Internal Wireless LAN Antennas

A Key to Maximizing Data Throughput

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Ensuring high, reliable wireless data throughput, especially in fringe coverage areas, can be a difficult design challenge for wireless LAN device engineers. System sensitivity plays an important role in maintaining high data throughput, but having the right kind of internal antenna can greatly improve throughput as well.

For the highest performance and data throughput characteristics, the internal antenna must be efficient when integrated inside a device in a real world configuration. Device engineers should also consider the antenna's average gain in some specific cuts often defined by industry standards.

Regardless of the parameter measured (efficiency, average gain, etc.), the best strategy to maximize data throughput is to use an isolated antenna technology. An isolated antenna technology improves the antenna's efficiency while enabling placement of multiple antennas in close proximity to one another for diversity purposes or multiple embedded system arrangements.

An important first step to maximize throughput is to characterize the antenna. Several different characterization methods will be presented within the framework of wireless LAN applications along with the advantages of using an isolated antenna technology such as Isolated Magnetic Dipole&#153 (IMD).

Antenna Characterization: Anechoic Chamber Measurements

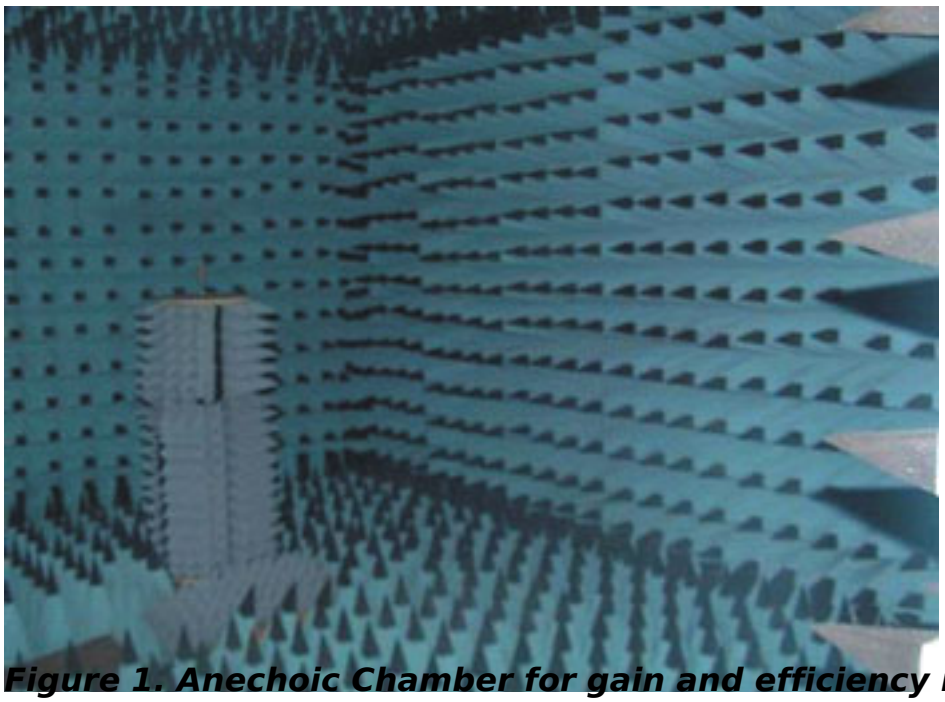


Figure 1. Anechoic Chamber for gain and efficiency measurements

The antenna's characterization inside an anechoic chamber (See Figure 1) consists of measuring the antenna's efficiency. The antenna is measured in a real world configuration, integrated inside the actual product housing or end user device it is intended for. For accurate results, it is important to verify that the antenna is well-grounded to the device and that the measured radiation comes from the antenna and not from any other sources (i.e. cables, test equipment, etc.).

The first step consists of tuning the antenna to the device. While this doesn't prove that the antenna will be efficient, it's a necessary step for accurate results. Generally, multiple uncontrolled resonances along the return loss indicate strong interactions within the device, creating parasitic inefficient resonances.

Once the antenna is tuned to the enclosure, the next step is to evaluate the efficiency. Ideally, efficiency is measured by calculating the ratio between the radiated power and the power at the antenna's input. Practically, the efficiency is evaluated by calculating the integrated power over the 3D radiation pattern of the antenna. The efficiency is equal to the ratio between the antenna's integrated power and a free space dipole's integrated power. Therefore, efficiency is the linear value of the average gain, where 100% corresponds to 0 dBi average gain over 4 pie steradiant. An antenna's efficiency can vary widely, from 10% to 80%, when mounted inside a device. This value depends on the type of antenna technology used and the way it is integrated within the product.

