A Write-Narrow Read-Wide Recording Head and Multi-track Detection System

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Abstract

A novel (G)MR head architecture and associated multi-track detection system is introduced. The head's write element is nominally about half the size of the read element, completely contrary to the traditional write-wide read-narrow head design. It is not an array head. Capacity increases from 35% to over 45% are predicted. Further, the user read data rate can effectively double without correspondingly faster write drivers or write field switching requirements.

The data in pairs of tracks must be written in two consecutive passes to minimize frequency differences between the tracks. Each pair of tracks is read simultaneously by the wider read element and accurately decoded using digital communication techniques for co-channel detection. This is accomplished without resorting to a complicated array head structure or multiple pre-amps and read channels.

Experimental performance of such a system is approximated by writing two overlapping tracks and capturing the readback waveform that results when an AMR read element is positioned over both tracks. The digitized waveform is then processed through a software co-channel detector. Promising performance is demonstrated under typical signal-to-noise ratio conditions.

The Problems

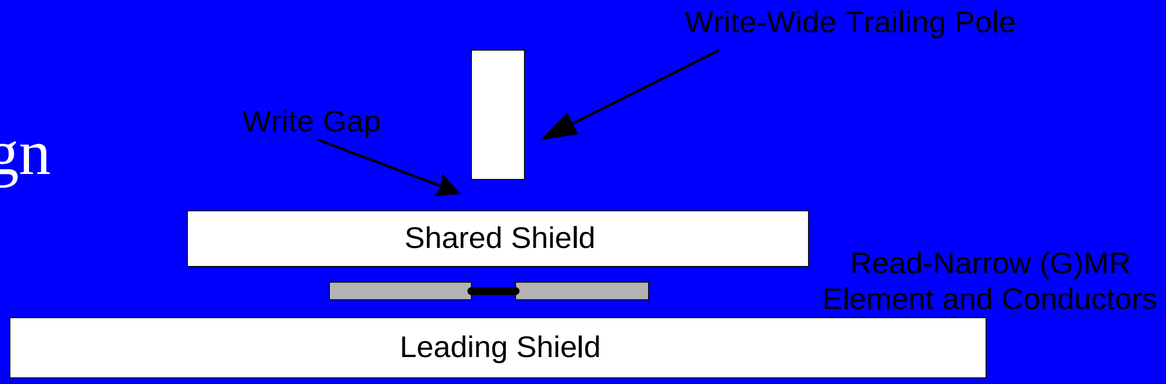
- Read Problem
  - Advanced detector architectures typically provide much less than 1dB advantage over more traditional detection methods such as EPR4ML. The advanced detectors usually involve feedback (error propagation), new equalization requirements and complex timing and gain algorithms that do not seem worth developing to achieve only a fraction of a dB improvement in SNR.
- Write Problem
  - Higher linear density (bpi) and faster spindle speeds are driving up data rates, especially in Internet servers. It is increasingly harder to achieve faster write driver rise times and faster head field switching times.
- Manufacturing Problem
  - It is difficult to make very narrow (G)MR stripes that are stable and efficient.
- ***Idea!***
  - Develop a detector architecture that provides enough capacity improvement to be worth the development effort and addresses the write problem and manufacturing problem.

The Solution

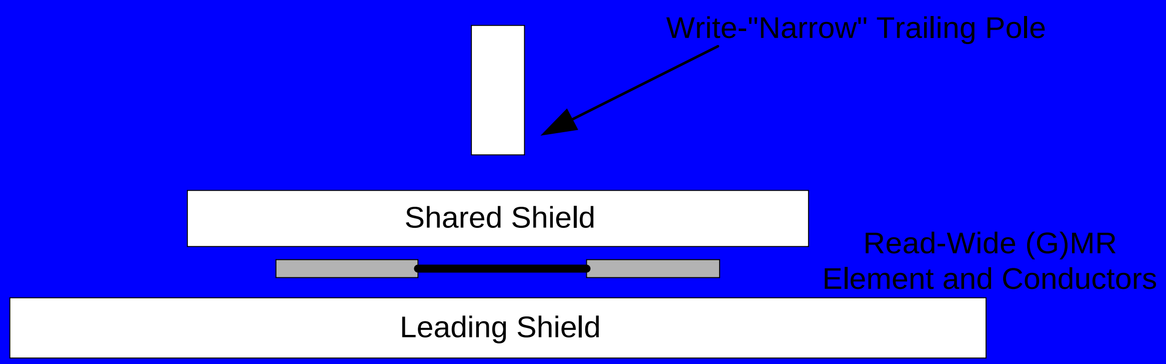
- Write pairs of tracks with a narrow track-trimmed thin-film inductive write element.
- Read back the pairs of adjacent tracks with a *single* WIDE (G)MR stripe (**NOT** AN ARRAY HEAD).
- Detect the data using co-channel techniques developed for multi-user digital cellular telephony.
- The data is available in parallel so data rates can potentially double without increased writing speeds.
- Capacity can be improved 35 to over 45% due to improved track format efficiency
- Areal density is not increased so the superparamagnetic effect is no more of a concern than in traditional designs
- Much better SNR of servo bursts is possible

