antenna designs require the trace to be laminated evenly across multiple layers on a board where vias are needed, to interconnect all the traces on each layer.

There are multiple key advantages with this antenna design approach. First, PCB antennas are the most cost-effective option to implement compared to all other internal antennas due to the fact that you are technically not purchasing a third-party component from a supplier. This is because the manufacturing cost of a PCB antenna is included in the PCB assembly process when a project is in the mass production phase.

A second advantage of using a PCB antenna is that it is the lowest profile approach for internal antennas due to it being a part of the PCB's surface. The only space a PCB antenna occupies is a copper-free surface where there is a sufficient amount of space for the antenna to be mounted (the antenna clearance area). However, keep in mind that because of this, the total area required is always much greater than the size of the metal trace itself which could be a potential waste of valuable PCB real estate.

Despite the affordable cost and low-profile benefits of PCB antennas, there are a couple of key drawbacks that can make them undesirable for certain projects. First, although they are a very simple design in principle, properly integrating them to achieve optimal performance for your specific PCB will require a considerable amount of RF design expertise–there is no "one fits all" approach for PCB antenna designs. Since the PCB antenna is part of the board itself and is entirely ground plane dependent, it makes it very susceptible to any subtle changes to the PCB size. Proximity to other components on the board can also cause undesirable effects to the antenna's performance. Any slight variation in the PCB design could result in the antenna being detuned from its intended center frequency and cause overall signal reception issues. Furthermore, when comparing the RF performance of a PCB antenna to other internal antennas, their inherently simple design and extreme sensitivity make them the poorest performing option in terms of range. Additionally, since the antenna is integrated during the PCB manufacturing process, customers will have no flexibility in terms of optimizing the antenna's performance. Consequently, it is common that multiple design iterations of the entire PCB will be required just to optimize the antenna, thus resulting in additional cost and development time for the customer.

CHIP ANTENNAS

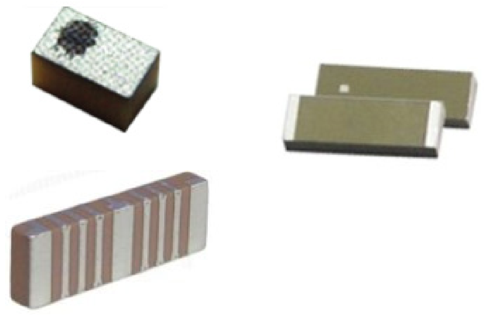


Figure 2: Ceramic Chip Antenna examples.

A chip antenna is made of ceramic and is the smallest, discrete type of internal antenna available. These antennas can be purchased as a separate component, which is one of their main advantages in comparison to that of a custom solution (such as a PCB antenna), as their performance optimization becomes easier and more flexible even after the chip antenna is integrated on the board. Chip antennas offer numerous features that contribute to their ease of optimization, including their impedance matching network and the option for additional ground clearance beneath the antenna to further adjust frequency tuning.

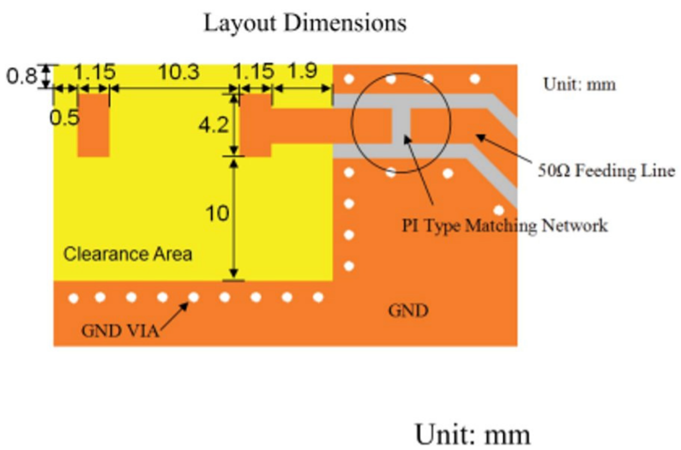


Figure 2: Ceramic Chip Antenna examples.

Chip antennas are the most ideal solution for small IoT applications that have strict size requirements for the PCB. A typical trace antenna will not be suitable in this scenario because although they are very low profile, they would still require more space on the PCB to account for both the metal trace and the required ground clearance area beneath it. Conversely, chip antennas are better suited for small boards since they typically take up less PCB area, despite being thicker in size. Additionally, there are chip antennas that are designed to work on-ground, or over a copper layer (often called "over-metal") of the PCB. These on-ground antennas require a more vertical design compared to their off-ground counterparts, fortunately without compromising radiation performance. This makes the chip antenna an even more viable solution for small form factor applications, as there will not be a need to increase PCB size to integrate them–thus saving on manufacturing costs. Chip antennas also boast superior performance when compared to a trace antenna, since they are less susceptible to detuning from other components or environmental factors that are within close proximity.

Although chip antennas have their benefits, they still come with a few disadvantages. One factor being their initial cost, since the customer will have to rely on a specific manufacturer to supply this component for mass production. Another prominent challenge that chip antennas present is that, despite them being easier to optimize, they are still very sensitive and are subject to similar design rules as trace antennas during integration. Finally, considerable RF design expertise would be required to achieve optimal system performance.

EXAMPLES OF CHIP ANTENNAS AVAILABLE AT SYMMETRY ELECTRONICS:

Taoglas Antennas: PCS.68.A, WLA.01
AVX Antennas: 1004795, M310220

PATCH ANTENNAS

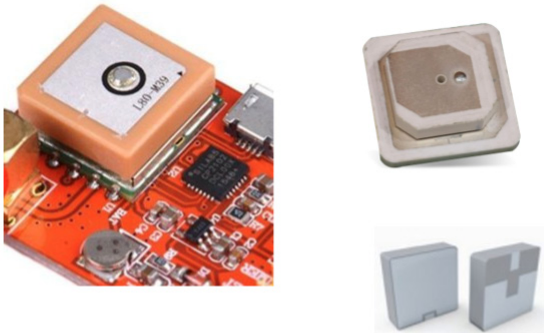


Figure 4: Patch Antenna examples.

A patch antenna, also known as a microstrip antenna, is essentially made up of two main layers: a ground plane at the bottom and a dielectric substrate on top. Upon the substrate layer lies a conductive patch including a specific geometry that serves as the radiating component that connects to the radio via a feedline. These antennas are popular due to their low profile, robust design, and stable performance for high volume applications. They are especially well-suited for very high frequency wireless protocols due to their physical dimensions that have a direct correlation with the wavelength. Additionally, the inherent design of patch antennas allow them to have a good amount of flexibility in terms of manufacturing and utilization.

