Evaluation of ACT Link Sync Burst Modulation

Aleksei Zherebtcov and Ragnar Jonsson - Infineon
September 4, 2025

Presentation to 802.3dm Ad Hoc Meeting September 4, 2025

Introduction

› The latest ACT text proposal includes Link Sync signaling based on repeated signal bursts. See Clause 200.8.3 of
  – https://ieee802.org/3/dm/public/0725/ACT_Clause200_proposal_v3.pdf

› This presentation evaluates three different approaches to modulating the burst signals in the two directions:
  – Both directions use 117MHz DME modulation for the burst signals
  – The low data rate direction uses 117MHz DME, but the high data rate direction uses higher rate square wave
  – The low data rate direction uses 117MHz DME, but the high data rate direction uses higher rate Near-Perfect code

› Our analysis shows that all burst modulation schemes are viable

Background

› The Link Sync Signal (LSS) should
  - Consist of periodically repeating short bursts
  - Have single burst duration of 4 DME signals periods
  - Be implemented with very simple DSP or analog technique
  - Tolerate +/-20% clock frequency offsets
  - Be very robust in the presence of noise

Burst Modulations

Modulation #1 (DME+DME):

› Low data rate direction:
  − The LDR DME LSS baud rate is 117.1875 MHz.
  − The burst modulation signal is deterministic signal which consists of four consecutive zeroes [0 0 0 0].
› High data rate direction:
  − The HDR DME LSS baud rate is 117.1875 MHz.
  − The burst modulation signal is deterministic signal which consists of four consecutive ones [1 1 1 1].
› The burst repetition period is 192 DME symbols.
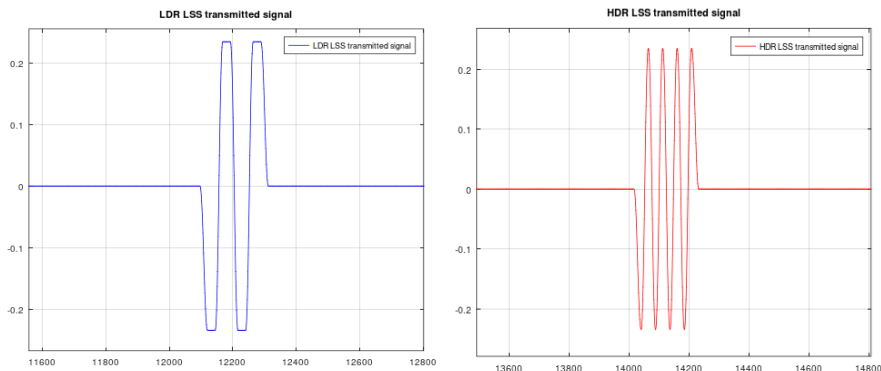
Modulation #2 (DME+SW):

› Low data rate direction:
  − The LDR DME LSS baud rate is 117.1875 MHz.
  − The burst modulation signal is deterministic signal which consists of four consecutive zeroes [0 0 0 0].
› High data rate direction:
  − The square wave frequency is 468.75 MHz.
  − The burst duration is 4 DME symbols.

› The burst repetition period is 192 DME symbols.
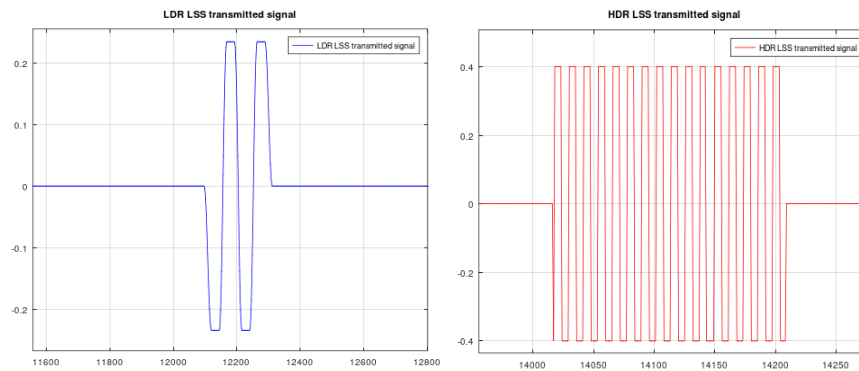
Simulation

