Follow-up to New Preamble Proposal for 10BASE-T1S

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Introduction

- In [1], Broadcom proposed a new preamble for 802.3cg Short Reach to improve synchronization performance.
- This presentation introduces some other benefits of the proposed preamble and adds support for 802.3br.

[1] “New Preamble Proposal for 10BASE-T1S” cordaro_8023cg_short_reach_new_preamble_proposal_1220.pdf on 12/20/2017

Outline

- Autocorrelation
- Proposed Sequence w/802.3br support
- Complexity
- Latency
  - MAC TX to MDI
  - MDI to MAC RX
- Channel Impulse Response Estimate with Proposed Preamble Sequence
- Signal Quality/Diagnostics with Proposed Preamble sequence
- Summary

Brief Review of Autocorrelation

- Autocorrelation of discrete sequence x[n] is defined as

$$R_{XX}[n] = \sum_{k=-\infty}^{k=\infty} x[k]x[k-n]$$

- For example, if sequence A of a Golay pair =[1 1 -1 1] is transmitted, and then sampled at the receiver with no degradation or channel impairments, the correlation of the transmitted sequence with the received sequence is:

```
 1*A =[1  1 -1  1  0  0 0]
-1*A=[0 -1 -1  1 -1  0 0]
 1*A =[0  0  1  1 -1  1 0]
 1*A =[0  0 0   1  1 -1 1]
 ---------------------------------
```

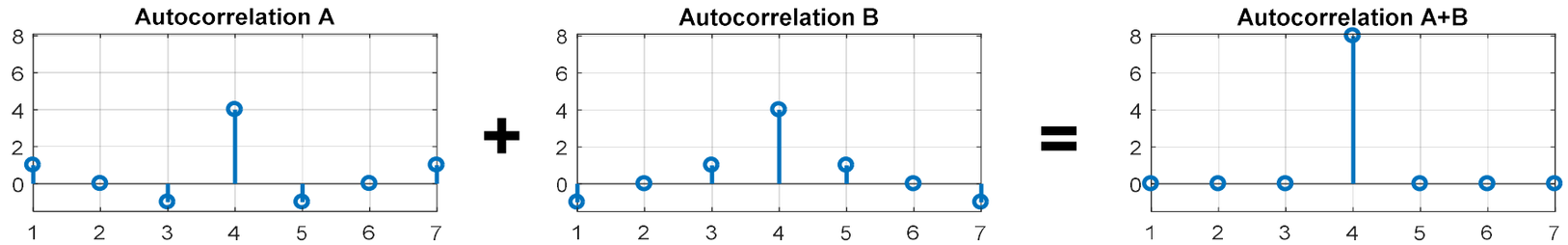
R_{AA} = [1 0 -1 4 -1 0 1]

The autocorrelation for sequence B= [1 1 1 -1] gives

R_{BB} =[-1 0 1 4 1 0 -1]

