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Synchronization for Coherent Averaging Based Communication System

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The sensitivity of a digital receiver can be improved by coherent or time synchronous averaging (TSA). The data to be transmitted are grouped into a block and the block is retransmitted several times. On the receiver side the blocks are synchronously averaged thus increasing the signal-to-noise ratio. In the receiver the TSA block is inserted between the demodulator and the decision circuit and implemented in digital way. TSA spreads the signal in time domain and increases the link budget and the communication range without changing the system bandwidth or increasing the RF transmitted power. Retransmitting N times the same data block and synchronously averaging the received signal leads to a theoretical improvement of the receiver's sensitivity by 10log(N). Theoretically TSA allows very large signal-to-noise improvement. The real performance is related to the receiver's synchronization system as the TSA is very critical to the time synchronization between the block to be averaged. The real improvement of the sensitivity is fixed mainly by the receiver's synchronization system. In a previous work [1] the TSA performance was investigated and 3 to 5 dB increase in standard receiver sensitivity was shown for N = 5.

The retransmission of the data block makes the received signal periodic. This *a priori* information can be used to improve the synchronization process. The signal periodicity can be detected by a correlator. When a signal composed of two identical consecutive blocks of length T is send to a correlator with an internal delay of T, a peak is generated at the end of the second block. This peak can serve as a time reference. For a signal composed of multiple retransmissions of the same block it is possible to correlate every two blocks in the received signal and to add the correlator's output to enhance the signal. Summing the signals at the correlators output is equivalent to an average and increases the ratio between the peak amplitude and the noise like signal around the peak. For N retransmission the number of correlators to proceed N data blocks two by two is the binomial coefficient C_N^2.

In this paper we present a system for coherent averaging and precise time synchronization based on a set of multiple correlators. The data block is retransmitted N = 4 times. The number of the correlators in the synchronization system is 6 and the maximum sensitivity improvement is 6 dB. The performances of the system are evaluated in presence of noise. It is shown that the method is suitable to detect the start and the end of the data block even for low signal-to-noise ratio. Some experimental results are presented as well. The TSA method and synchronization are suitable for implementation in software defined radio transceivers (SDR) dedicated for long range communications and IoT applications.

[1] E. Novakov, M. Asgharzadeh and G. Maury, "Enhancement of the Sensitivity of a Digital Receiver by Time Synchronous Averaging", 32nd URSI GAAS, 19-26 August 2017, Montreal, Canada.