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Understanding MIMO: Part I

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The use of multiple transmit and receive antennas is defined as MIMO, or multiple-input-multiple-output. This technology has garnered a fair amount of attention of late. As wireless systems become more popular, the need to ensure radio signal reception, quality and consistency become a top priority, MIMO has become a way to ensure optimal wireless performance. Furthermore, as wireless technologies evolve to their limits in terms of performance using DSP-based platforms with single antennas, multiple antennas can be a key technology to provide the necessary performance.

MIMO comes in many flavors of MIMO. One of the key design challenges is to determine which approach is most suited for the products being developed. Wireless systems impairments generally center on performance and capacity limitations due primarily to spectrum availability, multi-path, delay spread, and co-channel interference (Fig. 1 below).

Spectrum availability
There's a limited amount of spectrum available to transmit signals. This limited spectrum leads to various problems for wireless systems, including theoretical limits on data rate for a given transmit/receive power with one transmit/receive antenna. Ultimately, for wireless to reach its promise, limitations of the available spectrum must be overcome.

Consider the Rayleigh fading of a multi-path environment. Going from the transmitter to the receiver, signals in a wireless environment flow through various paths reflecting off many objectsbuildings, desks, walls, cabinets, etc. before reaching the intended receiver. Because these different paths arrive at the receiver with different phases, the signals may be in and out of phase. Many different paths gives rise to a complex Gaussian channel which generates the Rayleigh fading.

Plotting amplitude versus time as users move around or as the environment changes, the receive signal power varies (Fig. 2). Therefore, the amplitude isn't constant and at some points, the signal will fade out or have a low level. Assuming that the difference in time delays between different paths is smaller than the symbol period (i.e., the time delay is less than 10% of the symbol period), then there's negligible inter-symbol interference due to the multiple paths. This is called flat fading, where the channel has a flat response across the signal's bandwidth.

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