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MEASUREMENT OF MR INDUCED NONLINEARITIES USING A NOVEL SINGLE NEURON MODEL

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Introduction

The MR heads induced nonlinear effects include asymmetry and saturation. Superposition model with nonlinear transfer function are used to describe the magnetic recording channel with MR induced non-linearity [1~3]. In which the transfer function is modeled by either a set of data based on measurement or some polynomial. In this paper, a systematic asymmetry measurement method using a novel single neuron model is proposed. The nonlinear function used in this paper clearly separate the two nonlinear effects into a bias parameter and a saturation parameter. Both parameters can be obtained from written data and read back waveform.

A Novel Single Neuron Nonlinear Model

The response of a linear channel with a pure MR asymmetry distortion can be described as a novel single neuron model, i.e., linear superposition of the isolated pulses with a nonlinear transfer function and a bias.

$$y(t) = f \left\{ \sum_k [a(k+1) - a(k)]h(t - kT) + b \right\} + c \quad (1)$$

where $h(t)$ is the isolated waveform centered at $t=0$, T is the length of a bit cell; $a(k) \in \{-1, 1\}$ is the magnetization level in the k^{th} cell which is either positive or negative. b represents the excess read bias that causes the asymmetry, and c represents the DC components which results from asymmetry¹. The nonlinear transfer curve is a bipolar sigmoid type of function.

$$f(v) = g \frac{1 - e^{-2v}}{1 + e^{-2v}} \quad (2)$$

where g denotes the saturation effect of the transfer function. Fig. 1 shows the nonlinear function described in (2). It can be observed that the nonlinear function mimics the property of the MR transfer curves, i.e., with a linear region and two saturated region. The slope of the nonlinear function is 1, i.e., $f'(v)|_{v=0}=1$. By setting the slope of the nonlinear function to 1, the model only characterizes the nonlinear effects in the read back waveform without considering the influence of the gain. Assume the ideal read bias current corresponding to the center point of the transfer curve, the asymmetry caused by

the improper chosen read bias can be represented by the ratio of the excess read bias to the saturation bound $MR_{\text{asym}}=b/g$.

Results and Discussion

The output of the model (1) and the actual readback waveform is shown in Fig. 2. If no attention is paid on the nonlinear distortion caused by the excess read bias and saturation effect, and assumed the channel is characterized by linear model, $y_k = a_k^T d_k + b$, the output of the linear model and the actual readback waveform is shown in Fig. 3. It can be observed from Fig.2 and Fig.3 that the nonlinear distortion introduce extra noise if it is not properly identified.

Fig. 1. Nonlinear function. Fig. 2. Output of proposed model + and the actual readback waveform - Fig. 3. Output of linear model + and the actual readback waveform -

A novel single neuron model to describe the MR induced nonlinearities is proposed. By using the proposed model, three parameters, excess read bias b , saturation bound g , and DC component c can be identified from any written data and read back waveform. There is no constraint on data pattern; it is therefore applicable for any coded or uncoded data. The ratio b/g directly describes the amplitude asymmetry caused by saturation of the MR transfer curve and the excess read bias.

The advantage of the proposed model is that it gives clear description of the relationship between saturation, read bias and the MR transfer curve. No code constraint, no special experiment or equipment is required. It could be used in determining read bias adjustment in real time detection. Especially in read bias refine adjustment.

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¹ Usually the read back waveform can be processed by minus the mean of the waveform to remove the DC components and it can be assumed DC free. But it is not true when asymmetry is presented in the waveform.