› The simulation results in this presentation were generated using
  - 15m STP(Shielded Twisted Pair) cable with four inline connectors
  - 4th order Butterworth analog filters with 250MHz and 2812.5MHz cutoff frequency for the low and high data rate receivers, respectively
  - The matched filters were DME match filter for the 117MHz DME signaling and a bandpass filter for the 468.75 MHz square wave
  - Link Synchronization was declared when 6 consecutive pulses were detected within the expected time windows, without any unexpected pulses between the detected pulses

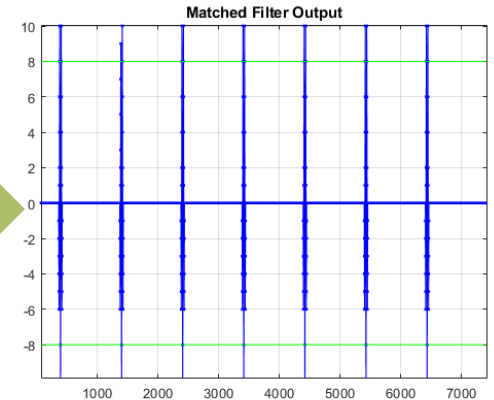# Modulation #1 – Low Data Rate Direction

Channel Output (before AWGN): Expected (blue), Echo (red)
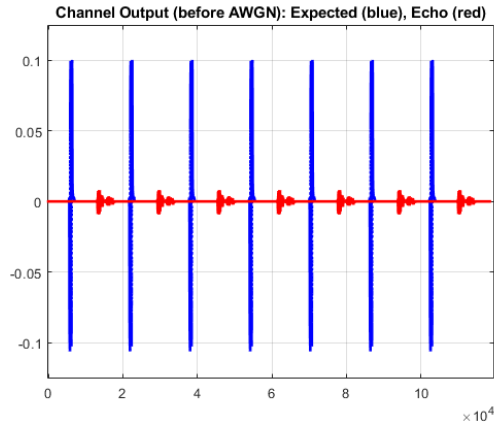
› Relatively low echo
› LP filter removes much of the Gaussian noise
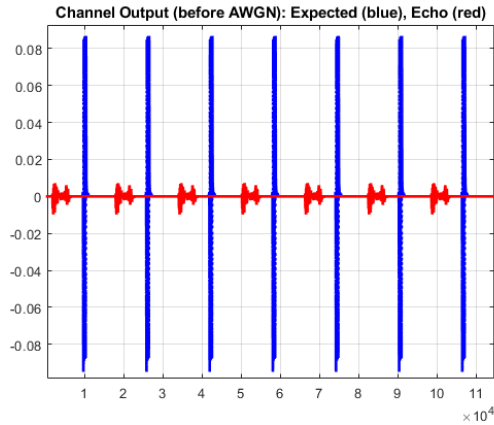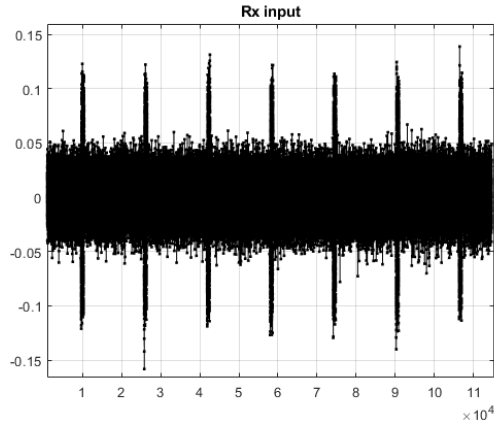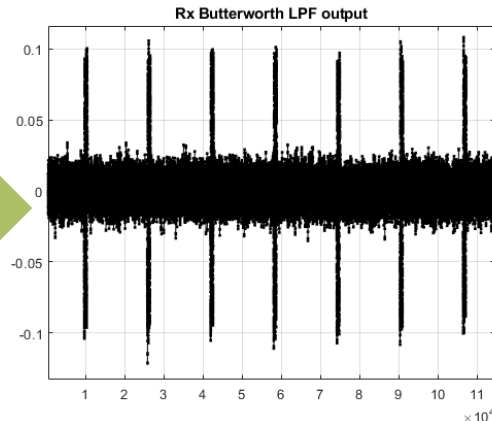› DME matched filter cleans up signal for reliable detection of pulse