There are multiple techniques that can be applied for feeding a patch antenna, including coaxial probe feeds, microstrip lines, aperture coupling, and proximity coupling. Each technique provides their own set of advantages in terms of ease of implementation, out-of-band spurious emissions, and bandwidth. Patch antennas are also diverse in terms of their polarization capabilities. Depending on their design, these antennas can be both linear and circular polarized (Dual Polarized). This is particularly useful for GNSS and satellite communication applications that typically rely on right-hand circular (RHCP) or left-hand circular (LHCP) polarizations for their antennas. The polarization of an antenna essentially describes the general direction of the electric field that is oscillating away from the source. Another unique feature of many patch antennas is that they can be integrated with ICs to effectively make them active antennas. The most common implementation is to have Low-Noise Amplifiers (LNA) embedded within these antennas to drastically improve signal reception. For example, this could be used to address weak satellite signals that are commonly found in GNSS applications. Additionally, this could be very useful for designers who typically have to design in the LNA as a separate external component on the antenna's feedline–which effectively takes up more PCB space, often resulting in the need to increase the board size and ultimately increasing costs.

Although patch antennas have several advantages, they also have a few disadvantages. For example, when compared to other discrete surface mounted antennas (i.e. chip antennas), patch antennas would generally take up more PCB area/size. Additionally, if the patch antenna has an LNA integrated, you would have to take into account the additional power consumption of that active component.

EXAMPLES OF PATCH ANTENNAS AVAILABLE AT SYMMETRY ELECTRONICS:

Taoglas Antennas: HP5010A, GPDF5012.A
AVX Antennas: 1001039, 1002649

FLEXIBLE PRINTED CIRCUIT (FPC) ANTENNAS

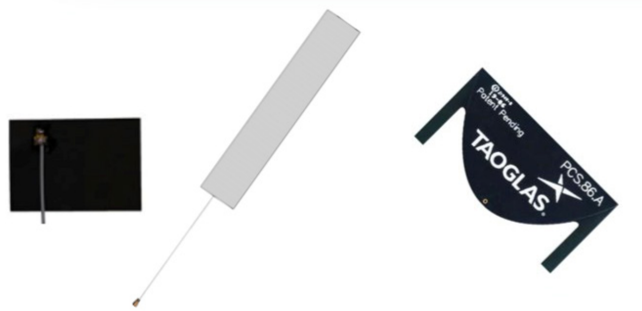


Figure 5: FPC Antenna examples.

When compared to all the other types of internal antennas discussed in this article, FPC antennas are by the far the easiest to work with in terms of integration and optimization. Unlike trace, chip, and patch antennas that tend to be ground plane dependent and are very sensitive to many factors of the PCB, FPC antennas already have their own ground plane embedded within. They serve as a "plug-and-play" solution, as they already come with a cable and connector and can operate efficiently using minimal PCB space. The only design modification needed to support an FPC is the addition of a miniaturized RF connector like an U.FL port on the PCB that would serve as the antenna's feed point to the radio. As a result, little to no RF expertise is required on the customer's side, as they will not have to implement an impedance matching network on the PCB to further optimize the antenna's performance. The absence of an impedance matching network and the fact that a FPC antenna is mounted "off-board" within a product's enclosure makes it the perfect solution for customers who do not have the sufficient board size to accommodate a surface mounted antenna.

Although FPC antennas are usually higher in price compared to other internal antenna options, being able to use them to bypass typical board design challenges could ultimately save time and engineering resources. The main design factors that have to be considered when using an FPC would be its cable length, as this would contribute to the FPC's signal path loss and its proximity to the PCB ground plane when it is mounted within the housing.

EXAMPLES OF FPC ANTENNAS AVAILABLE AT SYMMETRY ELECTRONICS:

Taoglas Antennas: FXUB66.07.0150C, FXUB71.A.07.C.001

AVX Antennas: 1002289, 1001932FT

CONCLUSION

With the increase in demand to make consumer electronics and many other embedded systems smaller, antenna suppliers are having to respond by developing a variety of diverse internal antenna options to support the unique requirements of new applications. Custom trace, ceramic chip, passive/active patch, and FPC antenna designs are all having to adapt to meet the demand of these shrinking devices. Due to this, it is very important that designers of these small-sized applications understand the specific advantages and drawbacks that each type of antenna has to offer. Factors during the design process like PCB area restrictions, product enclosure, minimum efficiency performance, cost, and access to RF expertise, are all crucial elements that must be considered prior to finalizing your internal antenna selection.

Need help narrowing down which type of antenna will work best for your specific use case? Consult our convenient Antenna Selector Guide for more information.

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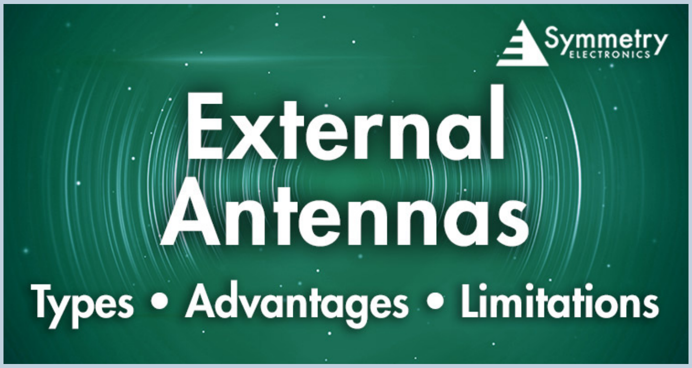
EXTERNAL ANTENNAS:
Different Types and Advantages

BY AUGUSTINE NGUYEN
APPLICATIONS ENGINEER

Antennas are major components used in wireless technologies that range from small antennas embedded in mobile devices to massive antenna arrays found in cellular or satellite base stations. Although antennas exist in many shapes and sizes, virtually all of them belong to one of two main categories: Internal or External. Internal antennas are embedded within a device's enclosure and are relatively out of reach to the end user. These range from small chip or PCB-etched antennas integrated onto the board, to flexible printed circuit (FPC) antennas that are mounted to the inside of a product's enclosure. Alternatively, external antennas are mounted on the outside of a device's enclosure via an RF connector. A typical example would be a "rubber-duck" antenna that mounts to the outside of an internet router. The purpose of this article is to outline the different types of external antennas, their key performance parameters, and their specific design advantages.



