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High Sensitivity RF Communication System Based on the Time Synchronized Averaging Technique (TSA)

E. Novakov
Centre de Radiofréquences, Optique et Micro-nanoélectronique des Alpes (CROMA)
Université Grenoble Alpes, Grenoble, France
e-mail : emil.novakov@univ-grenoble-alpes.fr

Time Synchronized Averaging (TSA) is a powerful technique to improve the signal-to-noise ratio in a periodic signal. This technique is widely used in physics, mechanics, medicine and in all fields that deal with weak periodic signals corrupted with additive non-coherent noise.

In a previous work [1] it was shown that this technique allows to improve the sensitivity of a digital RF receiver. At the transmitter side, the method consists in retransmitting a block of digital data N times. This makes the transmitted signal periodic. At the receiver, for each block of data (1 … N), the analog signal received after the demodulator is recorded. The N signals are then averaged. In the case of perfect synchronization, the averaging of N blocks improves the signal-to-noise ratio by 10log(N) dB. TSA increases the signal transmission time N times. As a result, the equivalent energy of each bit at the detector, after averaging, increases N times, which increases the equivalent sensitivity at the receiver input. TSA does not modify the bandwidth neither the power of the transmitted RF signal. In the first part of this work, we show that TSA is in fact the time domain equivalent of the direct sequence spread spectrum (DS-SS) technique. In the second part we describe an RF transmission system that has been realized and tested. The synoptic diagram of the system is shown in Figure 1.

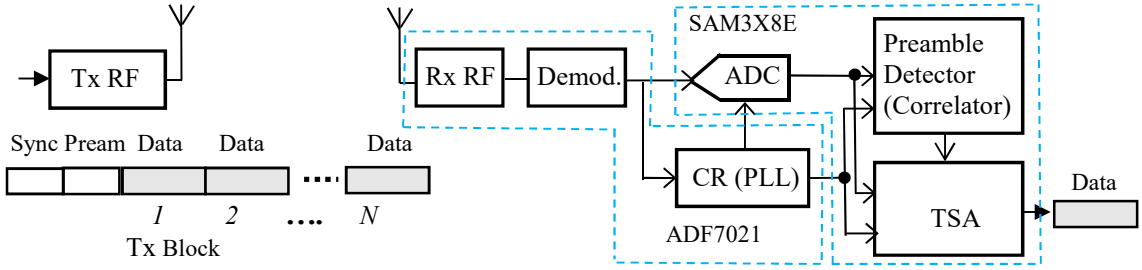

Figure 1. TSA based RF communication system

At the transmitter (Tx) the data block to be transmitted (Data) is repeated N times. At the beginning of the Tx Block a synchronization sequence (Sync) and a preamble (Pream) are added. The synchronization sequence (1010...) allows the receiver's Clock Recovery system (CR) circuit to hang up. The detection of the preamble performs the time synchronization and indicates the beginning of the data to be averaged. The analog signal at the demodulator's output is sampled by an ADC and all the processing is carried out in digital form. The data are stored, and once the whole block is received, the TSA is performed. The digital data are generated from the averaged analog signal with an adaptive threshold comparator. The real sensitivity improvement depends of the precision of the time synchronization of the receiver and the performance of the clock recovery circuit (PLL).

The system has been implemented and tested. A standard ADF7021 integrated transceiver was used. This circuit is chosen because it provides the analog signal of the demodulator output and has an internal CR circuit (PLL). All processing was done with an Atmel SAM3X8E microprocessor in real time. The data rate is 4.8 kbit/s. The measured sensitivity of the ADF7021 circuit is -126 dBm. Experimental measurements showed that with a number of retransmissions N = 6 the sensitivity obtained was -133 dBm, an improvement of 7 dB. The system suitable for software defined radio (SDR) implementation. The TSA method is appropriate for the realization of high sensitivity RF communication systems. This work has been carried out in the framework of the EU SOIL project.

References:

[1] E. Novakov, "Increasing the Sensitivity of a Digital Receiver by Time Synchronous Averaging (TSA)", 2016 IEEE Sixth International Conference on Communications and Electronics (ICCE 2016), Ha-Long City, Quang Ninh, Vietnam, 27-29 July 2016.