Rx input

Low Pass

Rx Butterworth LPF output
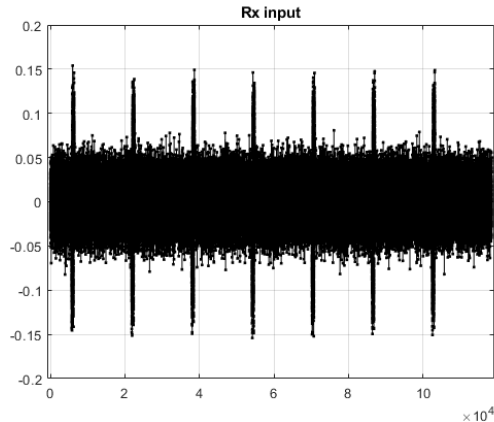
Matched Filter
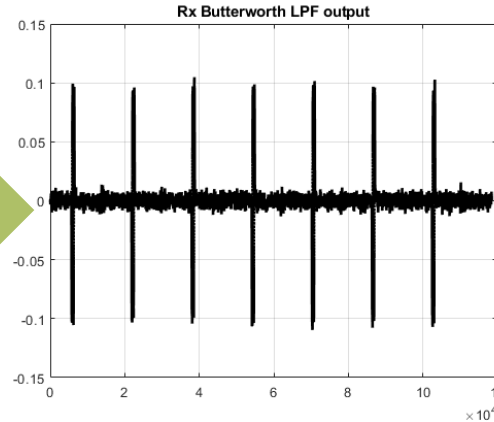
Matched Filter Output

Modulation #1 – High Data Rate Direction

Channel Output (before AWGN): Expected (blue), Echo (red)

› Relatively low echo
› LP filter removes less of the Gaussian noise, because of higher bandwidth
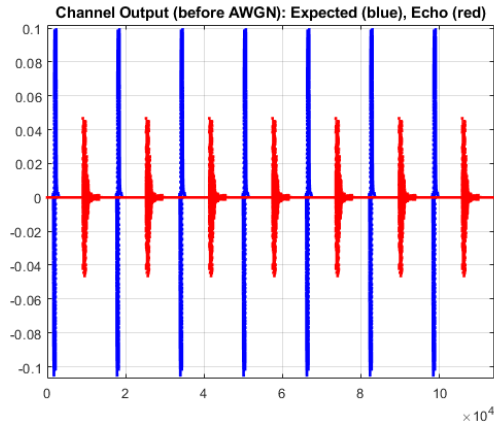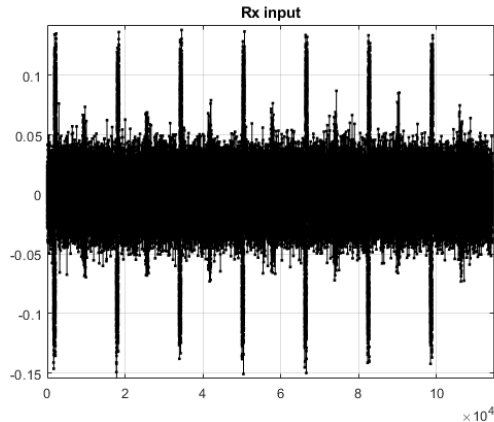› DME matched filter cleans up signal for reliable detection of pulse