External Antennas:
Different Types and Advantages

IMPORTANT EXTERNAL ANTENNA PERFORMANCE PARAMETERS

Bandwidth: This is defined as the optimal range of frequencies for an antenna to efficiently transmit and receive signals. For example, a Bluetooth antenna performs best in the 100 MHz bandwidth of frequencies at 2.4 - 2.5 GHz. By the inherent nature of antennas, this hypothetical Bluetooth antenna would also be susceptible to frequencies outside it's intended bandwidth, but it is over this specific range of frequencies (2.4-2.5GHz) that the antenna is expected to perform optimally at a certain efficiency (%) level. However, this is dictated by how precise the antenna element is designed. An antenna's bandwidth is typically defined in terms of Voltage

Standing Wave Ratio (VSWR)–a parameter that measures the amount of power that is reflected back to a radio from an antenna (Figure 1). The less power reflected back to the radio, the more efficiently the antenna is able to perform. The preferred VSWR for a particular bandwidth is usually less than or equal to 3:1. For example, an antenna that claims to operate from 100 to 400 MHz may state that its VSWR is less than 1.5 within this bandwidth efficiency. In this case, it would imply that the antenna is expected to reflect around 4% of the power back to the radio.

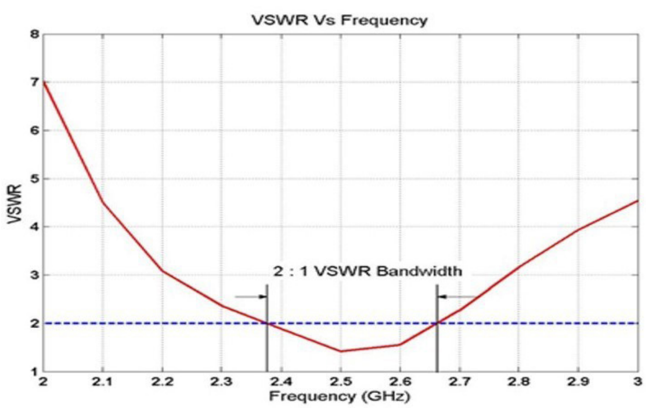


Figure 1: Antenna bandwidth defined by VSWR.

Radiation Pattern: This is less of a numerical parameter and more of a graphical 3D representation of the energy distribution surrounding an antenna. While a 3D radiation diagram is a full representation of an antenna's energy distribution, a 2D diagram is also beneficial in providing an easier way to identify where most of the antenna's energy is concentrated. The main purpose of a radiation pattern is to visualize how omnidirectional (Figure 2) or directional (Figure 3) an antenna is. An omnidirectional antenna is described as having a radiation pattern that is relatively the same in all directions within a single plane (i.e. horizontal x-y plane). Conversely, a directional antenna has less of a symmetrical radiation pattern, with most of its radiated energy concentrated in a single direction.

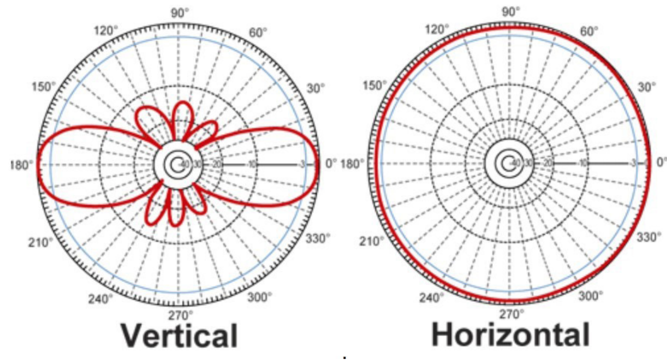


Figure 2: Generic vertical and horizontal radiation pattern of an omnidirectional antenna.

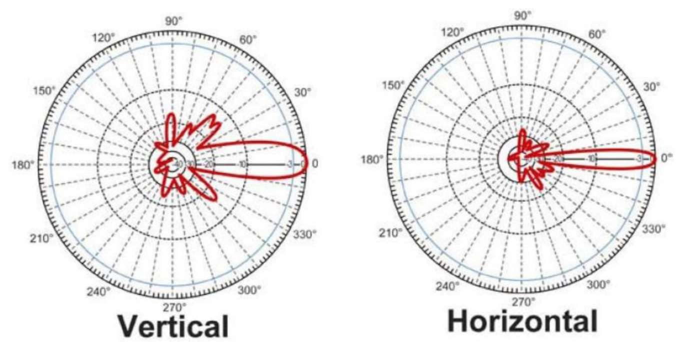


Figure 3: Generic vertical and horizontal radiation pattern of a directional antenna.

Gain: This is the first parameter that is considered when evaluating an antenna's performance. The gain is always described in context of the antenna's radiation pattern, as it is defined as the signal strength in the direction of its peak radiation when compared to that of an isotropic source. An isotropic source is meant to serve as a "reference antenna," although it does not exist physically. The "reference antenna" serves as an excellent comparison source to that of an actual antenna, as the radiation pattern is consistent in all directions.

Reference (Figure 4) for the general formula for antenna gain (dBi).

$$\text{Gain} = \frac{\text{signal intensity in the direction of maximum radiation}}{\text{signal strength of the reference antenna}}$$

Figure 4: Gain (dBi) formula.

For any antenna in practice, increasing its gain means you are increasing its "directivity", which in turn increases the power in a desired direction at the expense of the power being radiated in other directions.

EXTERNAL VS. INTERNAL ANTENNAS

Besides the obvious differences in size and form factor, external antennas offer a series of advantages for customer design in comparison to internal antennas–one being ease of integration. External antennas are typically designed to be "plug-and-play" solutions that simply mate to a transmitter via a specific connector. Conversely, internal antennas (like surface mounted chips) require additional design effort, as further antenna tuning and optimization is required. An internal antenna's performance is influenced by the PCB ground plane, as it serves as an extension of the antenna. In this case, the board area and components on the PCB would have to be considered. Additionally, an impedance matching network may have to be implemented before the antenna feed point to account for these factors on the PCB that will detune the antenna. An internal antenna is also susceptible to signal loss caused by the product enclosure. On the other hand, the majority of external antennas are "ground plane independent," making them an ideal approach for customers seeking a solution that requires fewer design resources and shorter time to integrate to allow for a more rapid time-to-market.

In addition to ease of integration, external antennas offer performance advantages in comparison to internal antennas. Overall, external antennas offer superior range and sensitivity due to the nature of their larger size. This often results in a higher rated gain (dBi) than their internal counterparts. Provided their higher gain, external antennas offer greater directional behavior for applications where signal transmissions are required to be concentrated in a specific direction. Another important factor to consider is that a larger antenna is required to support lower frequencies with longer wavelengths. Because of this, many high gain external antennas maintain a bandwidth that spans in the lower sub-GHz range with acceptable performance.

