N94-14993

Effects of a Shading Band in the Data Path of an Optical Drive

T.D. Milster and M.S. Wang
Optical Sciences Center / Optical Data Storage Center
University of Arizona, Tucson, Arizona, 85721, USA

(602) 621-8280

Weiquan Li
Shanghai Institute of Metallurgy
865 Changning Road, Shanghai 200050, China

Abstract

A shading band can alter the system transfer function. In our theory and experiment, both contast improvement and enhanced carrier-to-noise ratio are investigated.

Effects of a Shading Band in the Data Path of an Optical Drive

T.D. Milster and M.S. Wang
Optical Sciences Center / Optical Data Storage Center
University of Arizona, Tucson, Arizona, 85721, USA

Weiquan Li
Shanghai Institute of Metallurgy
865 Changning Road, Shanghai 200050, China

1. Introduction

Efforts to improve the density of data recorded onto optical media have included shaping the transfer function of the optical system. Several authors have described various methods for shaping the transfer function. Reference 1 contains a summary of the various techniques and plots of the transfer functions. In this paper, we describe the effects of a simple shading band in the data path of an optical drive. One effect of the shading band is to shape the transfer function of the optical system. This is similar to the technique of applying electronic equalizing filters for better frequency response. A second effect of the shading band is to decrease the noise associated with the laser and the medium. In our work, we implement a shading band in a commercial optical disk drive. The relevant parameters to this study are: shading band width = 30% of the pupil diameter, medium velocity = 5.7 m/s, NA = 0.55, and λ = 0.78 nm. We used a standard 130 mm magneto-optic disk with a plastic substrate. The following sections briefly describe the theory associated with using the shading band and the results of our experiments.

2. Theory

The data pattern can be considered a collection of gratings. Large bit spacings correspond to low frequencies and small bit spacings correspond to high frequencies. When the laser beam is focused onto the medium, the reflected light contains diffracted orders from the data-pattern gratings. The signal light is contained primarily in the ± 1st diffracted orders reflected from the disk. The amount of signal power that is retrieved by the data detectors depends on how much signal light is passed through the pupil of the objective lens. With reference to Figure 1, at low (2 Mhz) frequency the ± 1st orders are almost completely contained within the pupil, so signal amplitude is high. The shading band reduces the signal light by reducing the amount of ± 1st orders passed by the pupil. As the recording frequency is increased, thereby reducing the bit spacing, the ± 1st orders become more widely separated and the shading band mainly reduces the background light, and hence reduces the noise, in the data signal.

The calculated transfer functions for our system with and without a shading band are shown in Figure 2. In our calculations, we assume that the data pattern consists of wide marks in the direction perpendicular to the tracks. When the shading band is used, the signal amplitude is reduced at low frequencies, but not at high frequencies. This modification of the transfer function partially equalizes the frequency response of the system, thereby providing improved contrast. Reduction of the signal is detrimental unless the noise is reduced as well. Our experiments, which are described in the next section, were designed to investigate the properties of signal and noise with the shading band.

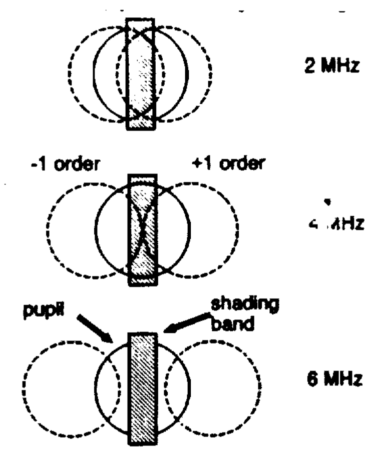

Figure 1. Pupil of the objective lens, shading band, and ± 1st diffracted orders of the data signal for three recording frequencies.

3. Experiment

The optical drive was modified to accept the shading band in its data path. The most convenient location of the shading band is after the partially polarizing beam splitter and before the lens that focuses light onto the data detectors.

Figure 3 displays the noise behavior of the system with and without the shading band. The electronic noise floor was measured with the data detectors blocked. It is not a function of the shading band. The detectors were unblocked, and the disk was stopped to measure the laser noise floor. Note that the laser noise includes the electronic noise contribution. With the shading band, the laser noise is only 1 dB above the electronic noise floor. Then, with the disk spinning, we measured the medium noise floor on an erased track. The medium noise is reduced 4 dB at low (0 to 1 MHz) frequencies, and 1 to 2 dB at high (5 to 7 MHz) frequencies.