A Write-Narrow Read-Wide (G)MR Head

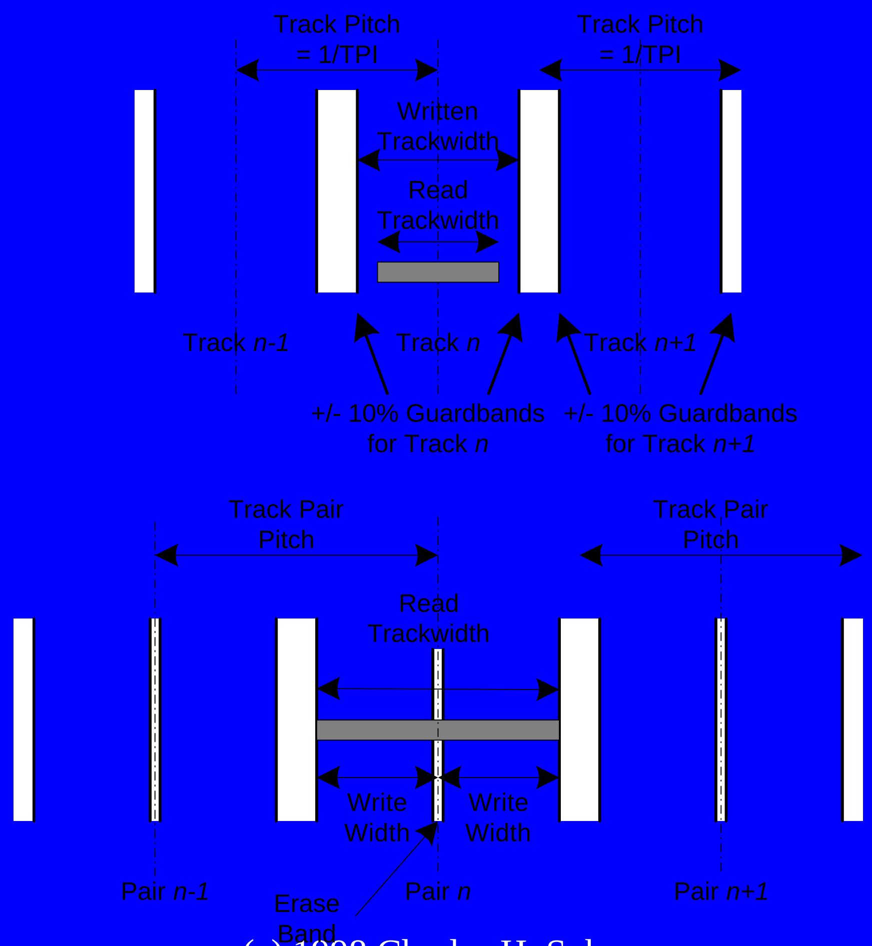
Traditional Design



New Design



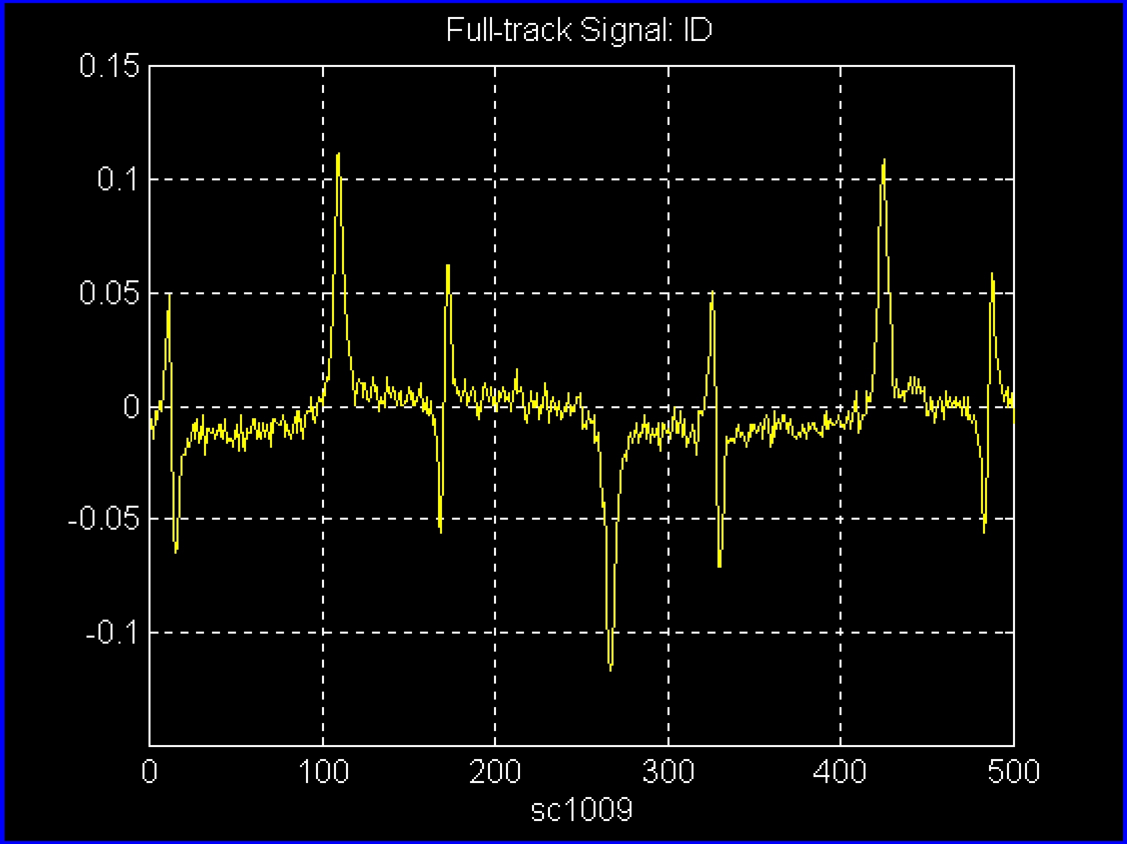
The Track Layout



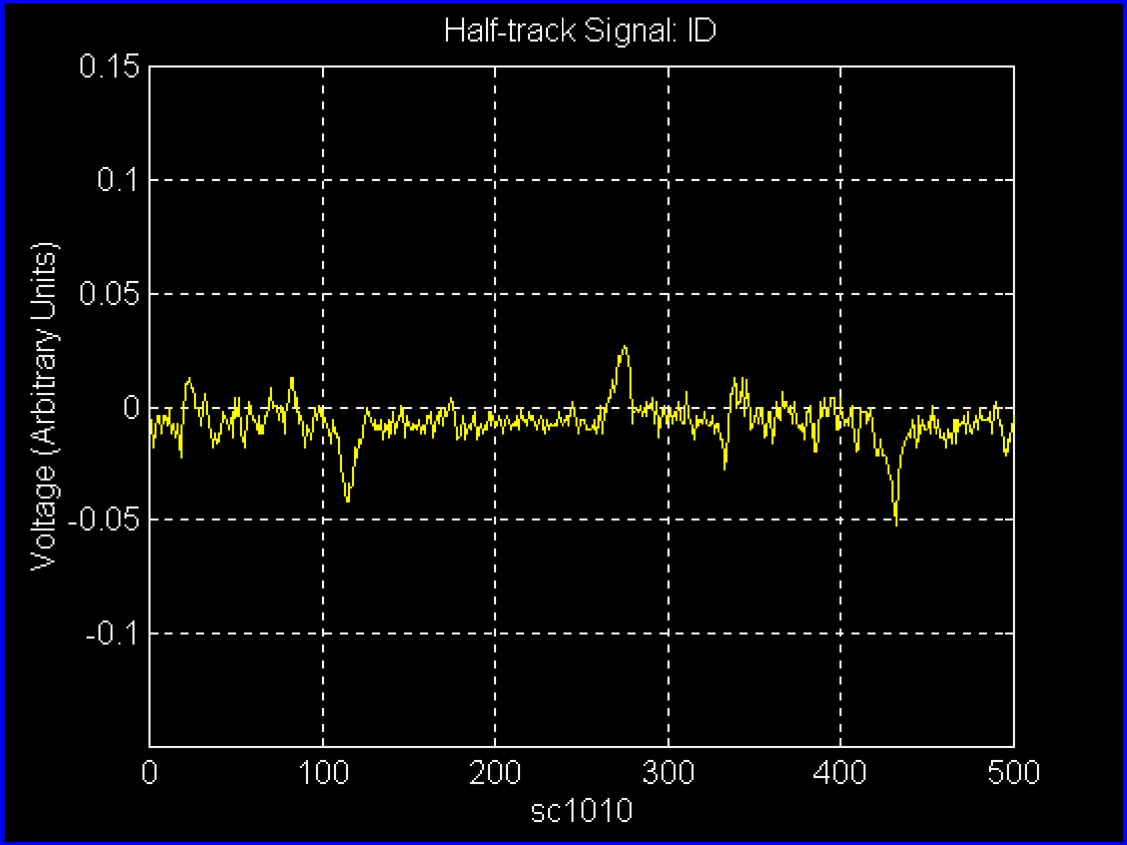
Capacity Improvement

- 35 to over 50% increase in *capacity*, over write-wide read-narrow designs without loss of on-track SNR
- Assumptions
  - Traditional write-wide read-narrow designs
    - » write width = 80% of track pitch
    - » read width = 80% of write width
  - "No guardband" write-wide read-narrow designs
    - » write width = track pitch
    - » read width = 55 to 75% of write width
- Onset of the superparamagnetic effect is not proportionally accelerated