Rx input

Low Pass

Rx Butterworth LPF output

Matched Filter

Matched Filter Output
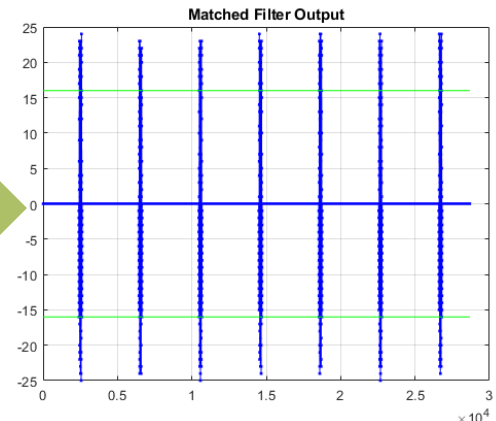
Modulation #2 – Low Data Rate Direction

Channel Output (before AWGN): Expected (blue), Echo (red)
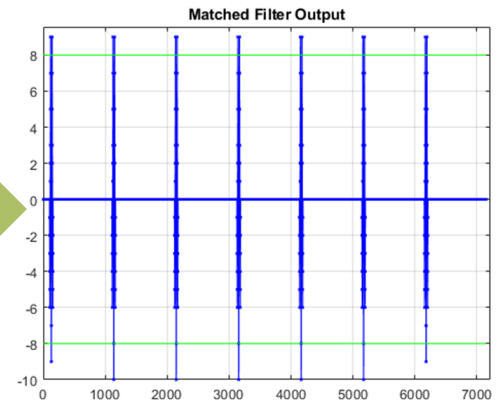
› Relatively high echo

› LP filter removes the echo and much of the Gaussian noise

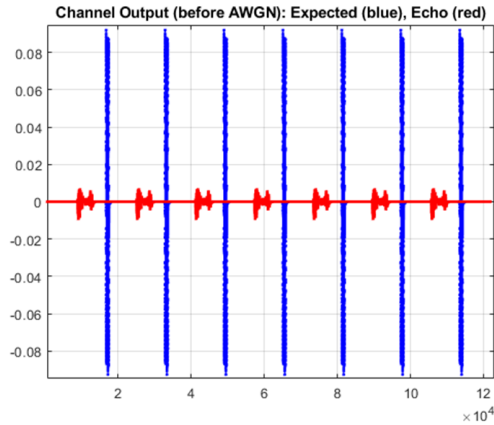› DME matched filter cleans up signal for reliable detection of pulse


Rx input

Low Pass

Rx Butterworth LPF output

Matched Filter
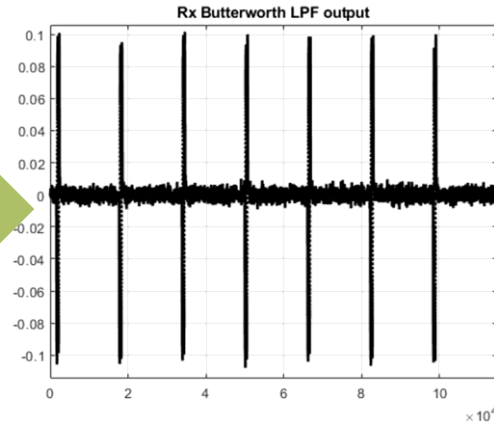
Matched Filter Output

Modulation #2 – High Data Rate Direction
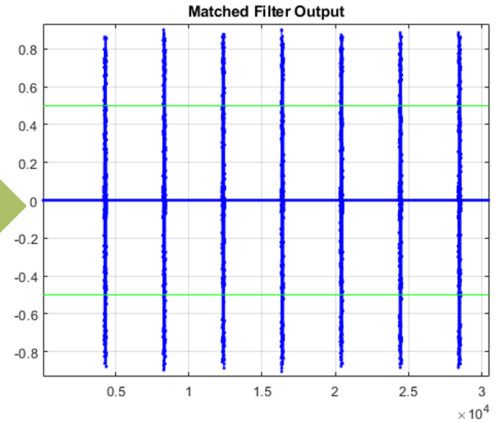