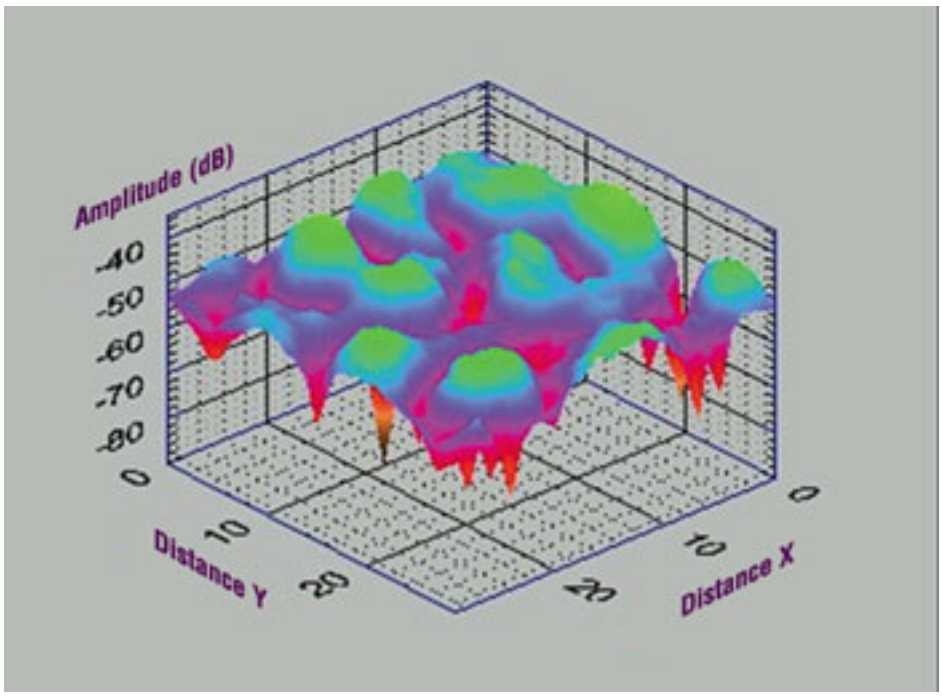
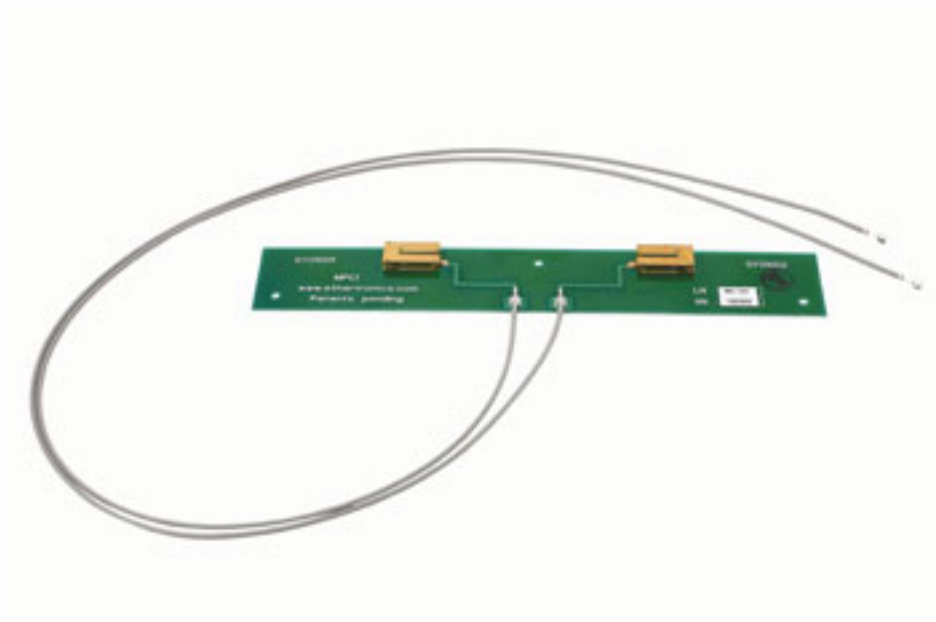


Figure 2. Signal Strength distribution versus space, exhibiting maximum and minimum of power (fading).