Due to its smaller size, an internal antenna would not function as well to support lower frequencies. For example, it would be difficult to find an internal antenna that could compete with an external antenna in terms of performance in the 400MHz bandwidth. All these inherent performance advantages (superior range, sensitivity, and ease of integration), combined with the fact that external antennas are outside the enclosure thus providing them with a better signal line-of-sight, makes them more suitable for applications with demanding requirements. However, customers must consider cost when pursuing this option, as additional manufacturing processes and materials are required to produce larger external antennas compared to something like a simple ceramic chip antenna.

TYPES OF EXTERNAL ANTENNAS

OMNIDIRECTIONAL ANTENNAS - TERMINAL-MOUNT, WHIP, "RUBBER DUCK," OUTDOOR DIPOLE

These types of antennas are akin to what you would find on wireless access points. A typical construction would consist of the antenna element enclosed within a rubber or plastic sheath with an exposed RF connector. These omnidirectional antennas are always ground plane independent, making simple coupling to the transmitter the only requirement for integration. Due to the non-directional nature of these antennas, they are meant to be vertically oriented to the ground, as they tend to radiate extensively in its horizontal (x-y) plane. Any wireless applications that require Point-to-Multipoint communication would benefit most from this type of radiation pattern. For example, any office environment where a router is needed to transmit and receive signals from many client devices like computers, phones, or any end-node modules.

EXAMPLES OF OMNIDIRECTIONAL ANTENNAS AVAILABLE AT SYMMETRY ELECTRONICS:

Taoglas Antennas:TG.55.8113, TG.45.8113
Abracon Antennas: AEACAC198013-S698, APAMPSLJ-140

Figure 5: Examples of Terminal-mount, Whip, "Rubber Duck," Outdoor Dipole Antennas.

OMNIDIRECTIONAL ANTENNAS - PUCK STYLE, MAGNETIC-MOUNT, SCREW-MOUNT

These "puck-style" antennas are meant to be mounted flat upon a surface such as a ceiling or roof of an automobile. They can be mounted on a metal or non-metal surface depending on the antenna model. The form factor is a big distinguishable trait, as they are generally a more low-profile design, making them ideal for customers looking for a different aesthetic to a larger profile like a terminal-mount antenna. By design, many puck style antennas are also capable of supporting integrated Low Noise Amplifiers (LNA) to dramatically improve signal reception–particularly for weak incoming GNSS signals. Unlike whip style antennas, puck style antennas are often meant to be horizontally oriented to the ground or sky, as they tend to have more of a 360-degree coverage in the vertical plane. An example would be a Wi-Fi ceiling mounted antenna in the center of a single floor of an office. Signal coverage would have to be downward-facing to ensure proper reception to all the computers, phones, and printers below.

Figure 6: Examples of Magnetic-Mount, Screw-Mount Puck antennas.

Another advantage of the puck-style antenna form factor is that many different models can support multiple wireless protocols. This is optimal for any base station that wants to consolidate all of the different antennas needed for GNSS, Cellular, and Wi-Fi into a single form factor.

A combinational antenna (Figure 7) like this is essentially three different antenna elements housed in a single enclosure, with each varying protocol having its own cable and connector.

Figure 7: Examples of Combinational Antennas.

EXAMPLES OF OMNIDIRECTIONAL ANTENNAS AVAILABLE AT SYMMETRY ELECTRONICS:

Taoglas Antennas: TLS.01.1F21, G30.B.108111
Abracon Antennas: AEACBK081014-M698, AEACAD097015-S698

DIRECTIONAL ANTENNAS - PANEL, DISH, YAGI ANTENNAS

Directional antennas are focused on applications that depend upon long range Point-to-Point or Point-to-Multipoint communication. Because of the very focused radiation patterns of these antennas, you can always expect to see a high rated gain (dBi) in their datasheets (typically above 9dBi). Provided the high peak gain that these antennas provide in a singular direction, they are ideal for any demanding long-range application where an end-node device or a collection of devices are concentrated in a specific area. For example, a pair of office buildings that are sharing the same wireless network would have an outdoor-rated Yagi or panel antenna on each side with both antennas oriented towards one another to form a Point-to-Point communication link.

Figure 8: Examples of Panel, Yagi Directional Antennas.

EXAMPLES OF DIRECTIONAL ANTENNAS AVAILABLE AT SYMMETRY ELECTRONICS:

Taoglas Antennas: LPDA.05.032111
EAD Antennas: LPM8270

CONCLUSION

The continuing evolution of IoT applications has resulted in an increase in demand for a wide variety of antenna options. Whether an engineer is leaning towards an internal solution to meet low cost, high volume, and size requirements; or towards an external solution for ease of design and guaranteed performance–the antenna will always be the crucial interface for your wireless system. It is recommended that the antenna be finalized early in a project's design phase to ensure optimal performance. Fully settling on your product's requirements (such as its PCB design, size, and enclosure) without taking the antenna into consideration will decrease your ability to modify your design in the event that a selected antenna does not fit or is incompatible. In addition to having a full understanding of your application's requirements, being familiar with the different antenna types, their unique advantages, and performance parameters (gain, bandwidth, VSWR, radiation pattern) will always be instrumental in narrowing down the numerous antenna designs that exist today.

ABOUT AUGUSTINE NGUYEN

Augustine Nguyen is an Applications Engineer at Symmetry Electronics. He has his Bachelor's in Electrical Engineering from University of California, Irvine, and five years of hands-on experience in application development and systems testing for Bluetooth and Wi-Fi. In his current role, Augustine works as a technical advisor to assist engineers in designing, developing, and implementing IoT and embedded system products. Augustine is customer service oriented and works diligently to meet customer objectives while providing innovative solutions to common problems. He has extensive knowledge of the latest products and technologies and active relationships with the world's leading electronic component manufacturers.

