Pulse compression comparison in Q-DAS system: Ternary codes vs. Binary codes

Nadav Arbel[1], Yair Ben Naeh and Avishay Eyal[1]

[1] Department of Physical Electronics, School of Electrical Engineering, Fleischman Faculty of Engineering, Tel-Aviv University, Tel-Aviv 69978, Israel

Pulse compression techniques became popular in the last decade in many optical fields such as Laser Range Finders (LRF), Quasi and fully Distributed Acoustic Sensing (Q-DAS and DAS), Brillouin Sensing and more. In general, it allows increasing the transmitted energy while keeping the spatial resolution the same as that of a single pulse. A promising approach for implementing pulse compression is via Perfect Periodic Autocorrelation codes (PPA). Ideally, the autocorrelation of PPA codes is a sequence delta functions. This is a manifestation of the codes ability to achieve perfect compression. Therefore, replacing each transmitted pulse by a PPA code and compressing the received returns, leads to a significant improvement in the SNR. Out of the binary PPA codes, i.e. codes whose basic elements (bits) are two complex numbers, the largest families are the M-sequence and the Legendre code.

In a Legendre code of length N the bits are of unit magnitude and phases: $\left\{0, \cos^{-1}(-\frac{N-1}{N+1})\right\}$. In practice, it is difficult to generate such sequences using typical optical modulators. An approximated sequence whose generation is more practical is obtained by using phases from $\{0, \pi\}$. A Legendre code with this alphabet has a periodic autocorrelation function of -1 everywhere except at the center where its value is N. Hence, its Peak to Sidelobe Ratio (PSLR) becomes N (rather than ∞ as in the ideal case). This may hinder the performance of systems which employ Legendre-codes as it may lead to increased crosstalk. On the other hand, shutting down the transmission adds no complexity to the system, hence a ternary code with the same alphabet as before and with few added zeros can be used. The use of such ternary PPA is expected to offer better PSLR and improved crosstalk performance.

In this research, we limited ourselves to the transmission of +1, 0,-1 bits and experimentally compared binary-phase codes with ternary perfect periodic codes at different SNRs.

The results show that for the same transmitted energy, the ternary code has better performances in a high SNR scenario but this advantage is lost as the SNR decreases.

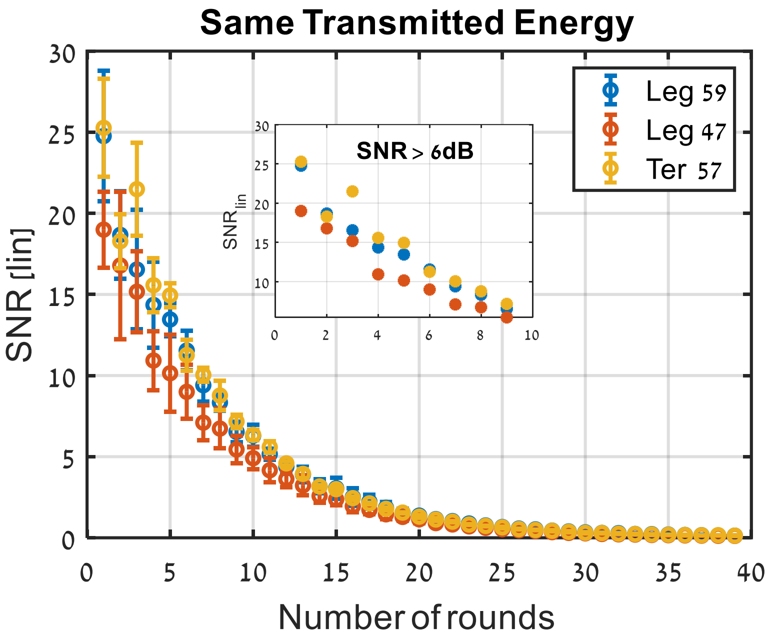

Figure 1 : SNR results of different PPA codes vs. number of rounds inside an optical ring. Leg is short for Legendre, Ter is short for Ternary. The number indicates the number of bits in the code.