Erratum

Correction to: "Measurements and Analysis of Transition Noise in Perpendicular Media"

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An error occurred in the second-order noise mode weight for the time domain analysis in [1]. In the transition noise expansion of a square wave recorded pattern at bit spacing B with an average isolated pulse $\bar{V}(x)$, the noise power may be written in terms of two dominant modes:

$$\mathrm{NP}(x) \approx \frac{\sigma_1^2}{B}\left(\frac{\partial \bar{V}}{\partial x}\right)^2 + \frac{\sigma_2^2}{B}\left(\frac{\partial^2 \bar{V}}{\partial x^2}\right)^2. \tag{1}$$

The error was to use, assuming a hyperbolic transition shape $(\tanh(2x/\pi a))$, the value $\sigma_2^2 = \pi^8 a^4 s_c / 5760 W_r$. The correct values for both σ_1^2, σ_2^2 as derived by the microtrack model of [2] are

$$\sigma_1^2 = \frac{\pi^4}{48}\frac{a^2 s_c}{W_r} \quad \sigma_2^2 = \frac{\pi^8}{2880}\frac{a^4 s_c}{W_r} \tag{2}$$

where a is the transition parameter, s_c is the cross-track correlation width, and W_r is the read width. This factor of 2 error in σ_2^2 led to an estimate of the transition parameter that was too large by a factor of $\sqrt{2}$ (and correspondingly an estimate of the cross track correlation width that was too small by factor of 2). This error also entered the spacing analysis in [3], because again the transition parameter estimate was too large.

The error arose from a confusion about the transition noise power spectrum. From the analysis of [4], the transition noise power spectrum is given by

$$\begin{aligned}\mathrm{PSD}(k) &= |\bar{V}_{\mathrm{sp}}(k)|^2 \frac{s_c}{BW_r}\left(\frac{4}{k^2|m(k)|^2} - 1\right) \\ &\approx \frac{\sigma_1^2}{B}k^2|\bar{V}_{\mathrm{sp}}(k)|^2 + \frac{\sigma_2^2}{2B}k^4|\bar{V}_{\mathrm{sp}}(k)|^2\end{aligned} \tag{3}$$

where $\bar{V}_{\mathrm{sp}}(k)$ is the Fourier transform of the noiseless (or averaged) isolated pulse $\bar{V}(x)$ evaluated at wavenumber $k = 2\pi/\lambda$. $m(k)$ is the Fourier transform of the normalized transition shape, which for a hyperbolic transition shape yields $k|m(k)|/2 = (\pi^2 ka/4)/\sinh(\pi^2 ka/4)$. Note that in comparing (1) with (3) there is an extra factor of 2 in the denominator of the k^4 term in the spectrum compared to the second-order term of the noise voltage power.

The factor of 2 discrepancy arises because in the time domain the goal is to specifically evaluate the weights of the first two modes. With values of σ_1^2, σ_2^2 and a knowledge of W_r, a, and s_c may be determined. However, a strict Fourier transform of the noise voltage modes changes the k^4 coefficient from simply σ_2^2 due to the addition of the cross product term of the first and third noise modes. The factor in the denominator of the second-order spectral term varies depending on the assumption for the transition shape. For an error function transition shape (erf$(x/a\sqrt{\pi})$), the factor is unity and the variances are $\sigma_{\mathrm{erf1}}^2 = \pi a^2 s_c/2W_r, \sigma_{\mathrm{erf2}}^2 = \pi^2 a^4 s_c/8W_r$. This analysis applies to both longitudinal and perpendicular recording.

Other publications on transition noise analysis have occurred where the above error was not made. In [5] and [6], the spectral technique (3) was used with the correct expansion, although in [6] the spectral expansion term was written down incorrectly. The time domain method was utilized correctly in [7] and [8].

References

[1] C. Fu, Z. Jin, H. N. Bertram, Y. Wu, and D. Guarisco, "Measurements and analysis of transition noise in perpendicular media," *IEEE Trans. Magn.*, vol. 39, no. 5, pp. 2606–2608, Sep. 2003.

[2] J. Caroselli and J. K. Wolf, "A new model for media noise in thin film media," *SPIE—Coding and Information Storage*, vol. 2605, pp. 29–38, Oct. 23, 1995.

[3] C. Fu, A. Takeo, and H. N. Bertram, "A technique to obtain head-medium magnetic spacing in a disk drive," *J. Appl. Phys.*, May 2005, to be published.

[4] B. Slutsky and H. N. Bertram, "Transition noise analysis of thin film magnetic recording media," *IEEE Trans. Magn.*, vol. 30, no. 5, pp. 2808–2817, Sep. 1994.

[5] G. H. Lin and H. N. Bertram, "Transition noise spectral measurements in thin film media," *IEEE Trans. Magn.*, vol. 29, no. 6, pp. 3697–3699, Nov. 1993.

[6] X. Xing and H. N. Bertram, "Analysis of transition noise in thin film media," *IEEE Trans. Magn.*, vol. 33, no. 5, pp. 2959–2961, Sep. 1997.

[7] Z. Jin, P. Luo, H. N. Bertram, K. Zhang, and G. H. Lin, "Determination of transition shape by transition mode noise analysis," *J. Appl. Phys.*, vol. 91, no. 10, pp. 8706–8708, 2002.

[8] Z. Jin, K. Zhang, G.-H. Lin, and H. N. Bertram, "Experimental study of the off-track dependence of medium noise using a mode projection method," *IEEE Trans. Magn.*, vol. 36, no. 5, pp. 2145–2156, Sep. 2000.

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