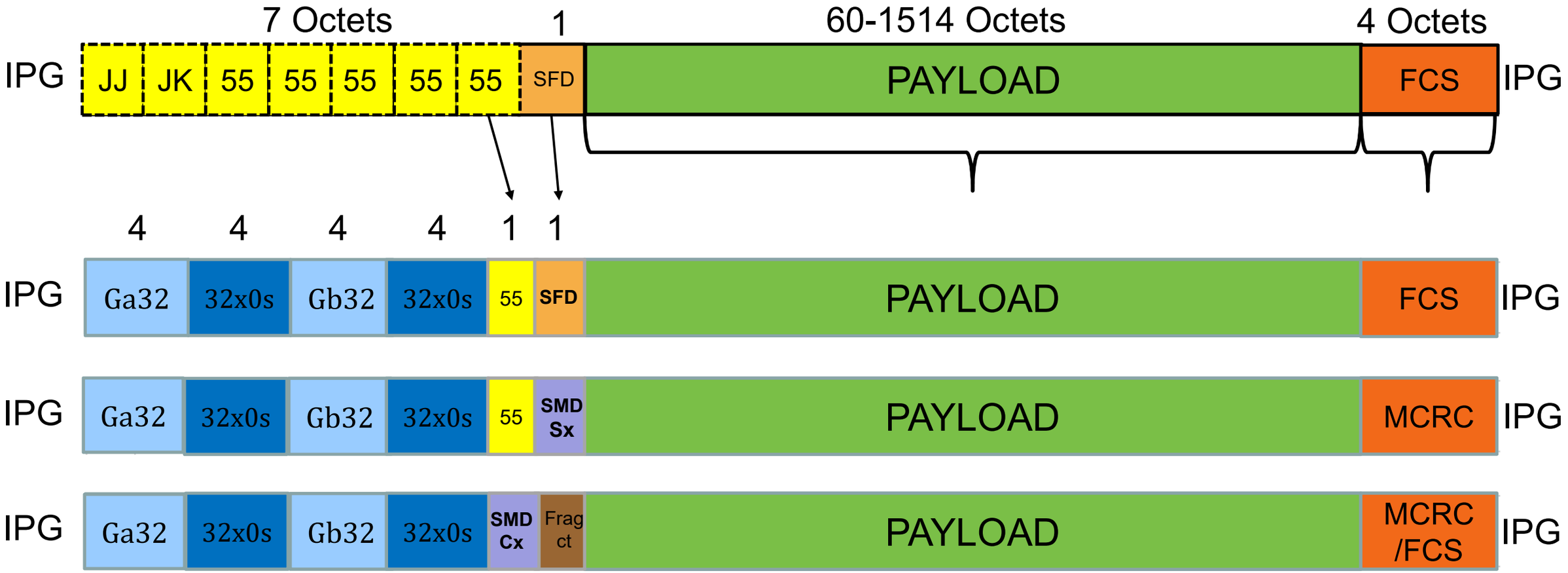
The sum of the autocorrelations $R_{AA} + R_{BB}$ for this Golay pair is

[0 0 0 8 0 0 0]