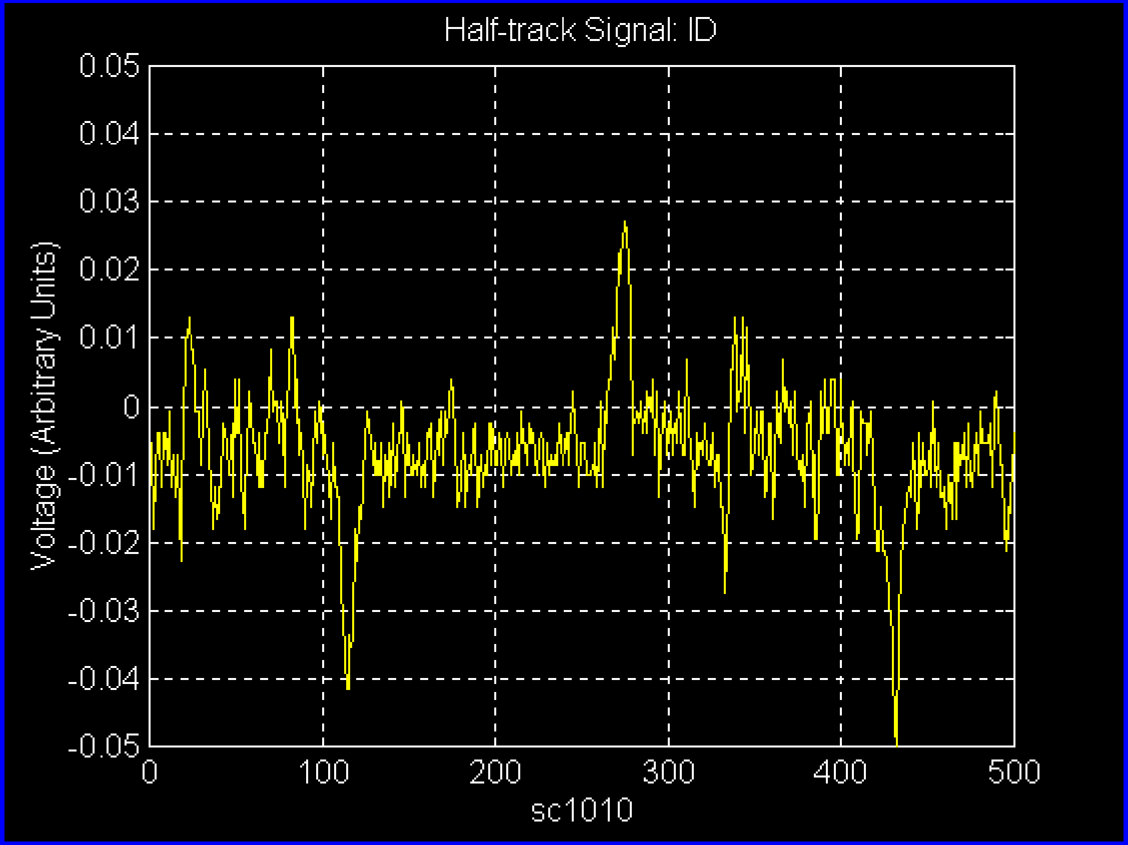
Full-track Signal: ID



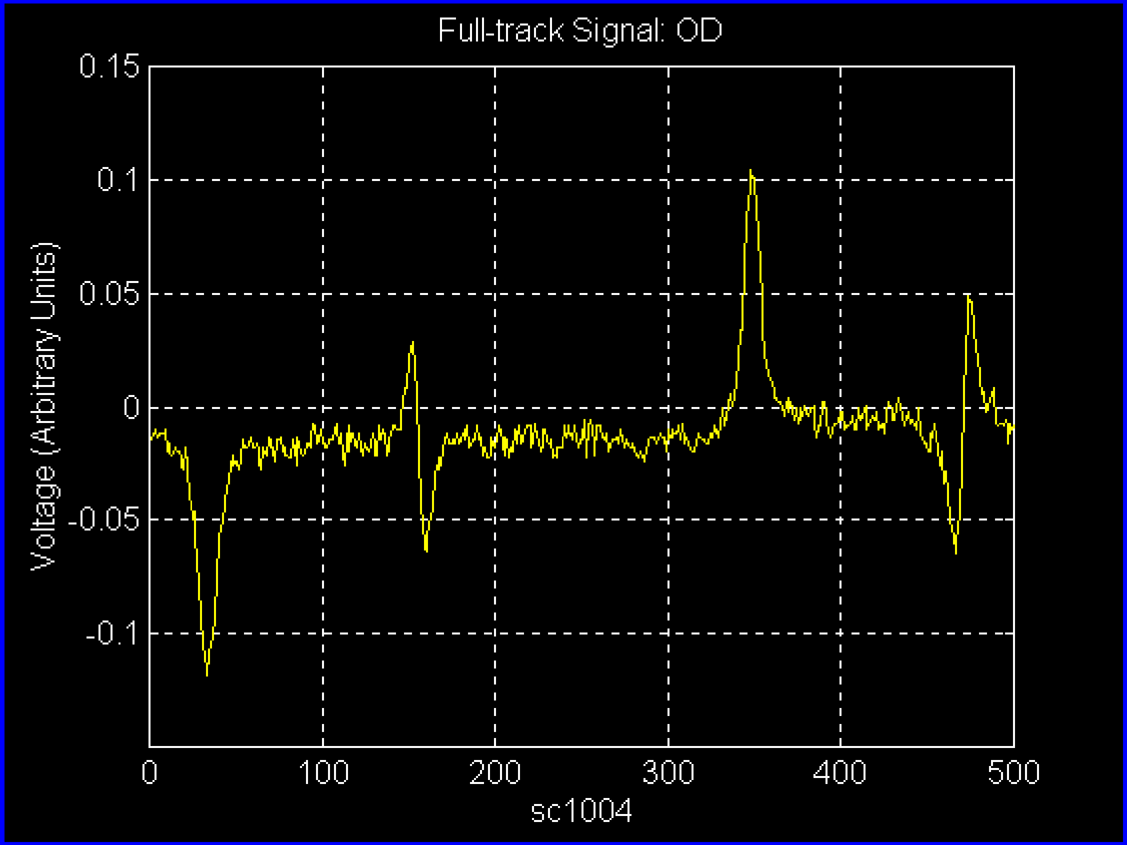
Half-track Signal: ID



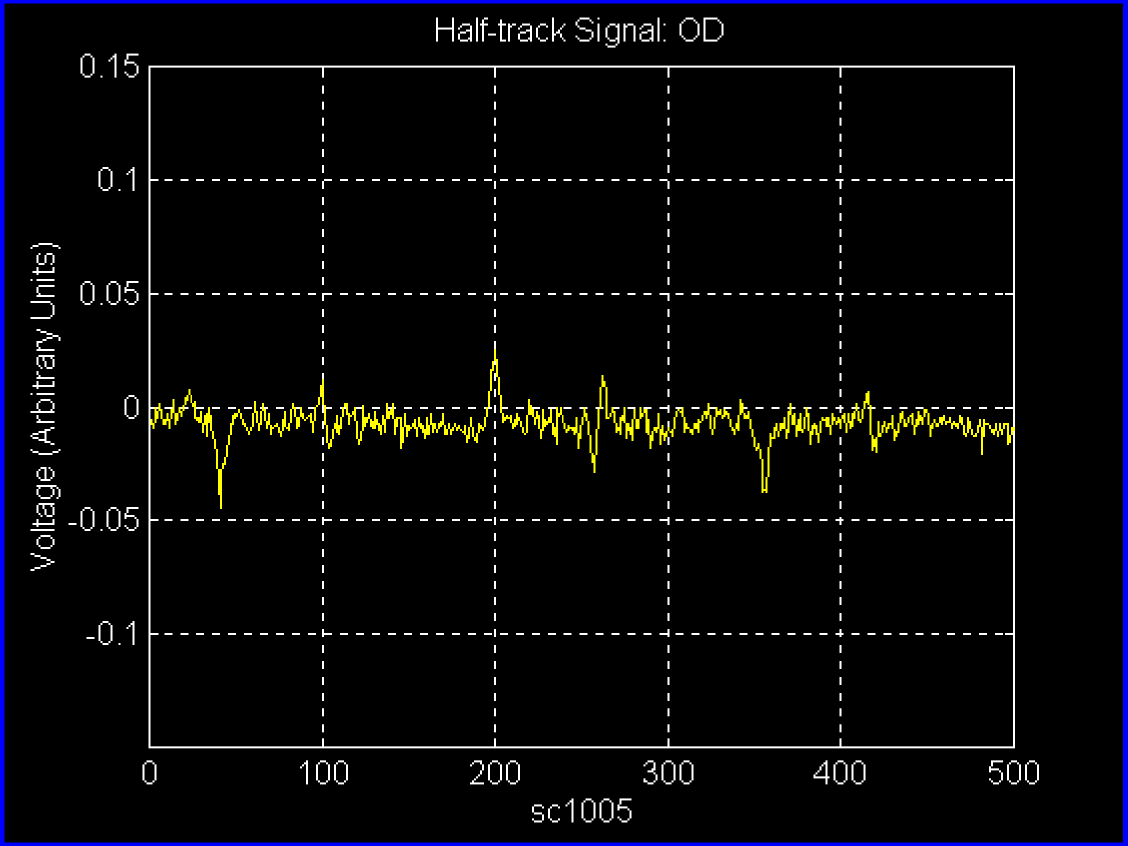
Half-track Signal: ID



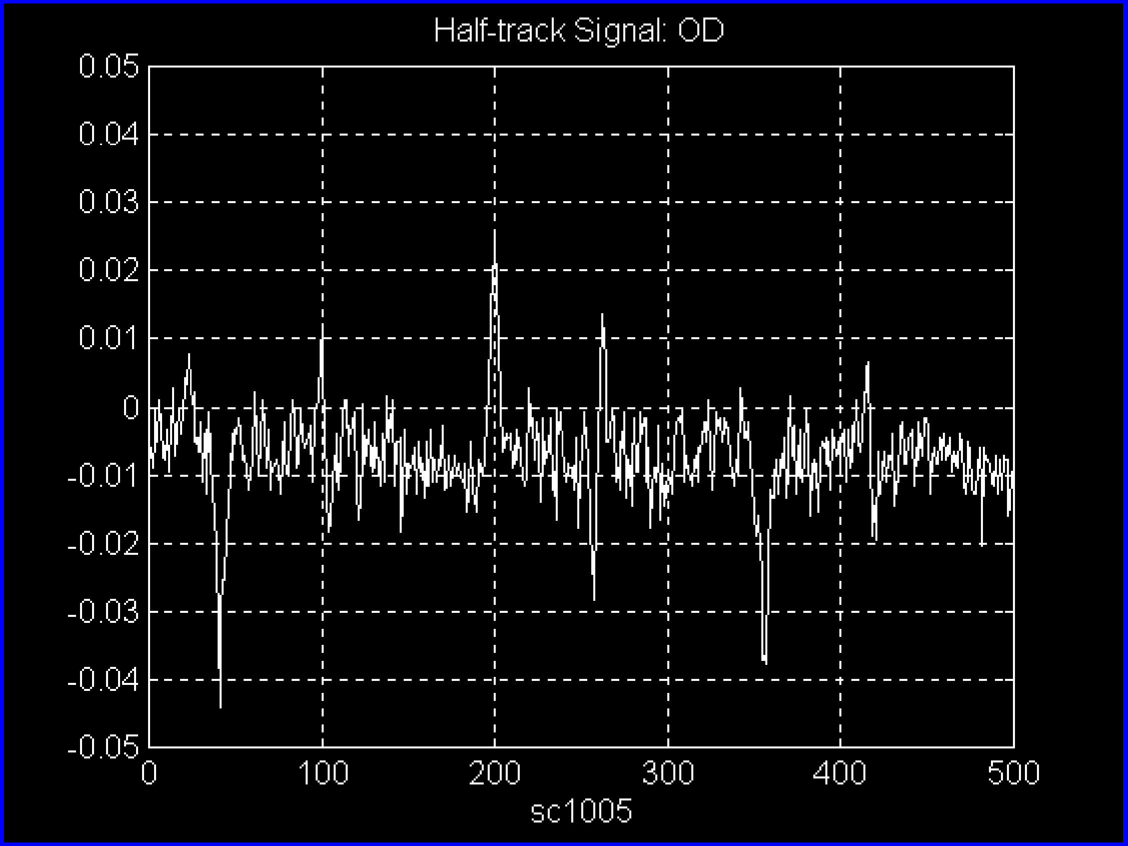
Full-track Signal: OD



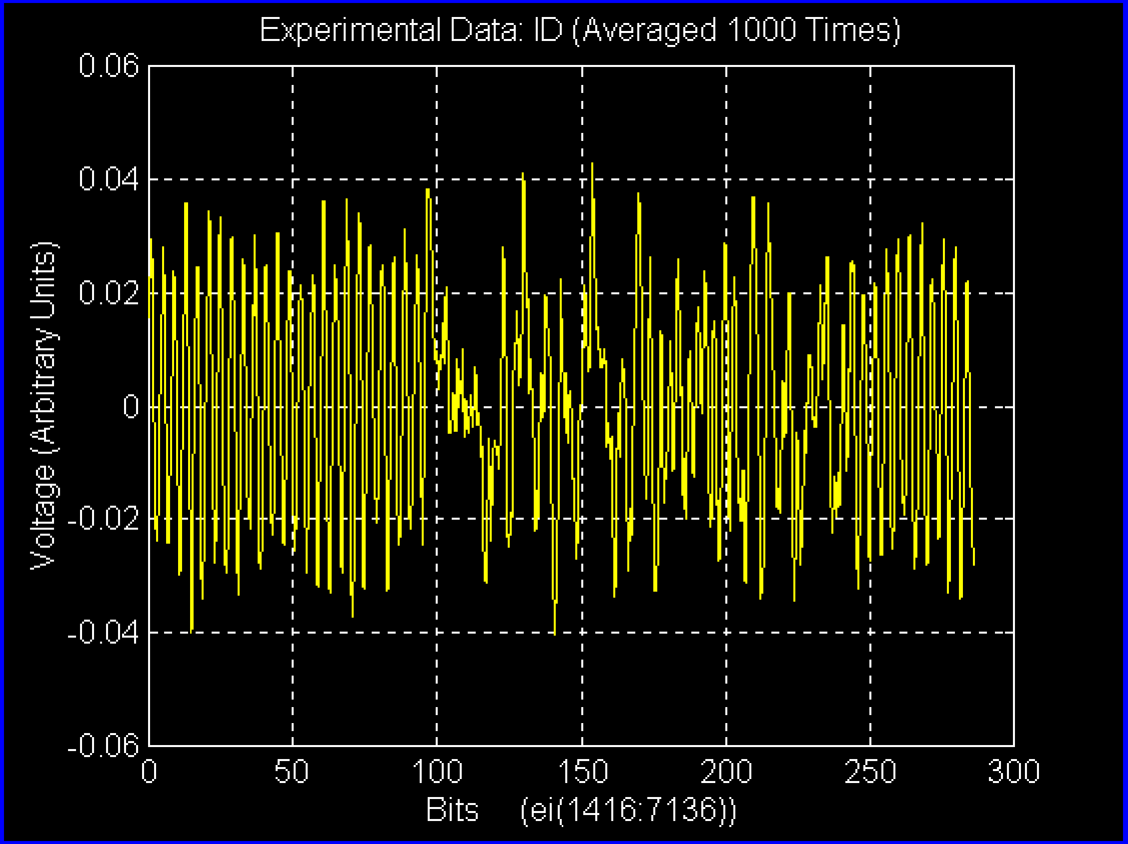
