EE5331

License-free bands
To enable development of wireless technologies to short range applications, FCC has set aside frequency bands for license-free use. These are intended for applications such as wireless internet access, cordless phones and a variety of wire replacement products. Examples include Bluetooth and various implementations of IEEE 802.11. The bands that were set aside are referred to as ISM bands. ISM refers to industrial, medical and scientific. Bands are around 900 MHz, 2.4 GHz and 5.3 GHz and have bandwidths varying from 15 MHz to 200 MHz.
Specific rules for using these bands are included in part 2.15 of FCC regulations. Two main aspects are to ensure that resources are fairly shared and that no interference is caused to licensed users of the bands. Generally, transmit powers must be low (10mW to 100mW) and energy must be spread over the available spectrum.

Due to the limited bandwidth datarates in these bands vary from about 10Mbps at 2.4GHz to 50Mbps at 5.3 GHz.
Ranges associated with these applications are typically < 100 m.

To facilitate higher data rates (at very short ranges, < several m), FCC has been considering allowing use of ultra wideband technologies over 3.6 GHz to 10.7 GHz.

Two competing approaches are currently being evaluated; these are orthogonal frequency division multiplexing (OFDM) and impulse UWB. OFDM makes use of the very wide spectrum by sending data at relatively low
rates over a large number of subcarriers. This results in an overall datarate that is quite high (hundreds of Mbps). To efficiently utilize the spectrum subchannels are separated according to the subchannel datarate. This leads to the situation shown.

Notice that sidebands from adjacent subchannels have 0 energy at neighboring subcarriers. This condition
provides for optimum use of the spectrum, and at the same time no interference between subchannels. Phases are critical, however, and small deviations in phase and/or amplitude can destroy the orthogonality, resulting in interference between subchannels.

In practice, multipath effects can destroy orthogonality. To combat this a cyclic prefix is added to the data that is of sufficient length to allow for delay spread of the signal.
FFT operations are most often used to achieve the multichannel modulation.

Two drawbacks of OFDM are complexity and high peak to average power ratio of the transmitted signal.

A major advantage of OFDM is that the spectrum can be shaped to avoid frequencies where critical or sensitive licensed services are present, or where frequency selective fading is severe.
Impulse UWB

With impulse UWB the entire spectrum (3.6 to 10.76 GHz) is utilized by each pulse. The pulses are unmodulated and about 100 psec in width, hence the term "impulse". Information is normally modulated onto the pulses by one of two approaches, i.e., pulse position modulation (PPM) or biphase modulation. In PPM the time at which the pulse is transmitted is dithered from a reference point according to whether a 0 or 1 is being transmitted.
In impulse UWB pulses are transmitted according to reference times referred to as frames, which are evenly spaced in time. In biphase modulation a bipolar pulse is transmitted and modulation is achieved by whether + or - of the pulse is transmitted first.

Basic pulse shapes in impulse UWB are Gaussian, first derivative of Gaussian, and second derivative of Gaussian. Multiple access is facilitated in OFDM by use of PN spreading.
whereas in impulse UWB either PN spreading (via a sequence) of impulses, or time hopping (dithering pulse positions according to a PN sequence) are used.

Impulse UWB transmitter architecture

Very short pulses in impulse UWB are most often generated by means of diodes distributed at points along a transmission line. The resulting combination of nonlinearity and dispersion causes the energy to cluster in time, i.e., in a form described mathematically
as a "soliton."

The impulses are also shaped by the antenna, which tends to integrate due to the highpass characteristic of the antenna.

**UWB receivers**

After the antenna the next receiver stage can be described by one of the following:

- simple peak sampler where the receiver gates the received signal over a period longer than the impulse.
- correlator where the receiver convolves a template pulse with the received pulse (to achieve an near-optimum matched filter effect)
- high speed sampling where information about shape of the pulse may be determined.

Integration
For best performance, multiple pulses are often used to represent each bit of information. The are integrated at the receiver.