AUGUSTINE NGUYEN
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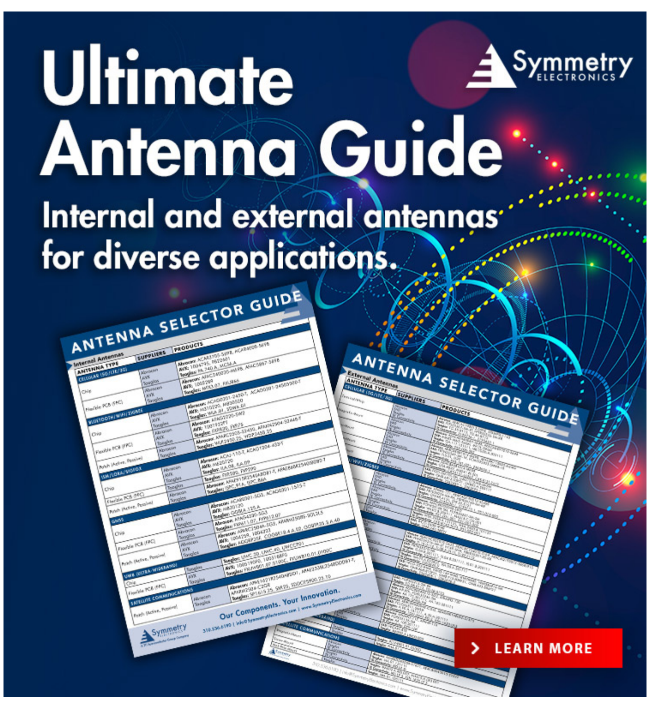

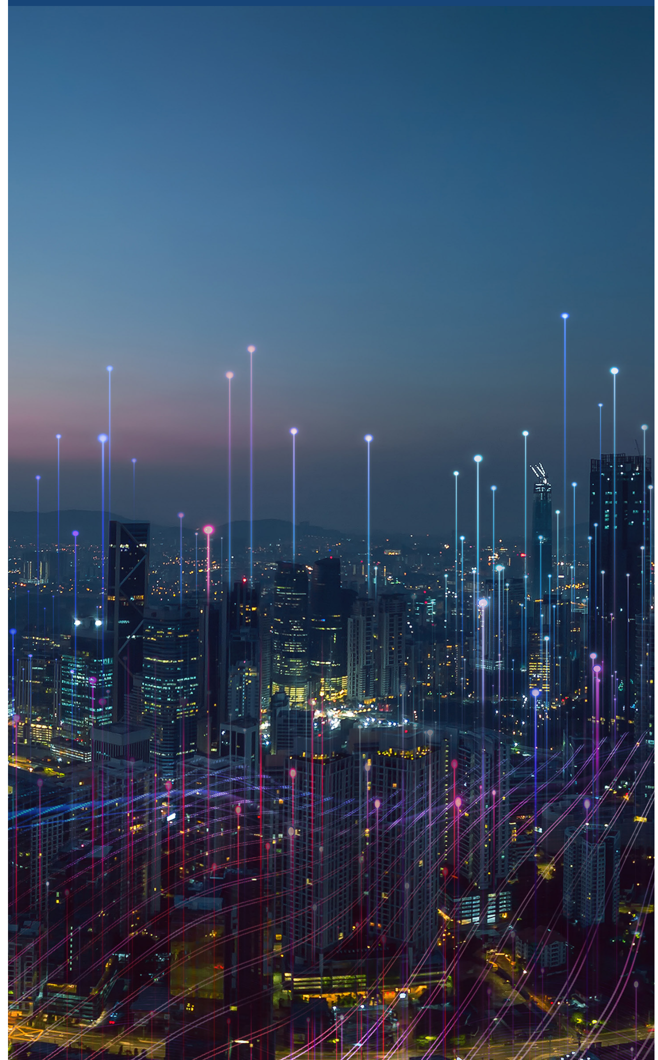

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ANTENNA SELECTOR GUIDE

Internal Antennas

ANTENNA TYPE	SUPPLIERS	PRODUCTS
CELLULAR (5G/LTE/3G)		
Chip	Abracon AVX Ignion Taoglas	**Abracon:** ACR4006X, ACAR3705-S698, ACAR4008-S698 **AVX:** 1004795, P822601, LSP69001299TR **Ignion:** NN03-310, NN02-220, NN02-201, NN02-224 **Taoglas:** MCS6.A, PCS.26.A, PCS.46.A, PCS.68.A
Flexible PCB (FPC)	Abracon AVX Taoglas	**Abracon:** ABB1102L, AFAC110020-S698, AFAG7020-S824, AFAC240020-M698 **AVX:** 1002289, 1002292, 1005460F0, 9001815F0 **Taoglas:** FXUB64.18.0150A, FXUB66.07.0150C
BLUETOOTH/WIFI/ZIGBEE		
Chip	Abracon AVX Ignion Taoglas	**Abracon:** ACAG0201-2450-T, ACAG0301-24505500-T, ACAR0301-SW2 **AVX:** M310220, M830520 **Ignion:** NN02-201, NN03-320, NN02-101 **Taoglas:** WLA.01, WLA.10, SDWA.01, LA.02
Flexible PCB (FPC)	Abracon AVX Taoglas	**Abracon:** AFAG2220-SW2, AFG4507W2 **AVX:** 1001932FT **Taoglas:** FXP840.07.0055B, FXP74.07.0100A, FXP72.07.0053A
Patch (Active, Passive)	Abracon AVX Taoglas	**Abracon:** APARC2505-S2450, APAKN2504-S2448-T **AVX:** 1003468 **Taoglas:** WLP.2450.25, WDP.2458.25, WLP.2450.50.6.A.08
ISM/LoRa®/SIGFOX		
Chip	Abracon AVX Taoglas	**Abracon:** ACAJ-110-T, ACAG1204-433-T **AVX:** M620720 **Taoglas:** ILA.08, ILA.09, ILA.01, ILA.02
Flexible PCB (FPC)	Taoglas	**Taoglas:** FXP280.07.0100A, FXP290.07.0100A
Patch (Active, Passive)	Abracon Taoglas	**Abracon:** APAE915R2540ABDB1-T, APAE868R2540JBDB2-T **Taoglas:** ISPC.91A, ISPC.86A
GNSS		
Chip	Abracon AVX Ignion Taoglas	**Abracon:** ACR1004GC, ACAR0301-SG3, ACAG0301-1575-T **AVX:** M830120 **Ignion:** NN02-224, NN03-320 **Taoglas:** GGBLA.125.A
Flexible PCB (FPC)	Abracon AVX Taoglas	**Abracon:** AFAG4330-SG3 **AVX:** 9000440 **Taoglas:** FXP611.07, FXP612.07
Patch (Active, Passive)	Abracon AVX Taoglas	**Abracon:** APARC2504A-SG3, APARM2508S-SGL2L5 **AVX:** 1004259, 1004627 **Taoglas:** AGGBP.35F, CGGBP.18.4.A.02, GGBTP.35.3.A.40, GVLB258.A
UWB (ULTRA-WIDEBAND)		
Chip	AVX Taoglas	**AVX:** 1001312 **Taoglas:** UWC.20, UWC.40, UWCCP.01
Flexible PCB (FPC)	AVX Taoglas	**AVX:** 1005190F0, 1005188F0 **Taoglas:** FXUWB01.07.0100C, FXUWB10.01.0100C, FXUWB20.07.0100C
SATELLITE COMMUNICATIONS		
Patch (Active, Passive)	Abracon Taoglas	**Abracon:** APAE1621R2540ABDD1, APAE2338L2540DDDB1-T, APARM2504-C2GR **Taoglas:** SP.1615.25, SXP.25, SDDCP.5900.25.10
MULTI-PROTOCOL		
Chip	Ignion	**Ignion:** NN03-310, NN03-320, NN02-101

