2. SIGNAL CHARACTERISTICS

The purpose of this section is to describe GPS and UWB signal characteristics in order to identify potential interference scenarios and rationalize measurement procedures.

2.1 GPS

GPS is a spread spectrum system. Each GPS satellite is assigned a unique PRN sequence, and all the PRN codes are nearly uncorrelated with respect to each other; therefore, an individual satellite signal is unique and is distinguished through code division multiple access (CDMA). The signals are transmitted at two frequencies: 1575.42 MHz (L1) and 1227.60 MHz (L2). L1 is quadrature-phase modulated with the C/A code and P(Y) code, and L2 is biphase modulated by the P(Y) code.

Each C/A code has a chipping rate of 1.023 Mchips/s and pseudorandom sequence length of 1023, resulting in a code repetition period of 1 ms. The relatively short periodic nature of the C/A code produces a discrete spectrum with spectral lines spaced 1 kHz apart. Because Gold codes are used to generate the pseudorandom sequences, the spectral envelope deviates slightly from a sinc^2 shape (common to maximal length codes) with a null-to-null main-lobe bandwidth of 2.046 MHz. Each P(Y) code has a chipping rate of 10.23 Mchips/s and a code repetition period of 7 days. The P(Y) code produces a sinc^2 power spectral envelope with a null-to-null main-lobe bandwidth of 20.46 MHz and essentially no spectral lines.

Interference imposed on a GPS receiver can have a number of effects. Gaussian-noise interference has the potential to reduce the signal-to-noise ratio (SNR) to such an extent that the GPS receiver can no longer de-correlate the signal. The effects of narrowband interference are more dependent on the proximity to sensitive C/A-code lines in the GPS spectrum. That is, a relatively weak narrowband interfering signal will have little or no effect on the performance of a GPS receiver unless it aligns with a GPS spectral line; if alignment occurs, then interference can be severe.

2.2 UWB

UWB signals are difficult to define. One definition of UWB signals describes the spectral emissions as having an instantaneous bandwidth of at least 25% of the center frequency. Other names for UWB, or terms associated with it, include: impulse radio, impulse radar, carrierless emission, time-domain processed signal, and others.

Terminology and definitions aside, the UWB signal is, in general, a sequence of narrow pulses sometimes encoded with digital information. UWB signal pulse widths are on the order of 0.2 to 10 ns and longer. Some have an impulse-like shape and others have many zero crossings. One form of modulation is pulse-position modulation (PPM) where, for example, a pulse that is slightly advanced from its nominal position represents a "zero," likewise, a slightly retarded pulse represents a "one." Another form of modulation is on-off keying (OOK) where, for example, an absent pulse represents a "zero." In addition to the modulation scheme, the pulses can be dithered. In other words, the pulse will be randomly located relative to its nominal, periodic location (absolute dithering) or relative to the previous pulse (relative dithering). For example, 50% absolute dithering describes a situation where the pulse is randomly located in the first half of the period following the nominal pulse location. Finally, some UWB systems employ gating. This is a process whereby the pulse train is turned on for some time and off for the remainder of a gating period.

The frequency domain characteristics (emission spectrum) of a UWB signal are dependent on the time-domain characteristics described above. The pulse width generally determines the overall shape – envelope – of the emission spectrum. The bandwidth of the pulse spectrum generally exceeds the reciprocal of the pulse width. If the pulse train is uniformly spaced, the emission spectrum will have a series of lines. If dithering is used, there will be a smooth component of the emission spectrum in addition to the line component. The higher the dithering, the greater the power contained in the smooth component versus the line component. Some types of modulation can also reduce the spectral line amplitude. Band-limiting changes the characteristics of the UWB signal further.