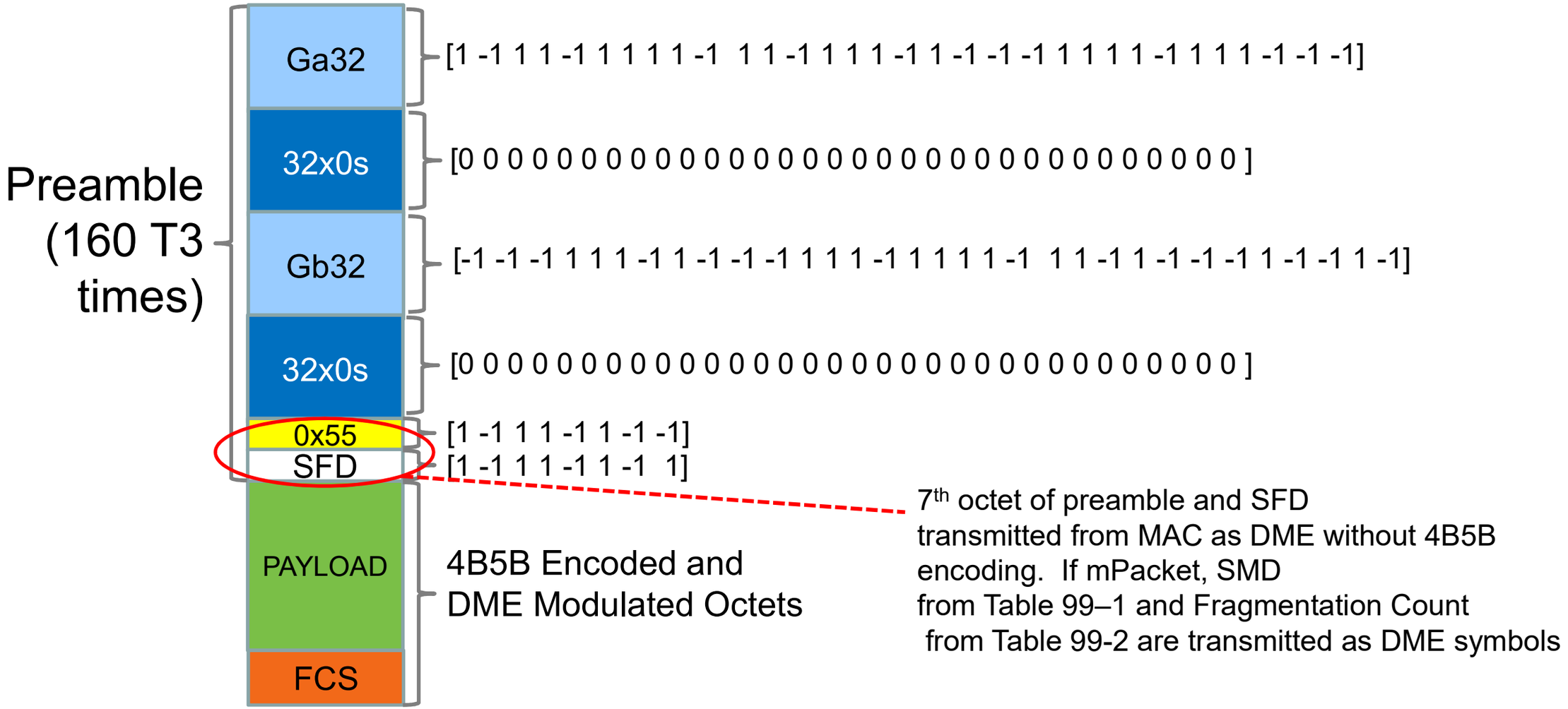
- The Fourier transform of the autocorrelation of a finite sequence gives the Energy Spectral Density (ESD) of the sequence. Golay sequence pair will have very flat ESD – good emissons.

Current vs. Proposed 10BASE-T1 Preamble w/802.3br Support



- 4B5B + DME encoded preamble + SFD in 802.3cg D1p0 is 64*($\frac{5}{4}$)=80 symbols (T2) or 160 T3 long.
- Proposed preamble -- Golay complementary sequence pair with zero padding, PLUS a suffix of two DME-encoded (not 4B5B-encoded) octets – fits into current 160 T3 long preamble spacing.
- Transmitting 7th octet of preamble and SFD allows 802.3br support for Express and Preemptable frames