ANTENNA SELECTOR GUIDE

External Antennas

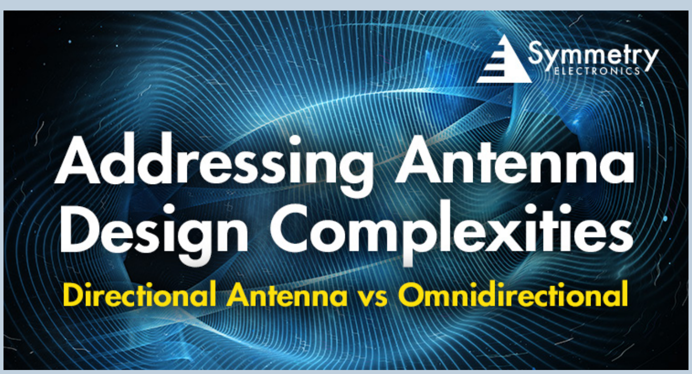
ANTENNA TYPE	SUPPLIERS	PRODUCTS
CELLULAR (5G/LTE/3G)		
Terminal/Whip	Abracon EAD Taoglas TE Connectivity	**Abracon:** AEACAC198013-S698, APAMPSLJ-140 **EAD:** FLTS35367-SM-ST, FPTR35235-SM-KR **Taoglas:** TG.55.8113, TG.45.8113 **TE Connectivity:** 2195736-1, 2195632-1
Magnetic-Mount	Abracon EAD Taoglas TE Connectivity	**Abracon:** AEACAD460065-S698, AEACAD097015-S698 **EAD:** MIMO-MAG-SMSM, MP-2L-SMSM **Taoglas:** GA.111.101111, MB.TG30.A.305111 **TE Connectivity:** 955-006-002
Screw-Mount	Abracon EAD Taoglas TE Connectivity	**Abracon:** AEACBK081014-M698, AEACBK110053-MLWG **EAD:** FBTN35369-SM-1K, FCMO35303-SMSM-1K **Taoglas:** TLS.01, G30 **TE Connectivity:** 955-181-001, 2363694-1
Adhesive-Mount	Abracon Taoglas TE Connectivity	**Abracon:** AEACBA081014-M698 **Taoglas:** GSA.8827, MA241.BI.001 **TE Connectivity:** CAT-R131-L6267, CAT-R131-T673
Wall/Pole Mount	EAD Taoglas TE Connectivity	**EAD:** FGO-5M195-SM, LMO6138-WB-SMSM **Taoglas:** OMB.6912.03F21, LWB02.A.505111 **TE Connectivity:** 2362683-1, 2363695-1
BLUETOOTH/WIFI/ZIGBEE		
Terminal/Whip	Abracon EAD Taoglas TE Connectivity	**Abracon:** APAMS-121, AEACAQ190012-S2400 **EAD:** FBTS35024-SM-RA, FBTR35160-SM-KR **Taoglas:** GW.48.A151, GW.22.5151 **TE Connectivity:** 2195630-1, 2195772-1, 951-012-003
Screw-Mount	Abracon EAD Taoglas TE Connectivity	**Abracon:** AEACBK050048-SW2 **EAD:** FCPW35168-SM, FCPD35227-SM-SM **Taoglas:** WS.02.B.205111, MA515.C.CG.001 **TE Connectivity:** 951-001-001, 951-001-002
Adhesive-Mount	Taoglas TE Connectivity	**Taoglas:** WSA.2458.A.101151, WSA.2400.A.101151 **TE Connectivity:** CAT-W743-T673, 951-002-001
Wall/Pole Mount	EAD Taoglas	**EAD:** WCO-2400-WMB **Taoglas:** OMB.242.08F21
ISM/LoRa®/SIGFOX		
Terminal/Whip	Abracon EAD Taoglas	**Abracon:** AEACAC053010-S433, AEACAC254010-S169, AEACAQ190012-S868/915 **EAD:** FHWD35316-SM-ST, H169-SMA, FBKR35301-RS-KR **Taoglas:** TI.10.0112, TI.08.A.0111, TI.92.2113
Screw-Mount	EAD Taoglas TE Connectivity	**EAD:** FBTN35370-SM **Taoglas:** IS.05.B.301111, IS.04.B.301111, IS.01.B.305111 **TE Connectivity:** 2363697-1
Adhesive-Mount	Taoglas TE Connectivity	**Taoglas:** ISA.05.A.033822, ISA.06.A.301111 **TE Connectivity:** 2363699-2
Wall/Pole Mount	EAD Taoglas TE Connectivity	**EAD:** WCO-433-WMB, WMO-169-WMB, WMO8685, WMO86916-SM **Taoglas:** OMB.868.B12F21, OMB.915.B08F21, OMB.433.B06F21 **TE Connectivity:** 2363698-1, 2363698-2
GNSS		
Terminal/Whip	EAD Taoglas	**EAD:** FGPS35216-SM-RA **Taoglas:** TG.08.0113, TG.08.0723
Magnetic-Mount	Abracon EAD Taoglas TE Connectivity	**Abracon:** AEACBD045015-SG2, APAMPG-130 **EAD:** MP-RTK, FGPX35246-SM **Taoglas:** AA.175.301111, AA.162.301111 **TE Connectivity:** 602-439-001
Screw-Mount	Abracon EAD Taoglas TE Connectivity	**Abracon:** AEACBK050048-C2LG, AEAGMK148060-S1575 **EAD:** FCLG35311-SMSM **Taoglas:** A.90.A.101111, A.30.A.301111 **TE Connectivity:** TGN-3847-RD-S, IGN-1620-LP-S
Adhesive-Mount	Abracon EAD Taoglas TE Connectivity	**Abracon:** APAMPG-117, APAMP-116 **EAD:** FGPX35135-SM **Taoglas:** AA.108.301111 **TE Connectivity:** GPS-10P
Wall/Pole Mount	EAD Taoglas	**EAD:** HIGAIN-RTK **Taoglas:** MA950.A.LBICG.005
UWB (ULTRA-WIDEBAND)		
Adhesive-Mount	Taoglas	**Taoglas:** PCUWB01.01.0500G
Wall/Pole Mount	Taoglas	**Taoglas:** PHA.01.A
SATELLITE COMMUNICATIONS		
Magnetic-Mount	Abracon Taoglas TE Connectivity	**Abracon:** AEARBD040038-S1621, AEACBD045015-S2332 **Taoglas:** IAA.01.121111 **TE Connectivity:** IRD LP M
Screw-Mount	Taoglas TE Connectivity	**Taoglas:** MA602.A.ABJ.002, MA410.A.LBIJ.001 **TE Connectivity:** IRD LP S, IGN 1620 LP S
Wall/Pole Mount	Taoglas	**Taoglas:** IMA.01.105111