Channel Output (before AWGN): Expected (blue), Echo (red)

› Relatively low echo
› LP filter removes less of the Gaussian noise, because of higher bandwidth
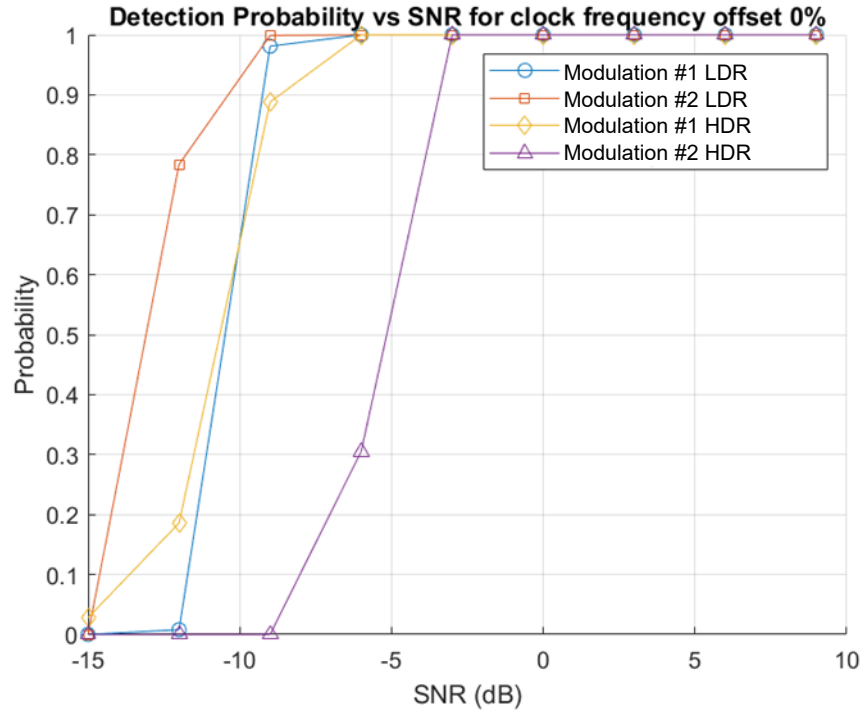› Matched filter (BP filter) cleans up signal for reliable detection of pulse

Rx input
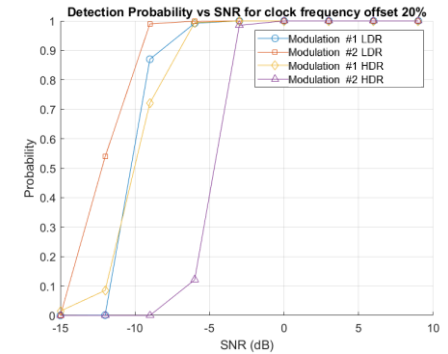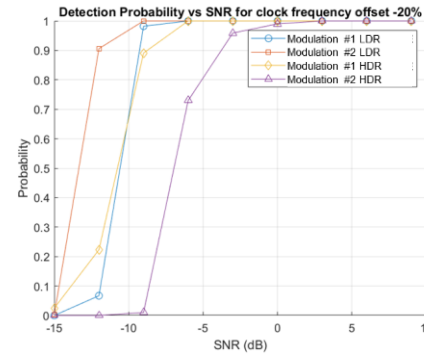
Low Pass