Half-track Signal: OD



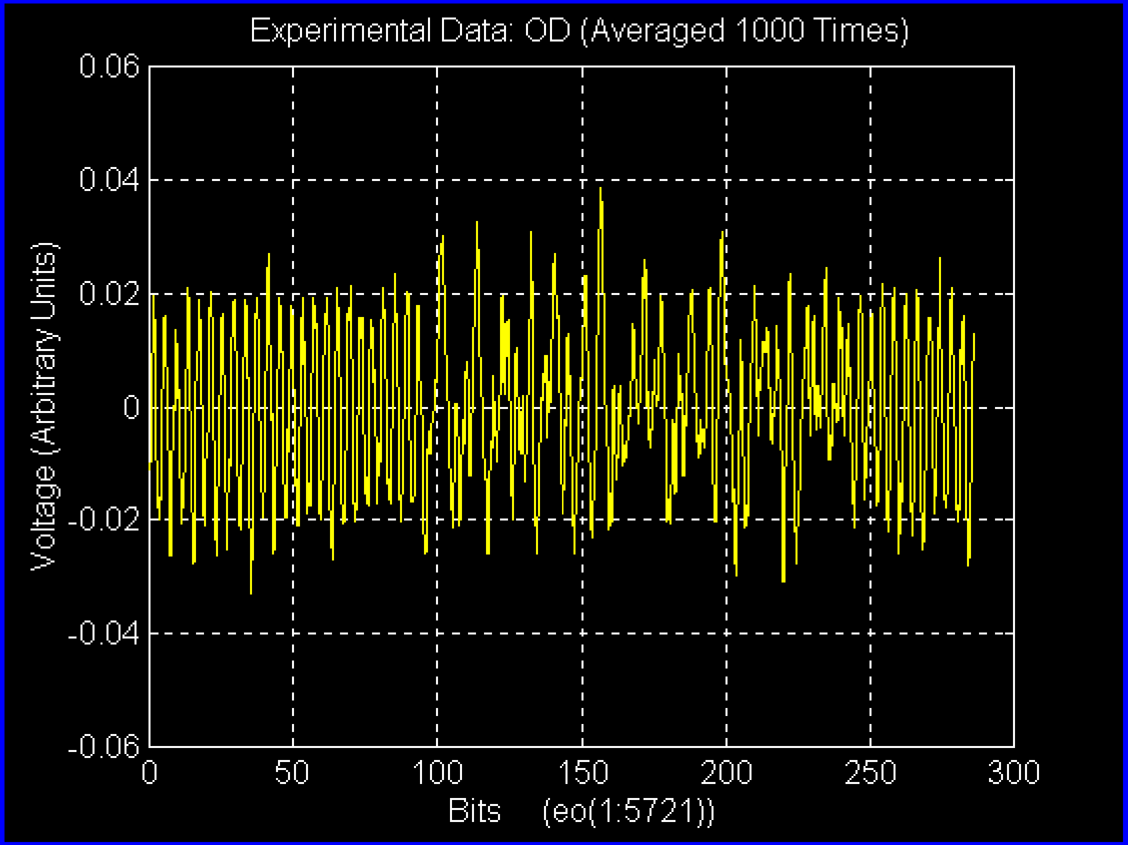
Half-track Signal: OD



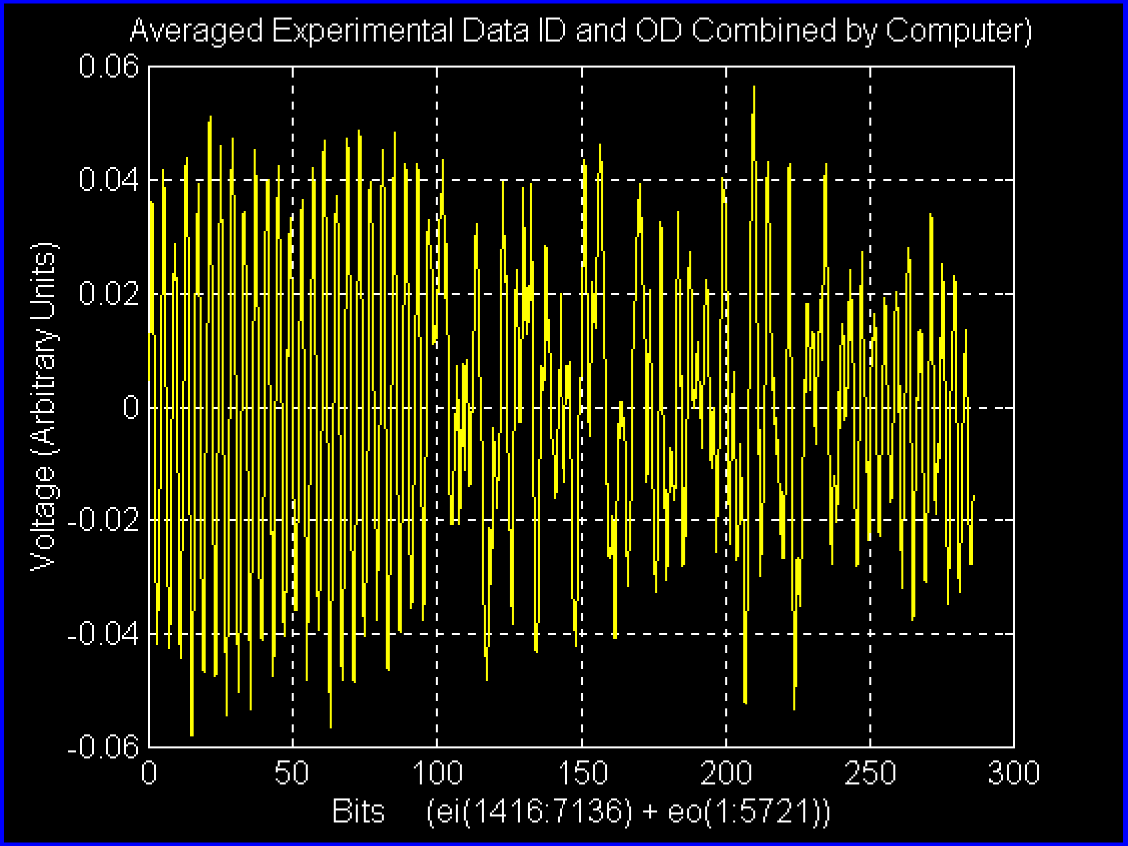
Half-track Pattern: ID



Half-track Pattern: OD



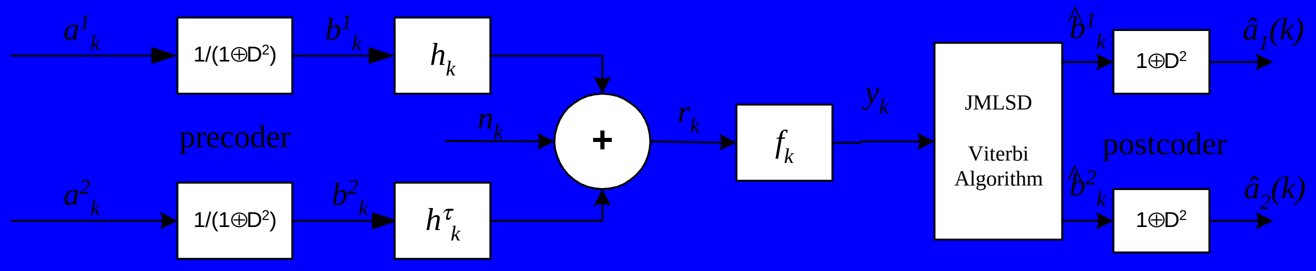
Co-Channel Pattern



Multi-track Detection System

- Use co-channel detection methods
  - Each track is phase shifted Tclk/4 oppositely away from ideal EPR4 sampling instants
  - The ID and OD sides of the read element naturally provide different signal amplitudes
- The two tracks are assumed to add linearly
- AWGN is the only noise source