In many wireless LAN applications, antenna diversity can be a crucial tool to avoid signal fading in multi-path environments. In this scenario, mapping measurements can help optimize the antenna diversity configuration. The mapping test set-up requires a transmitting antenna plugged into a network analyzer and a receiving antenna used to acquire the signal versus the position. The receiving antenna has to be placed in a real world configuration (i.e. PCMCIA card inserted in the notebook's PC Card slot or mounted in the notebook's lid, etc.). This will provide a mapping of the signal strength received in a multi-path configuration. Mapping the two different antennas shows the ideal distance necessary between them in order to make sure that when one antenna is inside a null signal area, the other antenna can still receive a strong signal.

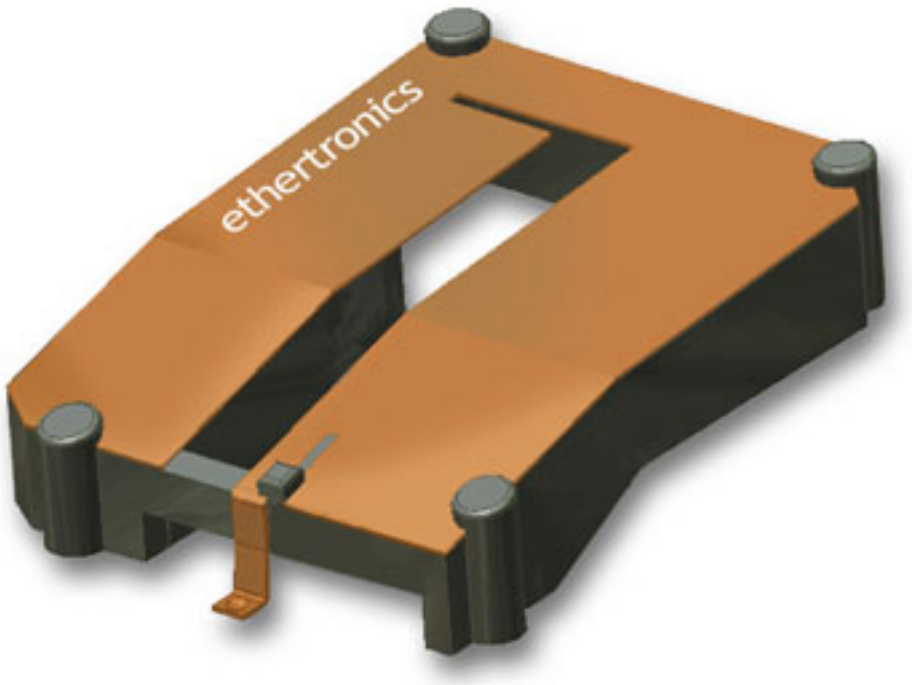


DualNet™ MPCI antenna for notebook computer applications.

Wireless LAN System Characterization: Data Throughput

Wireless bit rate measurements directly correspond to the efficiency of the internal antenna used, as well as the system used (i.e. modulation, transmitted power, protocol, etc.). For example, Bluetooth&#153 uses Spread Spectrum Frequency Hopping, whereas 802.11b uses Spread Spectrum Direct Sequence. Therefore, Bluetooth and 802.11b wireless devices with the same internal antenna configuration will suffer from different alterations. This observation can be made after many measurements have been performed in different configurations inside an office environment, for example with offices and cubicles.

Data throughput is measured as the distance and orientation changes between the devices. When data throughput is measured as a function of the distance between the devices, the transmission bit rate remains constant until the signal reaches a certain threshold. Then, as the distance increases, the bit rate gradually decreases until the link breaks up. This result is achieved when multi-path is reduced. In strong multi-path environments, the bit rate may suffer from minimum/maximum throughput fluctuations due to signal fading as presented in Figure 2. This can be compensated for by the system.



TrueWave™ G Series antenna for cellular applications.

With Spread Spectrum Frequency Hopping used by Bluetooth, the frequency hopping changes the space distribution of the fadings. By jumping from one frequency to another, the deep nulls of power move in the space depending on the frequency and there is very little chance that the device moves to the physical location where the null is present for that frequency. In the case of 802.11, antenna

diversity should be used to correct local fading. As presented before, if one antenna has low signal strength because of fading, most likely the other antenna will have a much stronger signal.

TrueWave G Series antenna mounted in a cellular phone.