Rx Butterworth LPF output
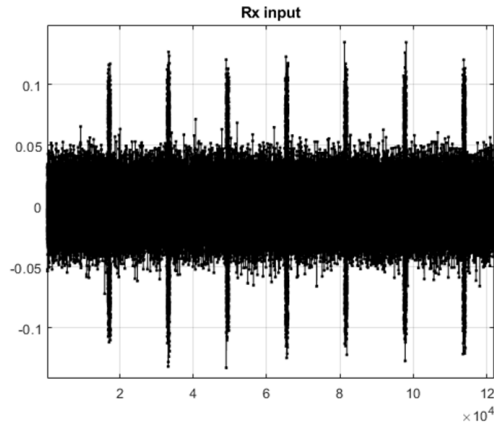
Matched Filter
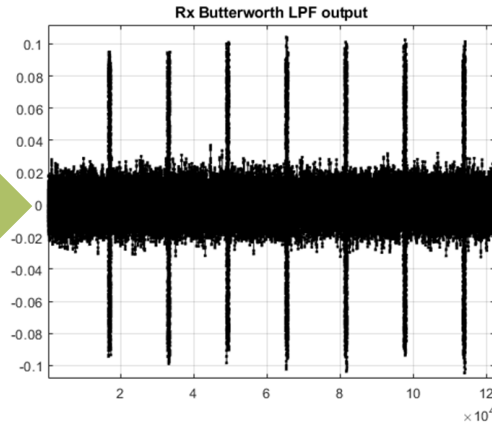
Matched Filter Output

Comparing Modulation #1 and #2

Detection Probability vs SNR for clock frequency offset 0%

› **Both modulation schemes have very good performance**

Third Burst Modulation Candidate

Modulation #3 (DME+Barker-like):

› Low data rate direction:
  - The LDR DME LSS baud rate is 117.1875 MHz.
  - The burst modulation signal is deterministic signal which consists of four DME symbols [1 0 0 1]
› High data rate direction:
  - Near-perfect code with 16 elements and a Baud rate equal to 468.75 MHz
› The burst repetition period is 192 DME symbols.
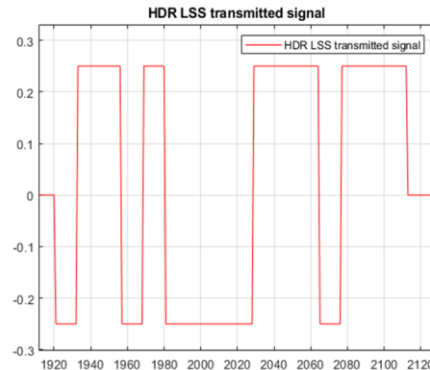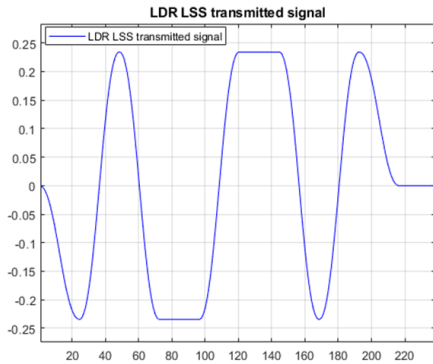
In case there is a high risk that channels may have deep notches (zeroes) in the frequency response near the frequencies of the LS signals, LS signals can be updated to have more widespread spectrum.
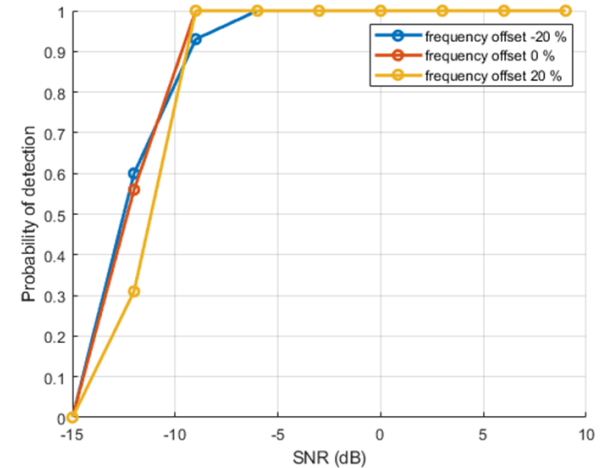
Conclusion

› This presentation compared three modulation candidates for the ACT Link Sinc burst signals

› All modulations had very robust performance across SNR values of interest