Low Complexity Multi-Carrier Modulation

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There is a significant demand for a decrease in the size, weight and power (SWaP) associated with wireless systems. In recent years, multiple-input, multiple-output (MIMO) wireless systems have received considerable attention due to the high data rates they provide. Orthogonal frequency division multiplexing (OFDM), a digital multi-carrier modulation technique, is well suited to be used in MIMO systems as it provides the ability to operate in frequency-selective channel environments. When OFDM is combined with the channel capacity increase provided by MIMO systems, the result is a very successful communication system. In this research, a low-complexity MIMO OFDM system is advanced. The proposed system is essentially multiplierless and thus requires much simpler digital hardware to be implemented. As a result, the chip area associated with the MIMO OFDM system can be significantly reduced.

The reduction in complexity is obtained via modifications to the Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) algorithms necessary to implement OFDM multi-carrier modulation. Computational complexity is decreased by quantizing what is known as the “twiddle factor” in traditional FFT algorithms such as the Radix-4. The quantization allows for multiplications to be done with values of one, negative one, zero or a power of two. Ensuring that multiplications are performed with any of the aforementioned values results in a transform where all multiplications are considered trivial. Replacing standard multiplications with trivial multiplications significantly reduces the computational complexity and allows for a simple hardware implementation. Depending on the application, different quantization levels can be utilized in order to obtain the necessary performance characteristics. As more quantization levels are used, the system performance increasingly approaches the performance of a system that uses the conventional transforms. The computational savings associated with MIMO OFDM systems are significant as the combination of the IFFT and FFT algorithms are implemented for every spatial stream (i.e. antenna). As such, the simplified approach provides a system that is a lower-cost, practical alternative to the MIMO OFDM systems used today.