ADDRESSING ANTENNA DESIGN COMPLEXITIES

DIRECTIONAL ANTENNA VS OMNIDIRECTIONAL

BY JARI HAISTON
DIGITAL MARKETING ASSISTANT

In simplified terms, Moore's Law states that as technology evolves, it becomes smaller and provides increased efficiency. Such is the case with antenna technology. Developers are continuously working to improve design elements like ground plane size, enclosure materials, and component placement within internal antennas and external antennas in order to keep up with the demand for a variety of compact antenna solutions. According to a Verified Market Research report, the global antenna market is projected to reach 37.96 billion by 2028.



Addressing Antenna Design Complexities
Directional Antenna vs Omnidirectional

WHAT IS THE DIFFERENCE BETWEEN DIRECTIONAL AND OMNIDIRECTIONAL ANTENNAS?

When developers are considering what type of antenna to include in their product design, use case and application are the ultimate determining factors. However, developers should also consider:

- The bandwidth of the selected antenna. Bandwidth refers to the range of frequencies in which an antenna can effectively receive and transmit signals. Defined by Voltage Standing Wave Radio (VSWR) ratings, bandwidth parameters of an antenna are an essential consideration to ensure optimal efficiency of a device.

- The desired gain of an antenna solution. Defined by an antenna's radiation pattern, an antenna's gain refers to the signal strength in the direction of its peak radiation when compared to an isotropic source.
- The radiation pattern of an antenna selection. Represented in graphical terms, the radiation pattern of an antenna provides a visualization of energy distribution around an antenna. A radiation pattern is key in determining how omnidirectional or directional an antenna is (Figure 1).

An omnidirectional antenna distributes its energy in a 360° radius surrounding its source. While a torus of energy distribution may seem advantageous, omnidirectional antennas are commonly less powerful in range than their directional counterparts. Directional antennas focus all of their energy in one direction. While this provides powerful signal strength, the antenna must be pointed in the direction of the signal. However, directional antennas seem to be more resistant to noise and multipath distortion.

Cellular omnidirectional antennas provide optimal performance with a clear line of site, meaning there are no physical obstacles to interfere, and where cellular

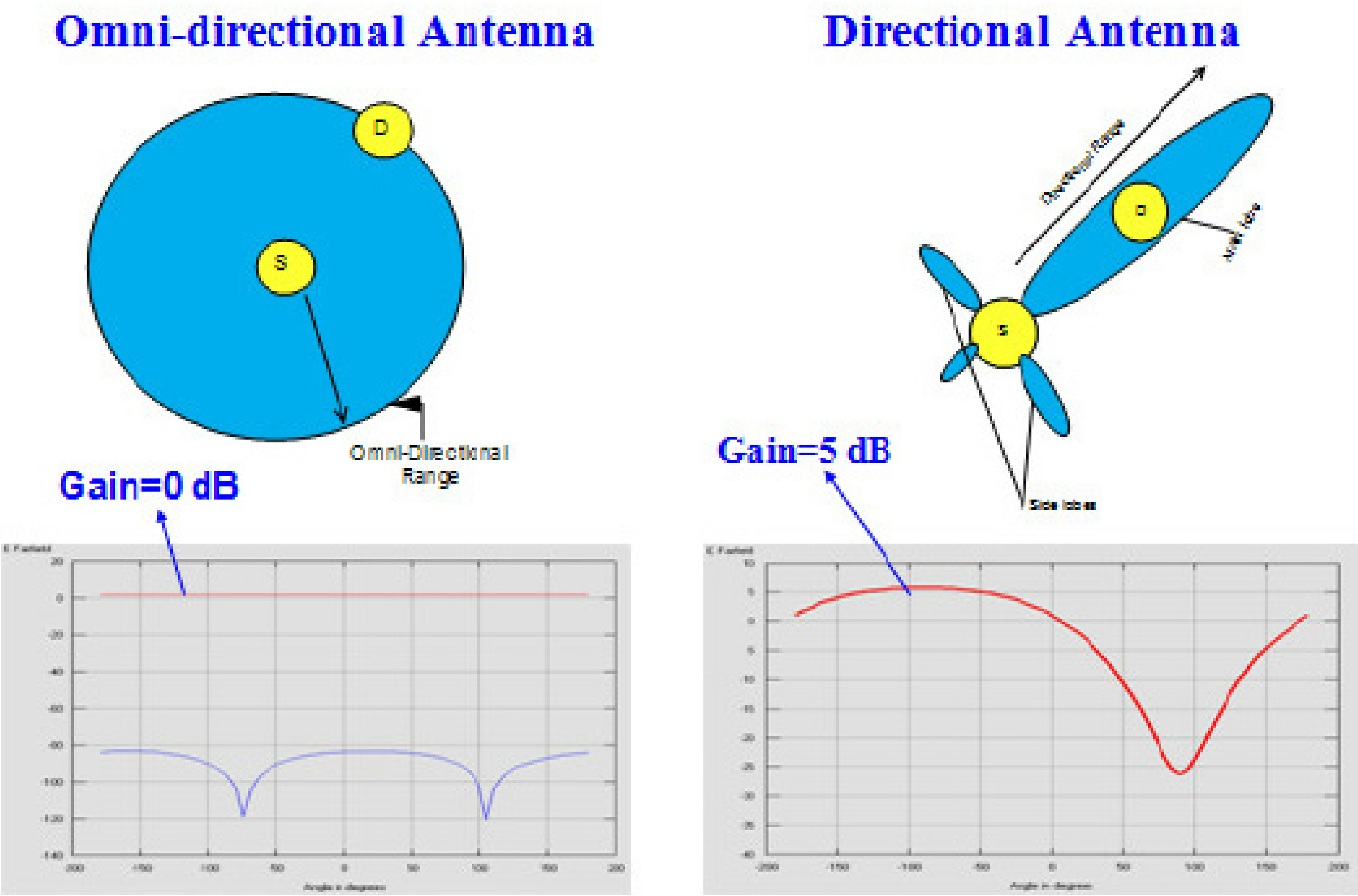


Figure 1: Radiation pattern comparison of an omnidirectional antenna and directional antenna. Source: Research Gate

signal is abundant. Traditional directional antennas commonly provide a beamwidth of 45-90 degrees and are useful in areas with a weak signal source.

