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Synchronous Trigger Detection for Pulse Laser Readout on Super Resolution Erasable Optical Disks

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The laser pulse readout scheme is advantageous in reading thermal super resolution disks, but the light modulation on the RF signal confuses the detection channel. A synchronous trigger detection scheme, using the pulse laser trigger signal to pick up the desired signal, is proposed to suppress the adverse effects of the light modulation. A 5-dB increase of the signal on an magneto-optical super resolution center aperture detection disk by the synchronous detection system was demonstrated experimentally.

KEYWORDS: pulse readout, synchronous detection, erasable optical disks, thermal super resolution disks, magneto-optical super resolution center aperture detection disk

1. Introduction

The pulse readout technique is viewed as a method to improve the carrier noise ratio (CNR) of readout signal on super resolution disks, such as the magneto-optical super resolution center aperture detection disk (MSR-CAD),[1–3] and erasable phase change super resolution disk (EPSR).[4] Thermal distribution generated by a pulse readout scheme results in more regular shape-apertures for detection and narrower wall width on super resolution disks, leading to higher signal quality.

Although the pulse readout technique is capable of yielding higher CNR, the readout waveform is contaminated with light modulation that confuses the detection channel. A detection system synchronized by the laser pump signal developed to pick up the RF signal with precise timing, thus, to alleviate the above problem, has resulted in an improved CNR.

2. Pulse Readout

Laser pulses that were properly delayed should be synchronized with the recording marks in the pulse readout system.[5] The pulsing frequency is at least twice the recording frequency so that mark and non-mark regions can be irradiated by the laser pulse, as shown in Fig. 1.

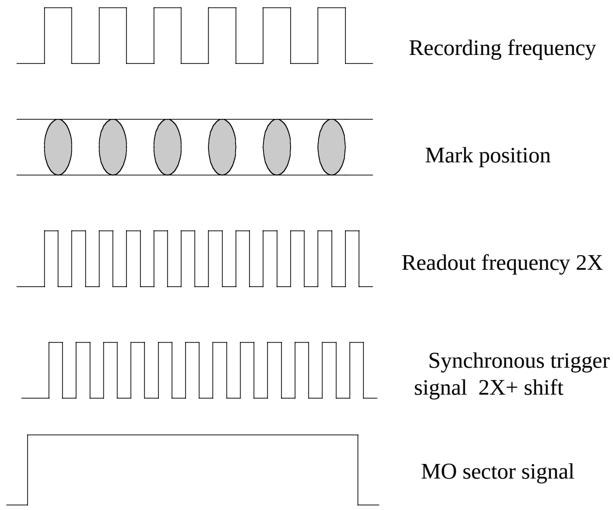

Fig. 1. Timing sequence of pulse readout.

When the pulse readout scheme is applied on the MSR-CAD disk, the readout waveform is not sinusoidal but a convolution of a larger light intensity modulation and a smaller mark modulation. The detected signal was simulated by taking the light intensity, reflectivity and Kerr signal into account, as shown in Fig. 2. The signal value was calculated by the product of light and mark profile. While the pulse laser power was irradiated on the marks rotating at a constant speed on the disk, the signal could be derived by summing all the signals. The simulation results reveal that the signal is varied by a large light intensity and slightly modulated by the mark profile, which can be understood by the three graphs next to the simulated signal. It is assumed that the spot moves from right to left. The vertical axis of three graphs indicates the relative signal value of magneto-optical (MO) marks, and the positive and negative values represent clockwise (CW) and counterclockwise (CCW) polarization directions of incident linear polarized light, respectively. The signal value is mainly proportional to the light intensity, Kerr rotation angle and mark profile. Thus, time variation of the calculated signal value-the pulse readout signal of the MO disk-is shown on the left in Fig. 2. Similar results were also obtained using the pulse readout scheme on EPSR disks.

