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Article *in* IEEE Magnetics Letters · August 2016

DOI: 10.1109/LMAG.2016.2589218

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Information Storage

An Intertrack Interference Subtraction Scheme for a Rate-4/5 Modulation Code for Two-Dimensional Magnetic Recording

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Received 30 May 2016, revised 28 Jun 2016, accepted 4 Jul 2016, published 13 Jul 2016, current version 11 Aug 2016.

Abstract—The performance of a rate-4/5 modulation code is evaluated in two-dimensional magnetic recording (TDMR) channels, where a magnetic medium is described by a discrete Voronoi model, and the two-dimensional sensitivity function of the reader is adopted to generate the TDMR readback signal. Since the read-head sensitivity function covers many tracks, it causes intertrack interference (ITI) that can deteriorate the system performance. Therefore, this letter proposes an ITI subtraction scheme in conjunction with the rate-4/5 modulation code in a coded TDMR channel to mitigate the ITI effect embedded in the readback signals before performing an iterative decoding process. We also investigate the data-dependent readback amplitude distributions and evaluate the TDMR system performance via computer simulation. Results show that the proposed scheme helps improve the TDMR system performance, especially when the areal density is high.

Index Terms—Information storage, intertrack interference, intertrack interference subtraction, two-dimensional magnetic recording, two-dimensional modulation code.

I. INTRODUCTION

Nowadays, data storage devices are important components and have been used in the digital world, which has rapidly grown in recent years. A magnetic recording device or hard disk drive (HDD) is a main choice of data storage devices because it has lower price per storage capacity than other devices. However, in the next few years, HDD's areal density (AD) will reach its fundamental limit known as superparamagnetic [Wood 2009]. This phenomenon causes the recorded bits to lose their thermal stability, thus resulting in irretrievable information from those recorded bits. In practice, the AD of perpendicular magnetic recording will be limited by around 1 terabit per square inch (Tb/in^2). Nevertheless, many alternative technologies that can cross this limitation have been proposed, such as bit-patterned media recording (BPMR) [Terris 2006], heat-assisted magnetic recording (HAMR) [Rausch 2004, Rottmayer 2006], heated-dot magnetic recording (HDMR) [Ghoreyshi 2014], and two-dimensional magnetic recording (TDMR) [Wood 2009].

Practically, TDMR is one of the promising magnetic recording technologies to achieve an AD of 10 Tb/in^2. To reach this high AD, the data must be written in narrow tracks, which can be obtained by using a shingled writing technique. However, the problem of reading data still remains because of severe intertrack interference (ITI), which results from the crosstalk between adjacent tracks and can significantly degrade the overall system performance if precautions are not taken. In our previous works [Arrayangkool 2014, Warisarn 2015], we proposed a rate-4/5 modulation code and a soft constructive ITI (CITI) coding scheme to prevent the data patterns that lead to severe ITI to be recorded onto a magnetic medium. Specifically, an input data sequence is first split into four tracks, which will then be encoded by a CITI encoder based on a look-up table to obtain the five recorded data tracks before recording them onto a magnetic medium. Here, the destructive data patterns, such as $[-1\ 1\ -1]^{\mathrm{T}}$ and $[1\ -1\ 1]^{\mathrm{T}}$, will not be allowed for recording, where $[\cdot]^{\mathrm{T}}$ is the matrix transpose operator. This guarantees that the readback signal of the three inner data tracks will not be corrupted by severe ITI, thus facilitating the data detection process. The results are satisfactory in a BPMR channel; however, we have not yet studied them in a TDMR channel.

Therefore, in this paper, we first investigate the data-dependent readback amplitude distributions for various input data patterns and ADs in the TDMR channel, where a granular medium is described by a discrete Voronoi model and the readback signal is generated using the two-dimensional (2D) sensitivity function of the reader [Yamashita 2011]. Then, we tested and found that our rate-4/5 modulation code can still be adopted in the TDMR channel. Although the rate-4/5 modulation code ensures that the readback signal of the three inner tracks will not be corrupted by severe ITI, the readback signal of the lowermost and uppermost tracks can still be interfered by the outer tracks, which may lead to some errors in the data recovery process. To improve this shortcoming, we propose the ITI subtraction scheme to subside the ITI effect experienced in the readback signal of the lowermost and uppermost tracks by utilizing the feedback data associated with the three inner tracks before performing the decoding process. Hence, we evaluate the proposed system in the coded TDMR channel. Simulation results indicate that the proposed system is superior to other systems, especially when AD is high.

The rest of this paper is organized as follows. Section II briefly describes a coded TDMR channel model, and Section III explains the rate-4/5 modulation code and the proposed ITI subtraction scheme. Simulation results and discussion are given in Section IV. Finally, Section V concludes this paper.

II. TDMR CHANNEL MODEL

Fig. 1 shows a coded TDMR channel model with the rate-4/5 modulation code and the ITI subtraction scheme. A message sequence

Corresponding author: C. Warisarn (chanon.wa@kmitl.ac.th). Advances in Magnetics Conference, Bormio, Italy, 14-16 March 2016.
Digital Object Identifier 10.1109/LMAG.2016.2589218