Mono-Phase and Bi-Phase Ultra-Wideband
WHITE PAPER

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In every commercially deployed radio technology, from cellular phones to Wi-Fi (802.11b) to Wi-Fi5 (802.11a), the methods employed to create the signal transport, called the modulation technique, are widespread early on. They can vary from mono-phase to bi-phase to multi-phase approaches. The marketplace drives these disparate approaches to a standard over time, and, typically, the most efficient methods (measured as a combination of factors such as power consumption, cost to build, data rate, transmission distance, and bit error rate) are the ones chosen in the end. In the case of Wi-Fi and Wi-Fi5, mono-phase approaches are all but extinct.

The same “survival of the fittest” process will occur in the newly forming market segment of high-speed wireless transmission made possible by emerging ultra-wideband (UWB) radio technologies.

Several modulation techniques can be used to create UWB signals, some more efficiently than others. In its formative years, some of the most popular methods to create UWB pulse streams used mono-phase techniques such as pulse amplitude (PAM), pulse position (PPM), or on-off keying (OOK). In these techniques, a “1” is differentiated from a “0” either by the size of the signal or when it arrives in time – but all the pulses are the same shape. A more efficient approach, bi-phase ultra-wideband, is also being deployed. Bi-phase differentiates a “1” with a “right-side-up” pulse and a “0” with an “upside-down” pulse and works by reading pulses both “backwards” and “forwards,” irrespective of time. Multi-phase UWB is not being deployed today as it is too cost-prohibitive for the consumer and enterprise markets.

Mono-phase Ultra-wideband: In this approach, all pulses are right side up, meaning they all look alike. Using pulses in time to create the desired ultra-wideband waveform, mono-phase ultra-wideband technologies are currently used in select military applications under a special license from the FCC. All of these deployed systems are much higher in power and much lower in frequency than the limits published by the FCC in their recent UWB approval guidelines.

The three most popular mono-phase ultra-wideband approaches include:

1. Pulse amplitude (PAM)—PAM works by separating the “tall” and the “short” waves. By varying the amplitude (height of pulse) the receiver can tell the difference between “1” and “0,” thereby encoding data in the signal.
2. Pulse position (PPM)—In PPM, all the pulses (both “1”s and “0”s) are the same height. The receiver distinguishes between a “1” or a “0” by when it arrives in time, or the time lag between pulses. In this case, a long time lag could mean a “1” and a short time lag could mean a “0”.
3. On-Off Keying (OOK)—In OOK, a “1” is a pulse and an absence of a pulse is a “0.”

Bi-phase Ultra-wideband: In this approach, the pulses can be sent right side up or upside down, which determines whether the pulse is a “1” or a “0”, so pulses can be sent at a much higher rate. Because bi-phase UWB can send so many more pulses in a given time period, much longer coding sequences can be added to the signal. This enables the receiver to “lock on” to the longer code, filtering out random noise and eliminating interference and multipath, a common issue with mono-phase techniques.

The bi-phase UWB approach had not been employed previously due to implementation design complexities. To create an efficient bi-phase design, high-speed transistors need to be utilized that, until recently, have not been affordably available. Recent commercial availability of affordable high-speed integrated circuit fabrication processes, such as CMOS and SiGe, have made techniques such as bi-phase modulation possible.
Bi-phase offers several advantages over mono-phase techniques, the most significant of which is a 2x improvement in overall power efficiency. In other words, bi-phase will always perform twice the bit rate as a function of distance compared to any of the mono-phase systems. This makes the bi-phase UWB approach extremely efficient for high data rate, portable applications such as adding wireless capability to camcorders, digital cameras, portable displays (DLPs) and laptops.
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