Proposed Preamble and Payload Format



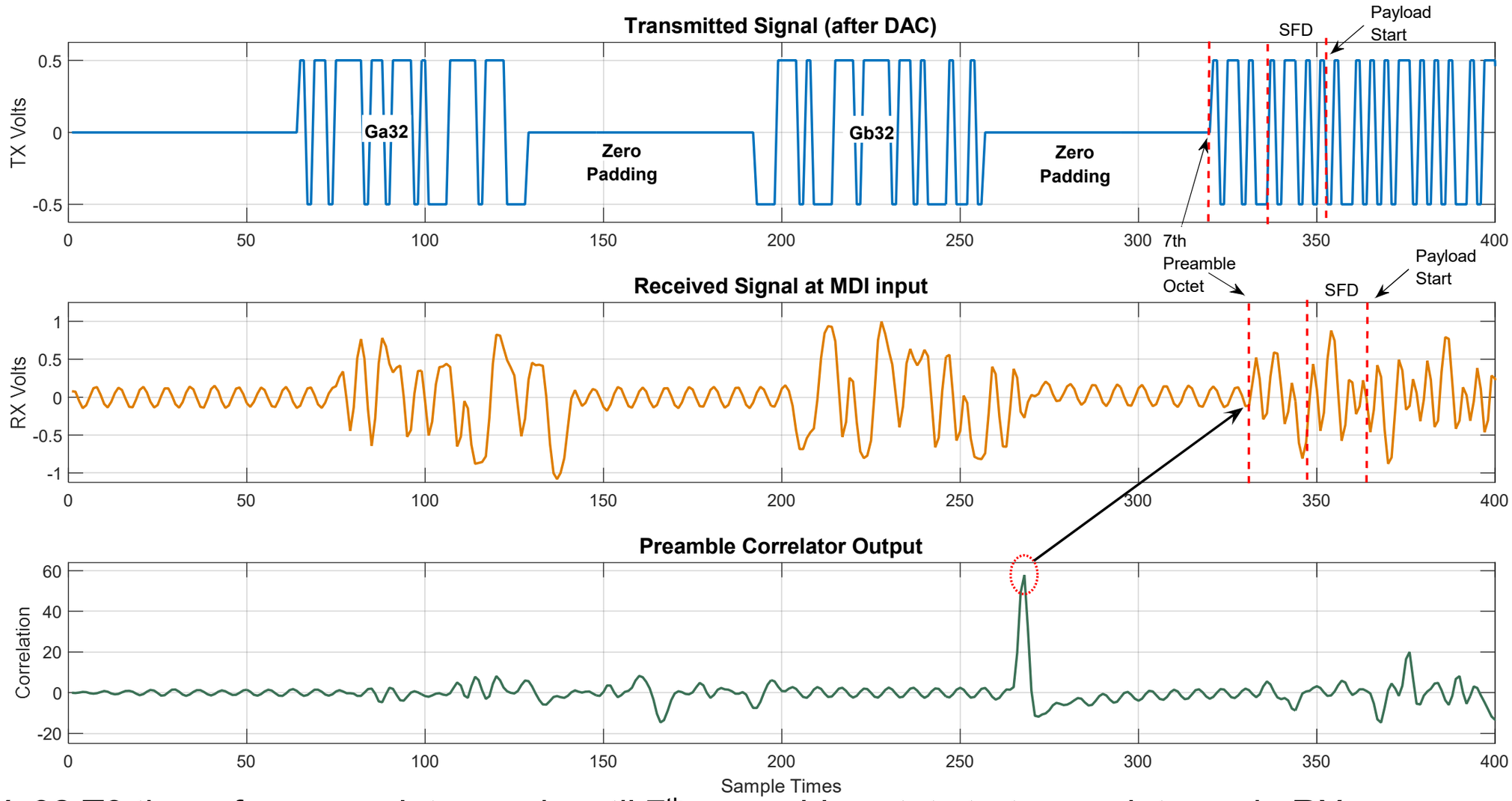
Bits for preamble read left to right, top to bottom.

Clause 22 Compliance

- New preamble allows 10BASE-T1 PHYs to interoperate with Clause 22 compatible MII MACs
- 22.2.2.3 -- Transmission of data from the MAC via the PHY
  - When TX_EN is asserted and the preamble is transmitted on TXD, replace first 6 octets with new preamble. DME encode the 7th preamble octet from MAC and the SFD (or, 802.3br octets sent by MAC)
- 22.2.2.7 and 22.2.2.8 -- RX_DV and RXD during packet reception
  - Once preamble correlator detects valid preamble, 32 bit times (T3) from correlation peak, assert RX_DV and output 7th octet of preamble and SFD to MAC on RXD<3:0> followed by frame payload.

Latency

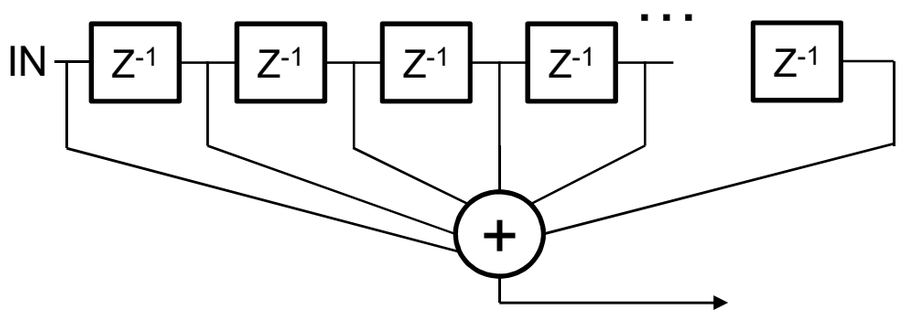
- TX- small (nibble) buffer required for 7th preamble octet and SFD. Payload has no latency.