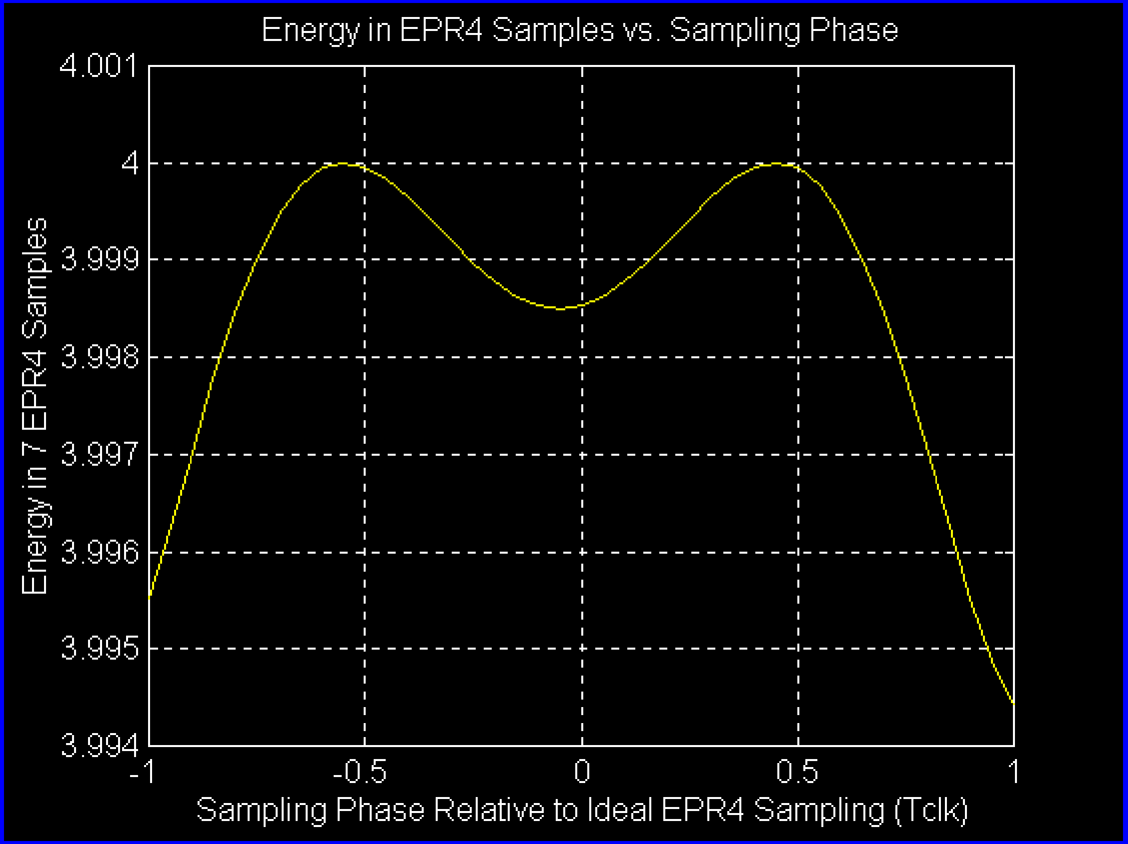
A Simple Co-Channel Model



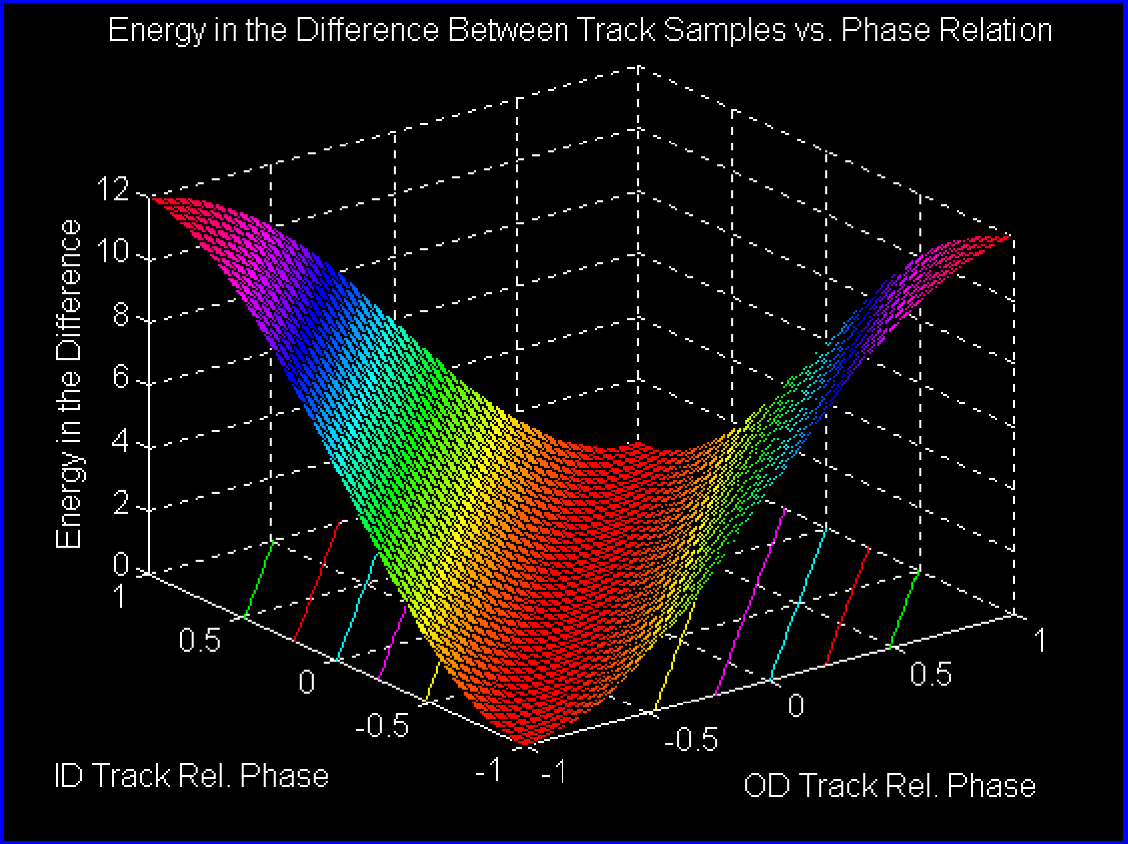
Joint Maximum Likelihood Sequence Detector (JMLSD)

- Implemented as a Viterbi Algorithm
  - 256 states (= 2^(2*(L-1))
  - L=5 for $EPR4_{co\text{-}channel}$
  - 4 branches enter and exit each state
- Easily reduced to 64 state (L=4) JMLSD
- Detector is greatly simplified using two cross-linked single-track FDTS/DF detectors