3. Experiment

The synchronized readout system is implemented in a dynamic disk tester ($\lambda = 780$ nm, $NA = 0.55$), with two high-speed function generators and a digital storage oscilloscope (DSO), as shown in Fig. 3. A timing signal from the MO disk sector marks synchronizes the mark position and laser pulse trigger source. The signal triggers the detection channel in order to pick up the peak value of the signal. After the signal is picked up, a comparator determines the signal level and sends out a digital output, which is estimated by fast fourier transform (FFT) using the DSO. The schematic of the MSR-CAD disk used in the experiment is shown in Fig. 4.

4. Results and Discussion

The experiment was designed to determine the minimum resolution point in the system. At 5 m/s linear velocity, 8 MHz-recording frequency, 16 MHz-readout frequency, duty cycle of 30%, pulse readout power at 2.8 mw, and DC readout at 2.4 mw, 0.3 um effective size marks were played back by both DC and synchronized pulse readout schemes, and the results are shown in Figs. 5(a) and 5(b), respectively. The detected signal is the product of input 1 and input 2, which are

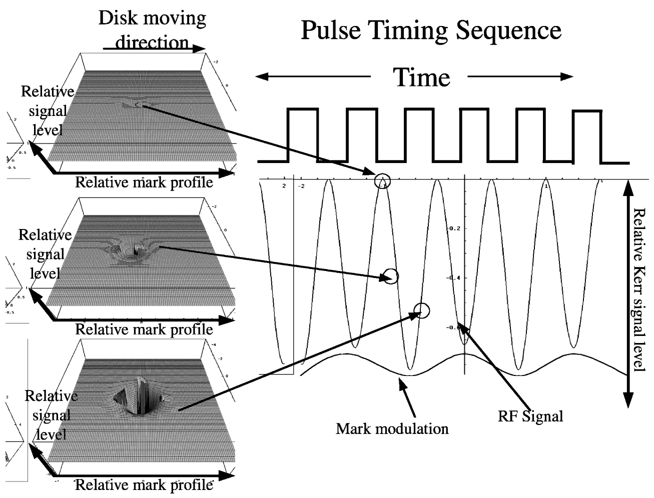

Fig. 2. Simulation of pulse readout.

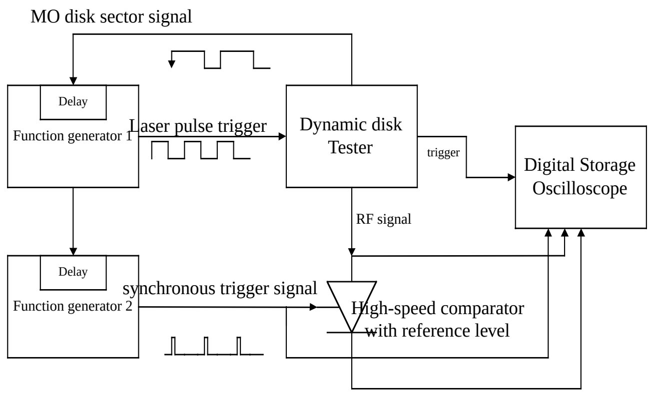

Fig. 3. Schematics of disk test system.

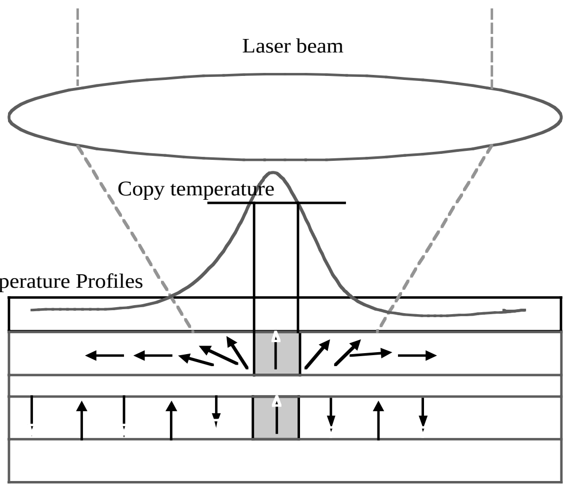

Fig. 4. MSR-CAD disk used in the experiment.