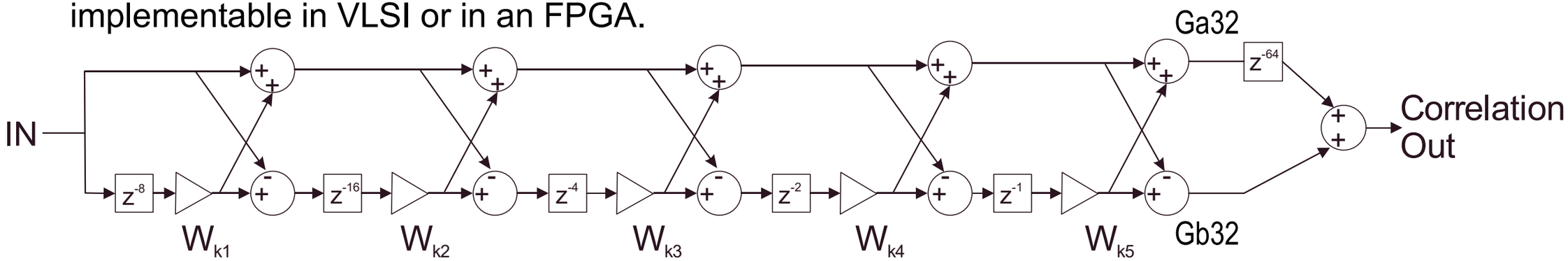
- RX: 32 T3 times from correlator peak until 7th preamble octet starts – no latency in RX

Complexity

- Correlation of Ga32 and Gb32 can be done using separate delay lines and adders for each pair.



