Implementation of Faster-Than-Nyquist (FTN) Signaling using Software Defined Radios

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Abstract

In this work, we develop and implement a Faster Than Nyquist (FTN) signaling system using a Binary Phase-Shift Keying modulation (BPSK). The popular open-source, and radio-specific, signal processing application GNU Radio was used to develop transmitter and receiver architectures. These architectures were then deployed for execution on a variety of Software Defined Radio (SDR) hardware. The final aim of the project is to experiment with a novel demodulation technique recently applied to FTN systems known as Probabilistic Data Association (PDA.) Since the seminal works of [1–3] showed that it would be possible to exceed the Nyquist signaling rate while maintaining an equivalent bit error rate (BER) performance, researchers have proposed many novel and creative methods for the implementation of a Faster-than-Nyquist (FTN) system. A large majority of these works have concentrated on the development of algorithms for mitigating or undoing the effects of intentionally introduced inter-symbol interference (ISI.) Furthermore, many of the works have relied purely on results produced from simulated models of FTN signaling. The reason for this being that these methods have very high computational complexity and would introduce far too great of an overhead cost on hardware, for example the turbo encoded and trellis based transceivers proposed in [4, 5]. However, there have been some works that have discussed and even attempted implementations of both FTN transmitters and receivers. These implementations have predominately been concentrated in the areas of non-orthogonal frequency domain multiplexing (NOFDM) and multi-carrier systems. With regards to an FTN transmitter architecture, [6] proposes a look up table (LUT) based transmitter architecture for an OFDM system. The LUT implements a mapping of offset-QAM symbols to set of pre-computed optimum FTN symbols for input into a traditional OFDM transmitter. In [7] the proposed FTN mapping system is actually implemented targeting a FPGA device. In [8] yet another transmitter architecture is implemented on FPGA but for a so called Spectrally Efficient Frequency Division Multiplexed (SEFDM) system, which intentionally overlaps carriers in OFDM. The SEFDM signal generated by hardware is compared to simulated models. The proposed FTN mapper system in [7] is combined with an FTN receiver for a full transceiver system on FPGA hardware in [9]. The transceiver has the ability to default to standard OFDM signaling depending on the quality of the channel. Follow up papers for this transceiver system [10, 11] make improvements in the VLSI parameters of memory, area and power consumption. The works discussed above are the only attempts made at hardware based implementation of an FTN communication system, to our knowledge. All these works use FPGAs and target more advanced communications schemes. In this work we seek to utilize existing Software Defined Radio (SDR) hardware and the digital communications toolbox GNU Radio to implement a FTN transceiver based on a low-complexity probabilistic data association algorithm (PDA) [12]. The transceiver intentionally employs a basic binary phase-shift keying (BPSK) scheme with root-raised cosine (RRC) pulse shaping filters. The implementation of our FTN BPSK transceiver was carried out partially in GNU Radio and in MATLAB. The SDR used was National Instruments (NI) USRP 2920.

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