In any case, the difference between an efficient and an inefficient antenna is readily apparent. With an inefficient antenna, data throughput decreases immediately as the distance between the devices increases. With an efficient antenna, the bit rate remains close to its maximum throughput in many configurations. An interesting parameter on the end user side is the ratio between the bit rate of the efficient and the inefficient antennas. This bit rate ratio increases in an exponential way as the distance between the devices increases until the inefficient antenna's link breaks up.

The range of the internal antenna system corresponds to the distance achieved before the wireless link breaks up. Models, like the cost 231 [1], approximate the range for a given level of radiated power. Therefore, by knowing the efficiency improvement, it is possible to model the range difference between the two antennas. For example, with a 3 dB difference between the two antennas, the range improvement is about 20%. But as stated previously, the range improvement actually hides a much bigger bit rate improvement far before the link breaks up.

Antenna Glossary

- Anechoic Chamber - an antenna testing facility for measuring the energy radiated in at a time (i.e. the absorption of the energy radiated towards the wall).
- Diversity - is used to take advantage of different paths of a wave propagating in a re environment, in order to improve overall system performance.

- Efficiency - quantifies an antenna's energy loss when a signal is transformed into a v
- Gain - describes the antenna's ability to radiate power in a certain direction when co Gain is usually calculated in the direction of maximum radiation. Gain is measured b against a standard antenna. This is known as the "gain transfer technique."
- Isolation - the opposite value of the amount of energy directly radiated from one ant component.
- Multi-path - the process which scatters a wave into multiple waves with different dir propagation. Multi-path signals cause fading fluctuations.
- Resonance/Tuning - the frequency at which the antenna is offering the best radiatin
- It is associated with a phenomenon called resonance, defined as the base of the tran to wave.
- Selectivity - refers to an antenna's rejection of out-of-band signals, like filters.
- Sensitivity - minimum level of signal necessary for the information carried by the sig

Isolated Antenna Technology Advantage

As illustrated, an integrated internal antenna can have a great effect on data throughput in wireless LAN applications. There are many different types of internal antennas available, but a highly isolated one will achieve the best efficiency resulting in the highest data throughput.

High antenna isolation has many advantages [2]. By confining the currents close to the antenna, it avoids creating parasitic resonances, which are often the reason for low efficiency. Parasitic resonances show up on radiation patterns as ripples due to the phase difference between the main source (the antenna) and the second source (any radiating edge). These parasitic resonances can make the design cycle difficult and lengthy. Each time one of the physical parameters is changed, the antenna has to be redesigned. With an isolated antenna technology, the efficiency is high because very little energy is trapped in different areas of the device. In addition, the design cycle is easier and shorter since the antenna is less affected by any changes in its surroundings.

An isolated antenna technology has many other advantages. For diversity purposes, two antennas can be placed in close proximity to each other with very low coupling. Non-isolated antennas must be placed further apart to avoid coupling. Low coupling between antennas is very important when multiple systems are placed on a single device, especially if they work in the same band like Bluetooth and 802.11b. In this case, the requirement is at least 40 dB of isolation between the antennas. This level of isolation is difficult to achieve with standard internal antennas. However, highly isolated antennas can meet this requirement and still provide a compact solution.

Such solutions also help to reduce the overall system cost which is very important for consumer products. Highly isolated antennas offer high selectivity helping to remove duplexers and also filters from the device. A rejection of 25 to 30 dB can easily be observed within less than a 100 MHz around 2.4 GHz, whereas standard antenna technology hardly offers 10 dB, not including parasitic resonances. Finally, isolation also helps to reduce EMI issues. EMI is very important, especially with processors working above 2 GHz. Therefore, it is imperative that the antenna does not generate currents &#151 which would disturb the processor &#151 and that the currents generated by the processor do not get trapped within the antenna. By confining the current close to the antenna it is possible to avoid these issues.

Conclusion

Antennas are becoming an integral part of handheld devices as wireless applications are adopted. Significant expertise is required to optimize the antenna and thereby maximize the data throughput of the device. By using a highly isolated antenna technology, the integration process can be greatly simplified, reducing valuable design time and getting products to market faster. For the end user, an isolated antenna technology improves the range and the data throughput of wireless network, as well as helping to reduce the overall system cost.

Ethertronics is an internal antenna manufacturer targeting the Cellular and WLAN markets. More info on its patented Isolated Magnetic Dipole&#153 (IMD) technology can be found at www.ethertronics.com.

Editor's Note: A list of references is available upon request. Please email kpotts@reedbusiness.com.

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