System Design and Simulation of a PSSS Based Mixed Signal Transceiver for a 20 Gbps Bandwidth Limited Communication Link

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Parallel Sequence Spread Spectrum (PSSS) is a physical layer baseband technology wherein parallel data streams are transmitted simultaneously by spreading them using orthogonal codes. PSSS was selected for the wireless sensor network standard IEEE802.15.4-2006 to increase data rate and improve performance in fading channels for frequency bands below 1 GHz. Since then it has gained interest for both wireless and wired communication links.

System design and simulations of a PSSS based mixed signal transceiver are discussed using a standard USB 3.0 cable model as an example of a wireline communication link. Simulation results using MATLAB/ Simulink show net data rate of more than 20 Gbps with full duplex communication over a standard USB 3.0 cable using BPSK modulation with spectral efficiency less than 1 bps/ Hz at a chip rate of 25 Gcps.

An important system level decision for PSSS based data communication systems is the type (e.g. maximum length sequences-MLS, Barker codes etc.) and length of orthogonal codes used. Moreover, the combination of unipolar {0,1} or bipolar {-1,1} variants of data, coding and decoding sequences results in different sets of possible PSSS amplitudes and cyclic cross correlation (CCC) result values thus allowing a certain degree of freedom for system design. Shorter codes e.g. MLS-7, MLS-15, Barker-11, Barker-13 etc. are preferred for mixed signal transceiver design because longer codes increase hardware complexity and cost excessively. Guard intervals in the form of cyclic prefix are added between successive PSSS blocks to eliminate inter block ISI. The length of cyclic prefix is dictated by delay spread of multipath wireless channels and by interface impedance mismatch and bandwidth limitation (or group delay dispersion) of wired channels. For a given code length, the shorter the guard interval, the higher will be the link utility (defined as ratio of channel capacity used for payload data to the channel capacity used for payload data plus that wasted during guard interval).

Simulation results shown below assume near and far end cross talk (NeXT and FeXT) distortion with BPSK modulation. The simulation results on the left show vertical eye opening (in percentage of ideal vertical eye opening) as a function of chip rate (assuming a constant guard interval length of 3 T_{chip}) for different orthogonal codes whereas those on the right show vertical eye opening as a function of guard interval length for different code sequences assuming a constant chip rate of 25 Gcps. The maximum achievable bit rate is mentioned on top which depends on chip rate, code length and guard interval length.