2-D EQUALIZATION WITH LOCATION DIVERSITY AND PRE-ADAPTATION TO HANDLE OFFTRACK IN ARRAY READER BASED HARD DISK DRIVES

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I. INTRODUCTION

The hard disk drive industry is transitioning into array-reader based magnetic recording (ARMR) to provide continued growth in recording density. A 2-D equalizer acts to electronically steer the array-reader to provide optimum signal pick-up from the track, thereby resulting in wider & deeper cross-track profile in error-rate performance. To realize this performance, the equalizer coefficients must be matched to the location of array-reader, which are not known precisely due to position errors during write and read. Two particularly challenging scenarios are reading shortly after seeking to a track and reading consecutive sectors which were not written sequentially. In both cases the offset between the array-reader and track cannot be inferred from previous sectors.

In this paper, we present a 2-D equalization strategy that uses location diversity and pre-adaptation to mitigate the mismatch between reader-location and equalizer coefficients. The data-decisions driving the various loops (timing/gain/dc, equalizer-adaptation) are generated using three 2-D equalizers (i.e. loop equalizer) that cover the range of expected offtrack. A delayed equalization strategy is used to mitigate the effect of offtrack in the 2-D equalizer (i.e. back-end equalizer) that is feeding the iterative detector. The proposed approach shows significantly improved read performance in the presence of large offtracks incurred by dual-reader.

II. 2-D EQUALIZER WITH LOCATION DIVERISTY AND PRE-ADAPTATION

Fig. 1 shows the schematic of the proposed 2-D equalization strategy [1].

The proposed structure uses three 2-D equalizers (LDF1, LDF2 & LDF3) and associated detectors for generating the detected data-bits (also called, loop decisions) necessary to drive the various loops. The equalizers LDF1, LDF2 & LDF3 are set based on positive offtrack location, track-center, and negative offtrack location, respectively, so as to get sufficient offtrack coverage. Final loop decisions are taken from the detector whose input signal best matches the chosen partial response (PR) equalization target. Coefficients of the equalizer whose output best matches the PR target are adapted. Because of loop latency considerations, different decision points and metrics may be used in determining the best detector for loop decisions and best loop equalizer for adaptation.

The back-end equalizer adopts a delayed equalization strategy. The first equalizer BDF-0 fast adapts over a block of the current sector to determine near-optimum coefficients for that sector, and the resulting coefficients are used to initialize the main equalizer BDF-1 that is feeding the back-end detector. Equalizer BDF-1 works on accordingly delayed version of the data samples. This strategy provides sufficient time to determine appropriate starting coefficients of BDF-1 so as to match the unknown location of the reader in each sector.

Performance evaluation of the proposed approach is done using a 2-D model of high-density magnetic recording (perpendicular, non-shingled) with 2050 KBPI, 460 KTPI, 55.22 nm magnetic write width, and dual-reader with 30 nm read width in each reader. The two read-sensors differ by 3dB in electronics noise. Fig.2 shows the bit error-rate (BER) performance of the individual fixed loop equalizers as well as performance of the overall diversity equalizer with adaptation, for reader-to-reader cross-track separation (CTS) of 20% and 40%. The individual equalizers LDF1, LDF2 and LDF3 are chosen based on offtrack locations {+25%, -5%, -30%} for 20% CTS and {+30%, -5%, -35%} for 40% CTS. Observe that the performance of diversity equalizer (black trace) is close to the optimum performance (solid red trace) over a large range of offtrack around track-center. Fig. 3 shows the corresponding detection performance from back-end detector (i.e. based on output BDF-1), with and without pre-adaptation, where the pre-adaptation block-length is chosen as 10000 bits. Observe that the use of pre-adaptation to initialize the coefficients of

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BDF-1 (i.e. magenta trace) results in significantly improving the performance without pre-adaptation (i.e. cyan trace) over a large range of offtrack around track-center.

The data in Figs. 2 and 3, which are for the 1st sector in seek-arrival scenario, imply that by appropriately choosing the offtrack locations for the three loop equalizers and the pre-adaptation block-length for the back-end equalizer, the read channel in ARMR HDDs will be able to respond quickly to changes in reader-location without having to explicitly estimate the reader-location.

REFERENCES

[1] Patent application filed with USPTO, Apr 2017.