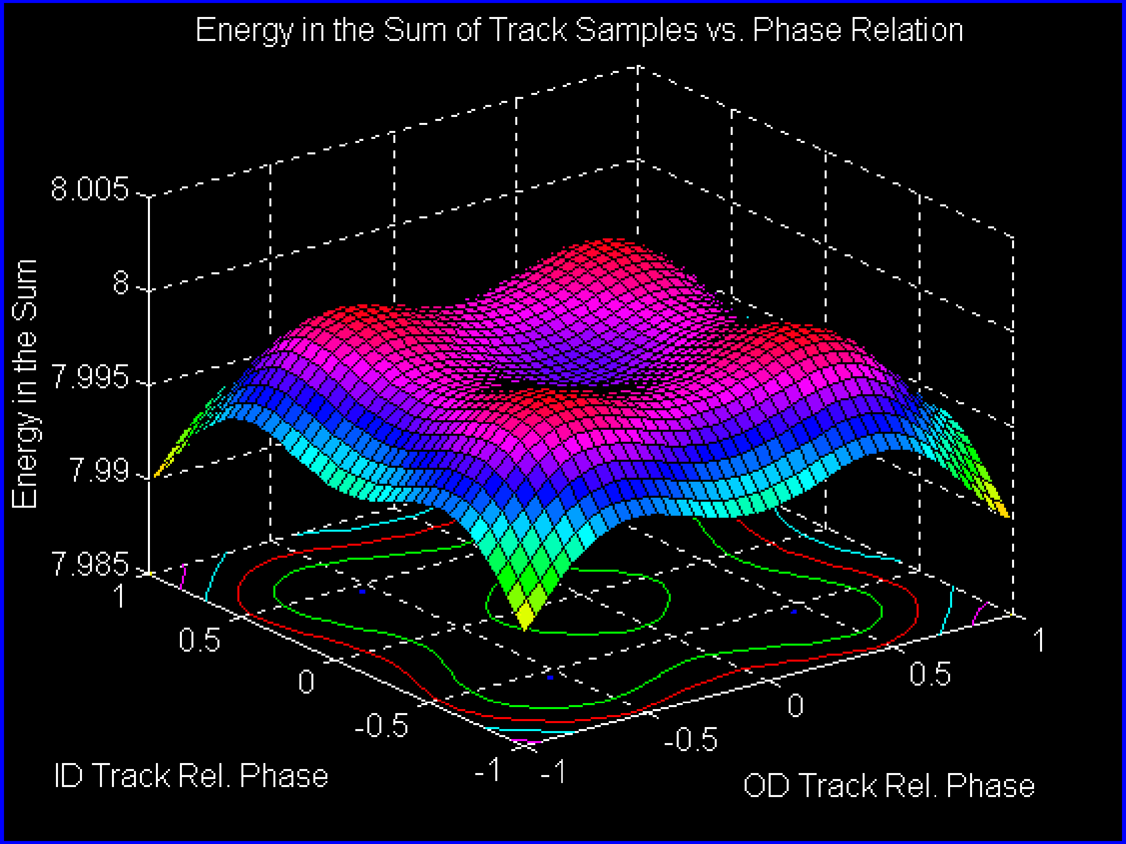
Energy vs. Sampling Phase



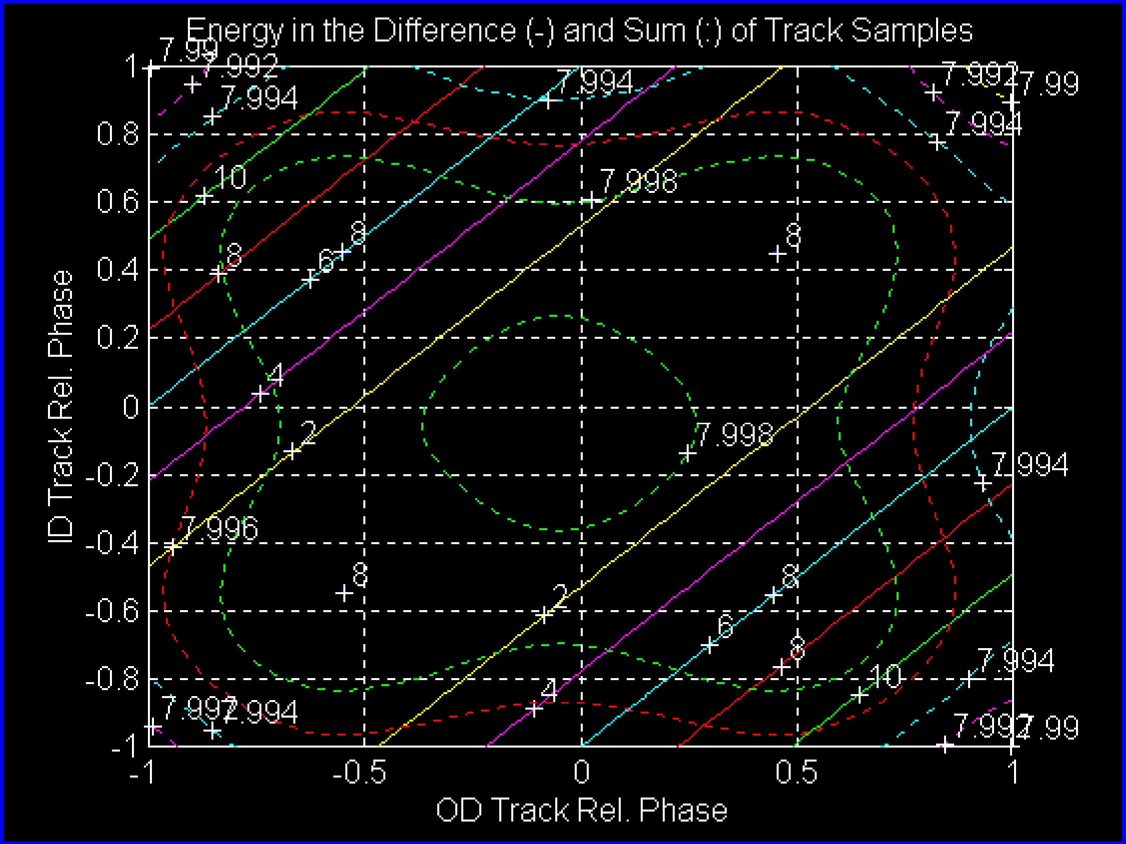
Energy in Difference Between Track Samples