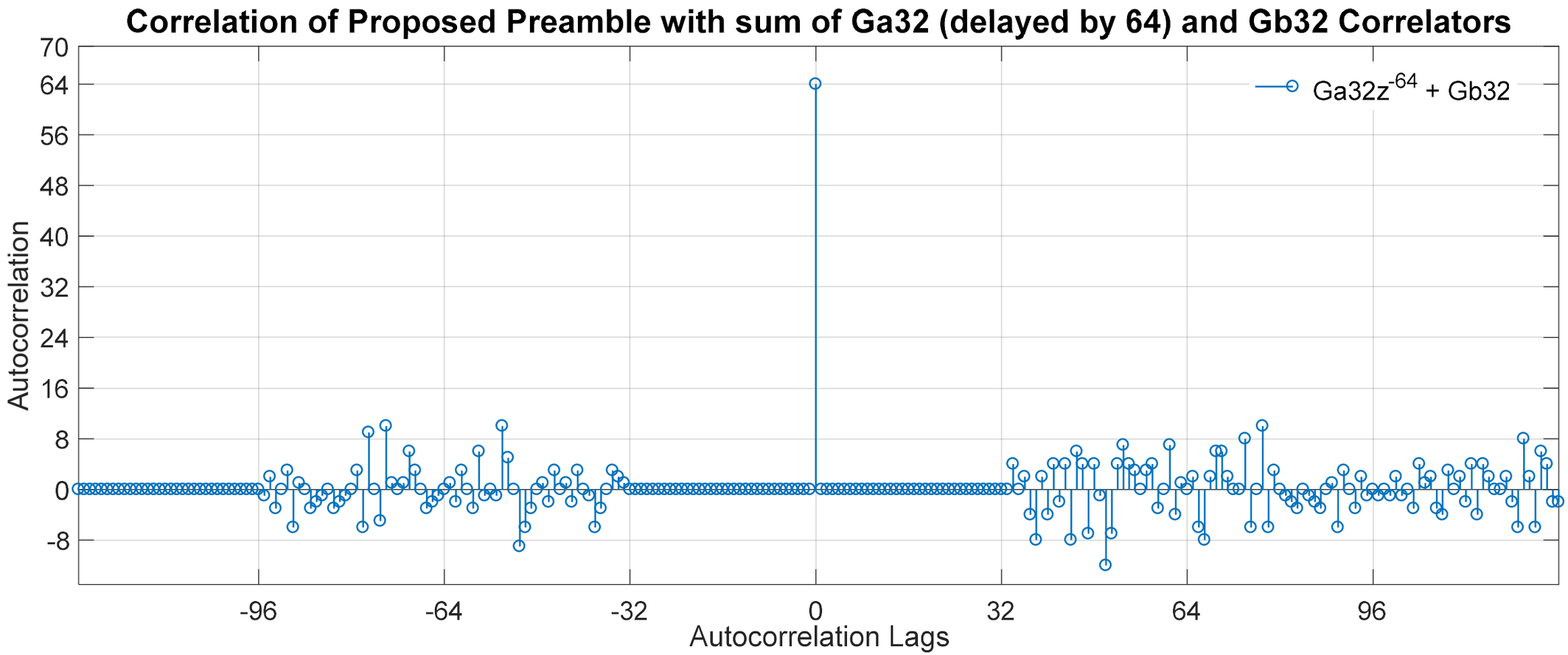
- However, Budišin [1] describes an efficient structure for generating/correlating Golay sequences which requires only 11 adds for correlating both sequences of the pair, and is easily implementable in VLSI or in an FPGA.



- Other efficient correlation structures for Golay sequences exist in the literature since they are used extensively in 802.11n, 802.11ad, and LTE and 5G cellular.

1. S.Z. Budišin, “Efficient Pulse Compressor For Golay Complementary Sequences”, Electronics Letters, Vol. 27 No. 3, 1991

Correlation of Proposed Preamble Sequence



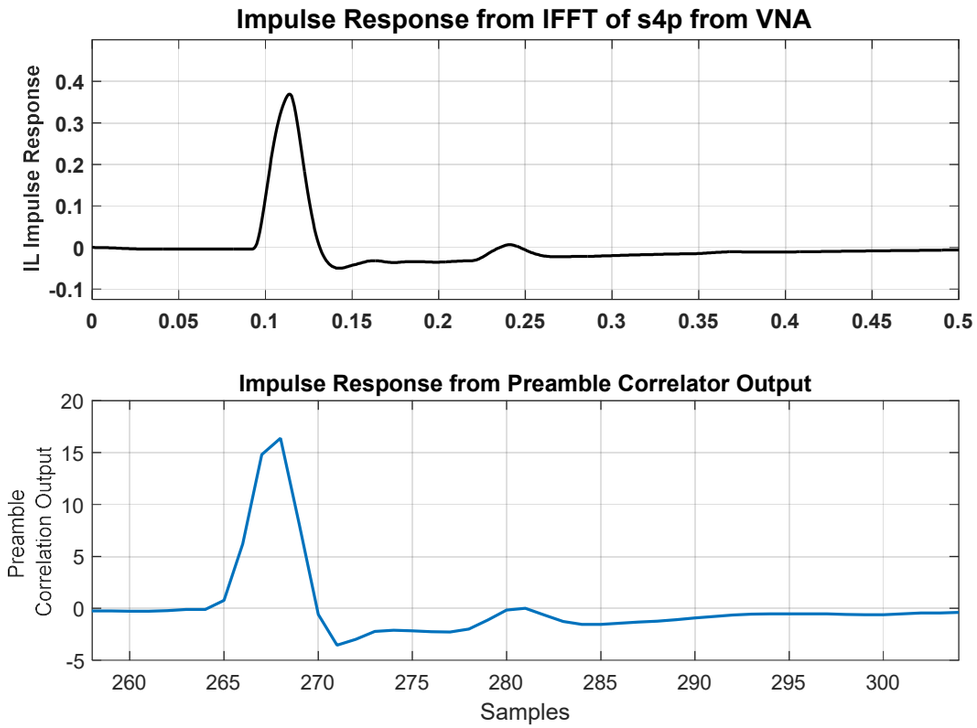
Note the large peak with zero sidelobes within 32 sample times either side of main lobes.