Figure 4 displays the narrow-band carrier and noise behavior. In the low (0 to 3 MHz) frequency region, the carrier is reduced about 2 dB more than the noise, resulting in a decrease in the carrier-to-noise ratio (CNR). In the mid (3 to 5 MHz) frequency range, the carrier and noise are reduced equally with no loss in CNR. In the high (5 to 6 MHz) frequency range, the carrier is not reduced, the noise is reduced significantly, and the resulting CNR is increased about 2 dB.

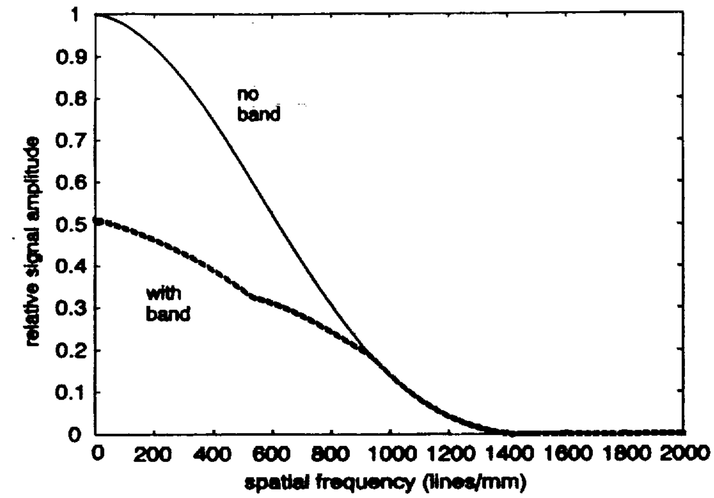

Figure 2. Optical transfer function without and with the shading band.

4. Conclusions

We have shown how a simple shading band modifies the optical transfer function of a data storage drive. This could improve contrast in the data signal. With the shading band, both laser and medium noise levels are reduced. With the particular shading band we choose, the CNR is reduced at low frequencies, unchanged for mid-range frequencies, and improved for high frequencies. Due to the property of reducing the noise floor, further improvements in CNR might be realized by a more clever design of the shading band.

5. References

1. T. Milster and C. Curtis, Applied Optics, 31, pp. 6272-6279 (1992).

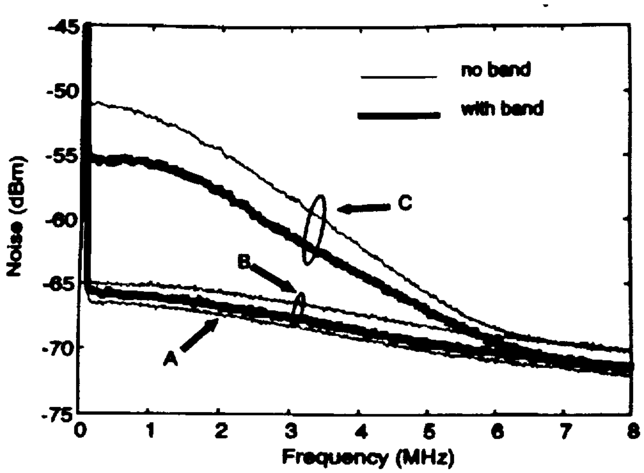

Figure 3. A) electronic noise floor, B) laser + electronic noise floor, and C) medium + laser + electronic noise floors for our system with and without the shading band.

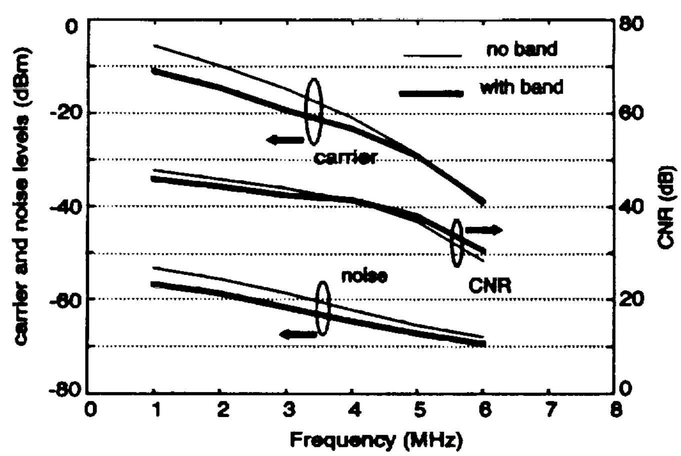

Figure 4. carrier, total noise, and narrow-band carrier-to-noise (CNR) measurements for our system. Note that, with the shading band, the CNR is reduced at low frequencies, unchanged for mid frequencies, and improved at high frequencies.

APPENDIX F