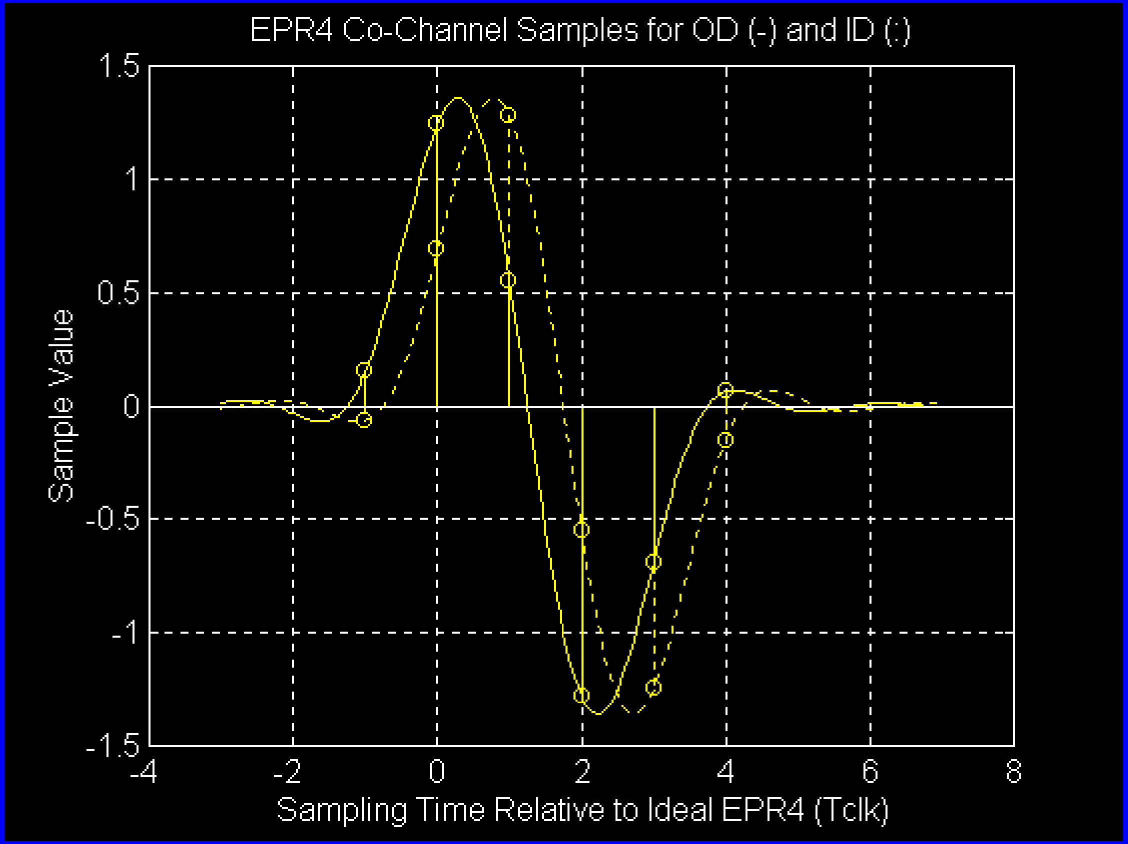
Energy in Sum of Track Samples



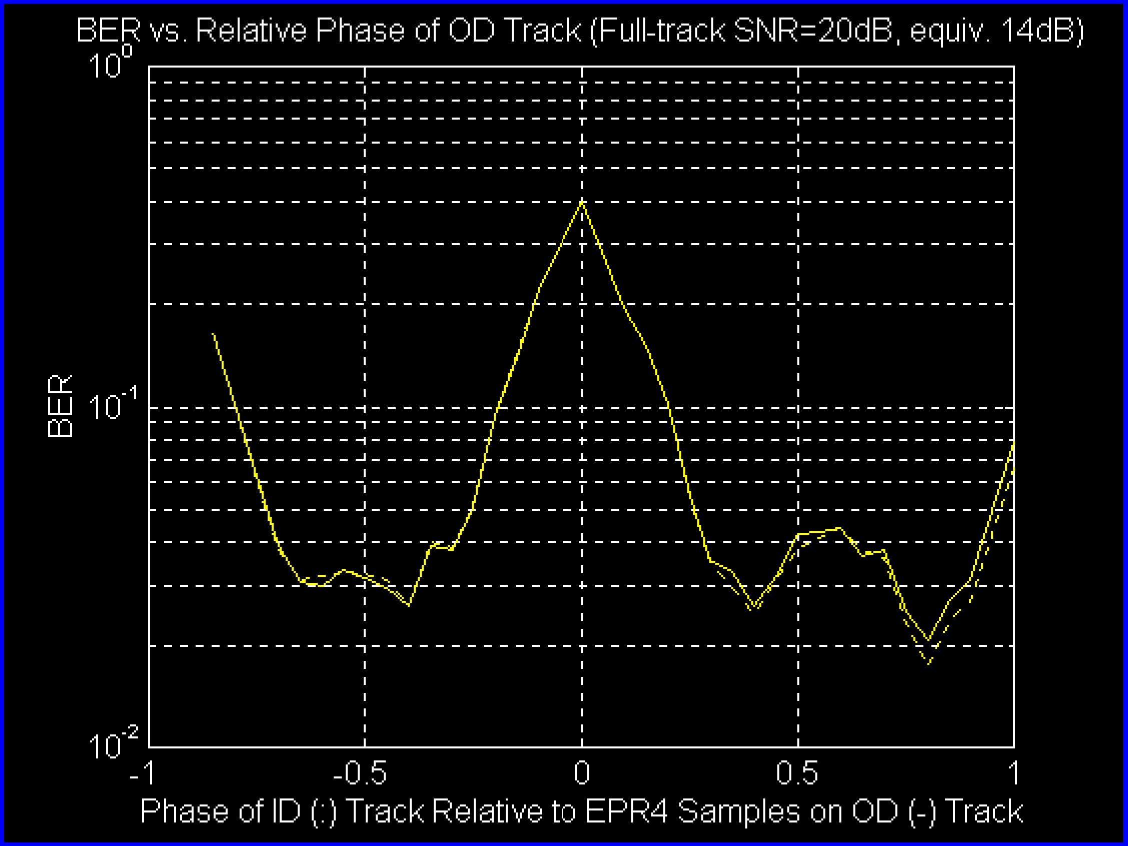
Energy in Difference and Sum of Track Samples



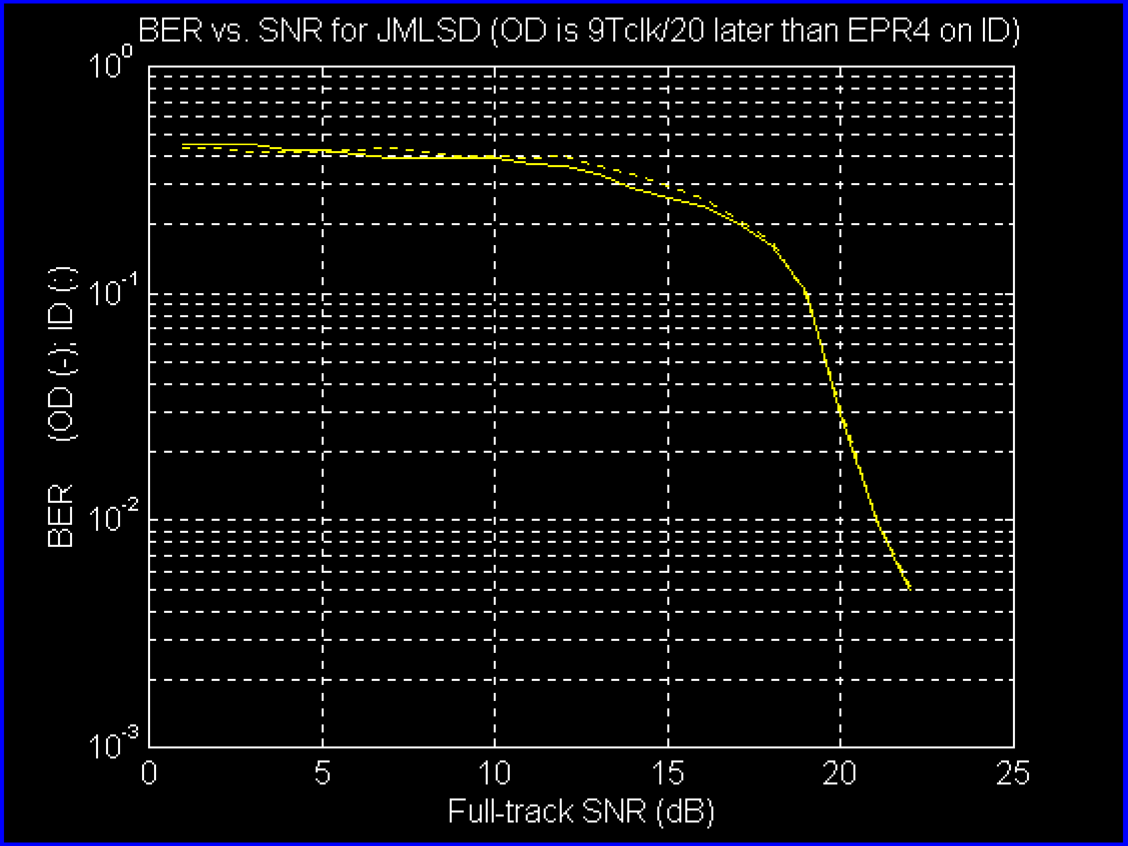
Selected Sampling Phases (± Tclk/4)



Simulation Results: BER vs. Relative Sampling Phase



Simulation Results: BER vs. Full-track SNR



Conclusion

- Promising experimental results show feasibility of write-narrow read-wide (G)MR head
- Promising simulated results show feasibility of co-channel detection
- Over 35% capacity gain and almost 2X read data rate make added detector complexity worth pursuing (e.g. 2 FDTS/DF detectors)
- Synchronization will be a key issue in practice

Acknowledgment

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