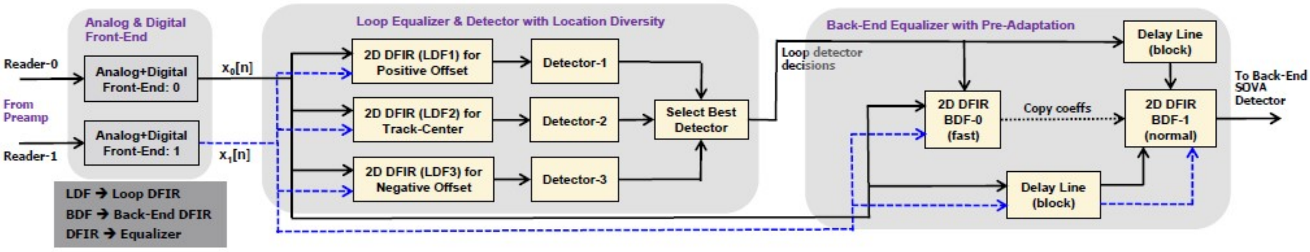

Fig. 1 ARMR 2-D equalization with location diversity in loop equalizer and pre-adaptation in back-end equalizer.

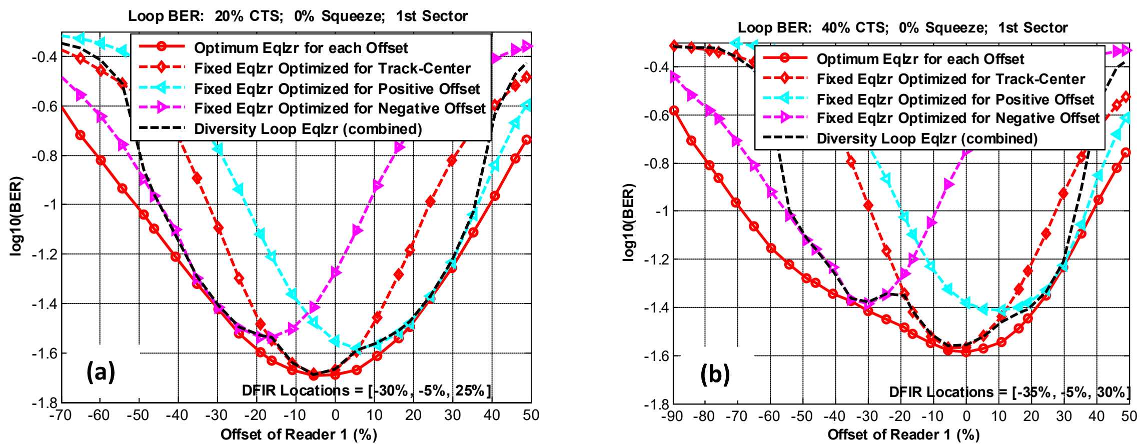

Fig. 2 BER performance of loop 2-D equalizer with location diversity: (a) 20% CTS, (b) 40% CTS.

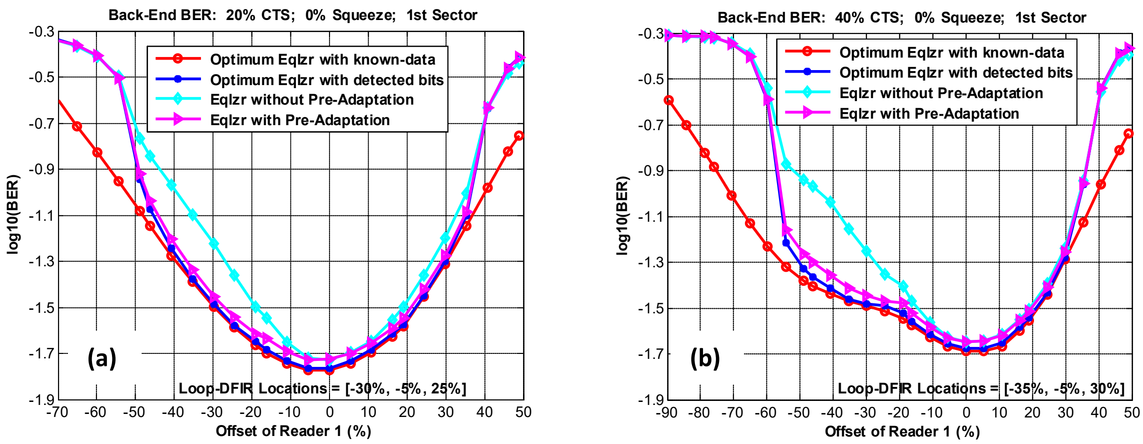

Fig. 3 BER performance of back-end 2-D equalizer pre-adaptation: (a) 20% CTS, (b) 40% CTS.