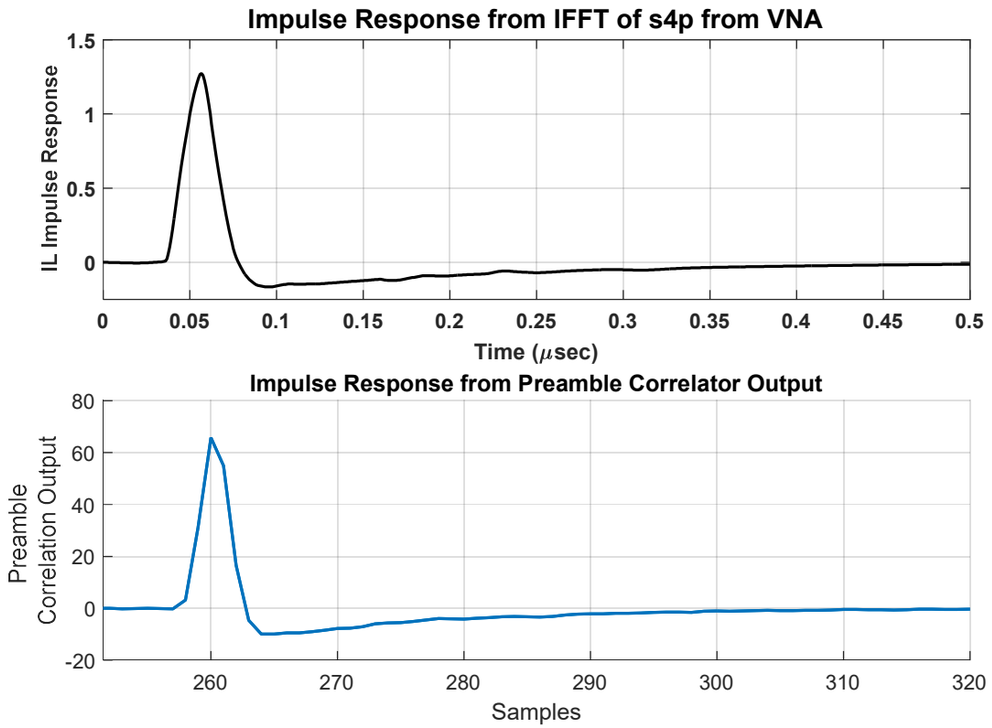
– Easy detection and synchronization in presence the of noise

Channel Impulse Response Estimate

- Another advantage of the proposed preamble is that it provides an accurate estimate of the channel impulse response.
- For longer multi-drop cable lengths, with spectral shaping for emissions control, and to deal with NBI, equalization may be required to obtain BER < 1E-9

Examples of channel impulse response estimates provided by the preamble correlator:





Signal Quality

- The channel impulse estimate can provide:
  - An estimate of SNR at receiver
  - Information to diagnose cable issues
  - help for the receiver to improve detection.

Summary

- A new preamble format for 802.3cg:
  - Compatible with 802.3br
  - Interoperates with Clause 22 compatible MACs
  - Has low latency
  - Low implementation complexity
  - Excellent synchronization performance in automotive high-noise environments
  - Provides the channel impulse response estimate which may be used at the receiver for:
    - Improving Detection
    - Estimating SNR
    - Cable Diagnostics