Robust High-Frequency Communications With Nonlinear Channelizer Array Pre-Processing

Radio frequency (RF) communications receivers often require analog-to-digital converters (ADC) to process signals. Unfortunately, ADC that operate above a few hundred megahertz are expensive, which prevents cost-effective signal digitization in the low gigahertz range. This cost can be partially mitigated via preprocessing by the nonlinear channelizer (Chaos 22.4 (2012): 047514-047514), a system of N coupled overdamped bistable oscillators which dynamically locks on to RF signals and provides frequency downconversion to frequency fc/N. The figure (upper left) shows a schematic drawing of two coupled arrays of three oscillators and a photograph (upper right) of the microcircuit of one overdamped bistable element. In this work, MPI/C++ parallel programming is used to simulate the preprocessing of RF signals (modulated with binary phase shift keying (BPSK)) by an array of three nonlinear channelizer elements. After dynamical frequency downconversion of the RF signal to frequency fc/3, the orthogonal signal components (In-Phase, Quadrature) are computed for each oscillator and passed through a low-pass filter. In the figure (lower right), the low-pass filtered samples for one oscillator are shown for different frequencies and amplitudes of the RF signal with a demodulator sampling rate of 1600 MHz. It is clear that it is possible to distinguish between the phases of BPSK signals (0: black, 1: yellow) if the signal amplitude (s0) and frequency (fc) are selected within the frequency downconversion channel boundary. This work demonstrates that low error reception of MPSK modulated RF signals is possible for a variety of frequencies in the low-gigahertz range with receiver-end signal pre-processing by a nonlinear channelizer array.

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