TYPES OF OMNIDIRECTIONAL ANTENNAS

- Terminal-Mount
- Whip
- Rubber Duck
- Dipole
- Puck Style
- Magnetic-Mount
- Screw-Mount
- Omnidirectional Antenna Applications

Applications seeking point-to-multipoint communications like computers, phones, and end-node modules would benefit from a terminal-mount, rubber duck, or outdoor dipole antenna as they are ground plane dependent. Omnidirectional antennas are optimal for applications surrounding broadcast transmissions, wireless networks, GPS, and other IoT applications.

TYPES OF DIRECTIONAL ANTENNAS

- Yagi
- Grid
- Parabolic
- Panel
- Dish
- Directional Antenna Applications

While directional antennas can be used across multiple industries, a directional antenna's application is dependent on the particular setup of the device. Generally, directional antennas are optimal for long range point-to-point and point-to-multipoint communication as they provide high gain. Cellular networks, land mobile radio (LMR) applications, GPS systems, and emergency response communication systems all benefit from directional antenna integration.

IN CONCLUSION:

It's important to note that an antenna's radiation pattern is not dependent on whether the technology is an internal or external component. There are internal and external omnidirectional antennas, just as there are external and internal directional antennas. The type of antenna technology you choose to incorporate into your design should be determined by the use case and set up of your device.

RESOURCES:

What's the Difference Between a Directional and Omnidirectional Antenna?

ABOUT JARI HAISTON

Jari Haiston is part of the growing digital marketing team at Symmetry Electronics. Jari comes from a background in technical writing and event coordination. In her current role, she specializes in content creation and social media management. Jari's focus as a writer is to create interesting content that is accessible to any audience.

BY JARI HAISTON
DIGITAL MARKETING ASSISTANT

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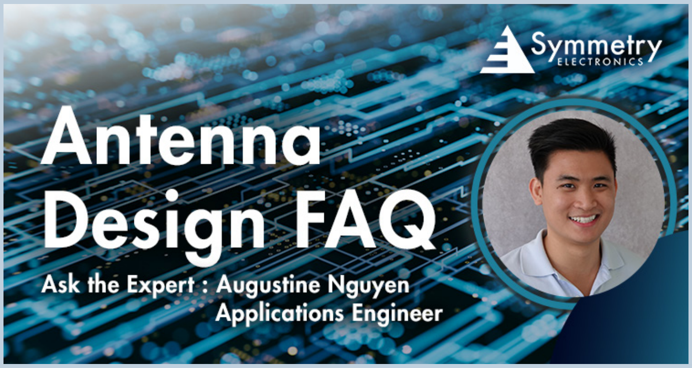
ANTENNA DESIGN FAQ

ASK THE EXPERT

BY AUGUSTINE NGUYEN
APPLICATIONS ENGINEER

Symmetry Electronics is an industry-leading distributor of wireless connectivity solutions. Our team of Applications Engineers provide best-in-class technical support and are available to help navigate you to your ideal antenna solution. Our knowledgeable Applications Engineer, Augustine Nguyen, is answering your most frequently asked questions about internal and external antenna designs.



Antenna Design FAQ
Ask the Expert

DO MORE EXPENSIVE ANTENNAS WORK BETTER?

Price doesn't necessarily equate to quality when it comes to antenna design. External antennas are generally more expensive than their internal counterparts since there are additional material costs associated with external antenna manufacturing. This is because external antennas are always bigger in size than internal antennas. However, the higher price point of external antennas does not mean that they function better than internal antennas. Antenna selection is ultimately dependent on its application requirements.

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WHAT ARE SOME OF THE MOST COMMON CAUSES OF POOR ANTENNA PERFORMANCE?

Poor antenna performance could be caused by a wide range of issues. Some of the most common causes include:

- Improper tuning (impedance matching)
- Poor PCB and enclosure design
- Inhibited line-of-sight (LOS)
- Antenna mutual coupling
- Environments with a lot of RF interference.

HOW DO YOU CHECK AN ANTENNA'S PERFORMANCE?

An antenna's performance can be determined by measuring various parameters like the gain, VSWR, and efficiency. The radiation performance (3D radiation pattern) of an antenna will have to be measured in an RF anechoic chamber. Radiated performance measurement tests are administered by antenna suppliers or engineering design services (EDS) firms. Laird Connectivity offers comprehensive EMC and RF testing services. Kyocera-AVX also has an anechoic test chamber that is capable of testing devices from 600 MHz to 6 GHz. Additionally, Connected Development is one of the EDS companies within the Exponential Technology Group (XTG), and has their own in-house anechoic chamber capable of conducting a variety of wireless test and measurement services.

DO ALL ANTENNAS NEED TO BE TUNED?

Yes, all antennas are tuned in order to be resonant at specific frequency bands depending on the supported wireless protocol to be supported. For example, antennas are tuned to the 2.4 GHz band for Bluetooth Low Energy (BLE) and Zigbee. Antennas using LoRa as their supported wireless protocol are tuned to the 868 or 915 MHz band.

DOES THE SIZE OF AN ANTENNA AFFECT SIGNAL STRENGTH AND RANGE?

Generally, the size of an antenna indicates its dBi gain, or directivity. Larger antennas will have a higher dBi gain, whereas smaller antennas will have lower gain with a more omnidirectional radiation pattern.

ABOUT AUGUSTINE NGUYEN

Augustine Nguyen is an Applications Engineer at Symmetry Electronics. He has his Bachelor's in Electrical Engineering from University of California, Irvine, and five years of hands-on experience in application development and systems testing for Bluetooth and Wi-Fi. In his current role, Augustine works as a technical advisor to assist engineers in designing, developing, and implementing IoT and embedded system products. Augustine is customer service oriented and works diligently to meet customer objectives while providing innovative solutions to common problems. He has extensive knowledge of the latest products and technologies and active relationships with the world's leading electronic component manufacturers.

EBOOK

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Technical Engineering Support

Symmetry Electronics employs experienced Applications Engineers to provide complementary design engineering consulting to our customers. In combination with our Application Engineering support, we offer product samples when available along with useful design resources like data sheets, product selector guides, technology-focused articles, and product demo videos to set engineers off on the right design path. Additionally, benefit from a comprehensive engineering design services service with access to anechoic chamber pre-compliance testing and product manufacturing services from sister companies in our XTG ecosystem.

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