

MIMO Antennas for 802.11n Based WLAN System

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Over past two to three years there has been a significant surge in real time, low latency video and data applications over wireless networks. These applications drive large amounts of data over both cellular and wireless local area network (LAN) based enterprise networks.

The implementation of wireless LANs by enterprises across various vertical industries seeking to support a growing mobile workforce with voice, data and video accessibility has increased the need for network speed, capacity and reliability. Research firm ABI reports that the uptake of Wi-Fi within healthcare institutions has grown more than 60 percent during the past 12 months in both wireless LAN and Wi-Fi RTLS (real-time locations systems) deployments. Double-digit growth is expected to continue for at least the near term, and the revenue from worldwide sales of Wi-Fi enabled healthcare products will reach nearly \$5 billion in 2014.[1] Other industries, including education, utilities (smart grids), mass transit and manufacturing, are being affected by similar trends.

In addition, the exploding use of multi-media through smart-phone technology in the consumer market is expected to fuel this industry's growth. A recent release by research firm iSuppli Corp. reports that global smart phone shipments are expected to increase 105 percent from 246.9 million in 2010 to more than 506 million units by 2014.[2] This growth has put tremendous pressure on existing cellular networks in terms of capacity.

As a result of increasing consumer and business demand for voice and data video streaming capabilities worldwide, IT network architects and cellular operators are leveraging 802.11n based wireless LAN networks that utilize Multiple Input, Multiple Output (MIMO) antenna technology to off-load and support the high data rate demand.

Conventional 802.11 (a, b or g) networks typically utilize single input single output (SISO) technology. This technology utilizes a single transmitter and a single receiver with either one or two antennas on each side. Networks that use this technology are designed to avoid multipath and line-of-sight obstacles that can create signal nulls and degrade wireless coverage.

MIMO technology, on the other hand, uses multiple transmitters and receivers. It leverages multipath signals to deliver enhanced data throughput, range, reliability and spectral efficiency, even in environments that would typically be susceptible to line of sight interference and signal fading. In optimal signal to noise ratio (SNR) conditions, a data stream can also be split between multiple transceivers with independent antennas for transmission allowing for higher data rates.



In MIMO 2x3 Receive Diversity Systems, smart antennas use spatial diversity technology to improve signal-to-noise ratio. For example, if the receiver has more antennas than spatial streams (in a 2x3 system two antennas transmit while three antennas receive) the third antenna can add diversity to the receiver end, improving system robustness through longer distances at given speeds.

When multiple spatial streams are used with MIMO (3x3, three transmit antennas and three receive antennas) it is called SDM (spatial division multiplexing). This method requires advanced signal processing for transmit (Tx) and receive (Rx) streams in order to avoid cross signal interference that can lead to degraded system performance. Spatial streams require complete

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matching Tx/Rx radio links while diversity only systems require a single Rx (receive) radio.

Several of the 802.11n wireless LAN systems that are currently being deployed are dual band covering 2.4 GHz and 5 GHz bands. These systems get deployed in a variety of different locations including transportation hubs (airports, train stations), entertainment venues (stadiums, concert halls) and office buildings to name a few. Each of these locations present their own set of propagation environment, coverage and antenna installation challenges. Most of these locations are space constrained resulting in requirements for compact antennas. Aesthetics are important, so antennas need to either blend in with the environment or have to be hidden in locations that may not be ideal for radio signal propagation and coverage.

Multiple stand alone antennas are commonly used in MIMO systems, but because the spacing and interaction between the antenna elements is crucial to achieve optimal throughput rates, system designers often opt to house multiple antennas into a single radome. This allows them to control the exact spacing between the antenna elements.

Since antennas are utilized, among other things, to mitigate multipath, they cannot be designed and their performance cannot be assessed without considering the propagation environment. Antenna installation and placement requirements should be thoroughly understood at the beginning of the design cycle. (For example, will the antenna be wall, mast or ceiling mounted?) Other considerations, including customer size restrictions for the antenna as it relates to cosmetic or practical installation issues are also important, but often overlooked until far too late into the design development cycle.

WLAN MIMO antennas typically involve multiple element covering 2.4 GHz and 5 GHz frequencies in a single housing with each element linked to a separate transceiver. A well designed MIMO antenna must provide consistent radiation patterns among spatial streams, stable gain performance across all the operating frequencies, and proper isolation between radiating elements. A key fact to keep in mind is that electrical performance is dependent on the size of the antenna. Larger antennas can provide higher gain and narrower beam widths ideal for deployments where there is a high concentration of data intensive users

For example, one can look at a scenario where there is a need to have dual band 802.11n coverage in a large sports arena for offloading voice and video traffic from smart phones. A typical football stadium would require more than 200 access point, with each access point providing coverage over a

fairly narrow area to limit the number of users and minimize interference. Antennas for these access points will need to have narrow beam widths, about 35° elevation and 55° azimuth. One needs a fairly large antenna housing (about 14 inches by 14 inches) to achieve this beam width and to collocate six antenna elements (3 for 2.4 GHz and 3 for 6 GHz) with ideal port to port isolation. This design would yield a gain of 12 dBi or higher for both frequency bands; however gain may have to be attenuated to meet FCC requirements. A well designed antenna would yield fairly consistent patterns across frequency range and among different radiating elements. There may be several scenarios where space is limited and a 14 inch by 14 inch housing may be too large. For these cases, one can consider a smaller 8 inch by 12 inch housing as an example. This design will face several challenges in meeting the desired specifications as the beam width would be larger, approximately 35° elevation and 90° azimuth at 2.4 GHz. Port to port isolation between elements would suffer and would be about 10 dB lower than the larger antenna. Gain would be lower and patterns would not be as consistent due to reflections caused by the close proximity of other radiating elements.

Customer expectations for higher gain in small packages, set by their experience with traditional SISO systems, have forced designers to find attractive, less obtrusive ways to implement their MIMO systems. As long as the antenna designer has a full understanding of the system requirements, various techniques can be utilized to achieve the optimal MIMO antenna design.

For example, to address size constraint issues while delivering required spatial stream RF properties, designers can optimize their antenna designs by making fine adjustments to the antenna radome shape or thickness; also, variations in the placement and/or the spacing of the antenna elements within the required footprint can help a designer achieve targeted azimuth ripple or isolation specs, despite the size constraints.

Demand for high data rate applications is going to continue to grow and MIMO based 802.11n WiFi systems will play a key role in enabling high throughput wireless access. Good Signal to noise ratio is key to realize the high throughput potential of 802.11n based wireless systems. Antennas play a critical role in providing appropriate coverage and desired signal to noise ratio conditions. It's important that MIMO antennas are designed with a proper understanding of the complete network i.e. radio specifications, antenna placement and propagation environment.

REFERENCES:

- [1] ABI Research –July 9th, 2009 / June 23rd 2010
- [2] iSuppli – June 7th, 2010



Currently, Rishi Bharadwaj, leads the Product Management & Marketing organization of PCTEL's Antenna Products Group. Rishi has been instrumental in expanding PCTEL's Antenna Product Group's leadership in various vertical markets and technologies including Broadband Wireless Access (BWA), Fleet Management & Asset Tracking, Industrial Communications and Defense. Rishi joined PCTEL in 2003 as Business Development Manager responsible for PCTEL's successful patent portfolio management and intellectual property licensing Program. Rishi also did strategy development and M&A support in that role. Rishi began his career in 1996 with SAFCO Technologies then Moving on to Agilent Technologies performing various product development and business development roles in the area of wireless test and measurement.