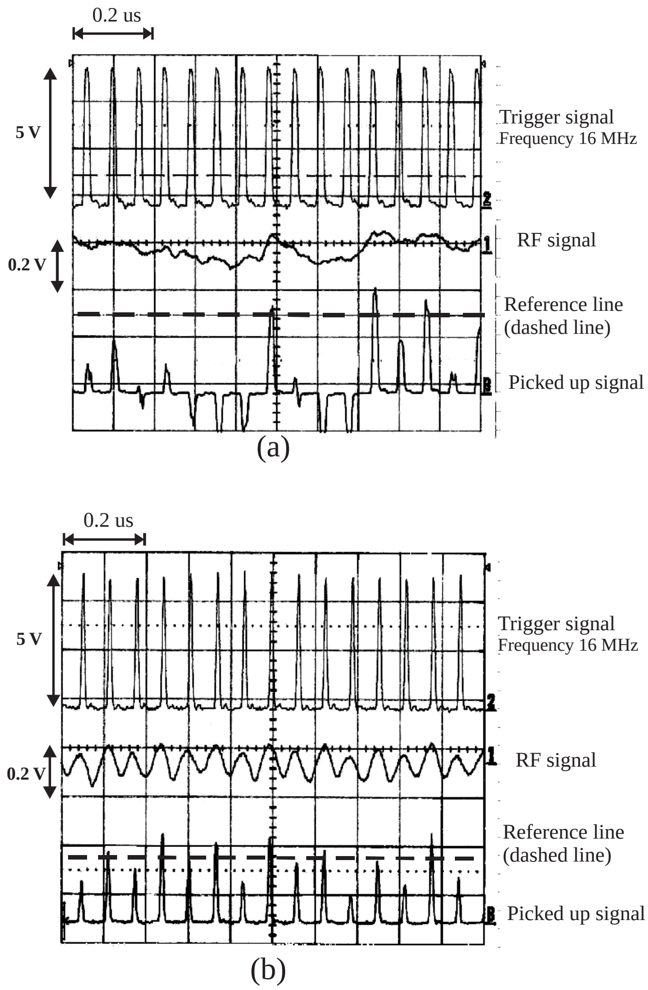

Fig. 5. 0.3 um marks playback by (a) DC and (b) synchronous pulse readout.

the RF and trigger signals, respectively. The signal observed in Fig. 5(a) is contaminated by the light modulation, which makes further processing of the signal difficult. Although the pulse readout signal is contaminated with light modulation, “1” or “0” state can be determined by the reference line except for an occasional error due to the light modulation of the pulse readout signal. Thus, further improvement would be required for practical applecatoins. The result, indicating the benefits of using synchronous process to pick up the signal, is much better than the result of DC readout, shown in Figs. 5(b). It also implies that the pulse readout yields a more controllable thermal condition on super resolution disks, which lead to a higher signal quality than DC readout. However, the pulse readout signal has to be reprocessed in order to suppress the light modulation. Thus, a synchronous detection system is developed to suppress the light modulation effects. An experimental setup with double the readout frequency and signal frequency is shown in Fig. 1.

The use of double-frequency to read out sub-um marks on the super-resolution disk can be treated as a filtering process to narrow the detection bandwidth, and consequently eliminate the power spectra of other frequencies, including noise. To accommodate all the information on the carrier frequency, the process is found to be adequate in terms of picking up the pulse readout RF signal and resolving the light modulation problem as shown in Fig. 2. Moreover, pulse timing should be synchronized in order to irradiate the mark at the exact moment, and the trigger signal should be synchronized with the detection signal.

CNRs of the output waveform by reading of effective 0.6 um marks after a comparator by synchronous and nonsynchronous processes are shown in Figs. 6(a) and 6(b), respectively. In the nonsynchronous process, the trigger line from FG1 to FG2 is disconnected so that the trigger signal is

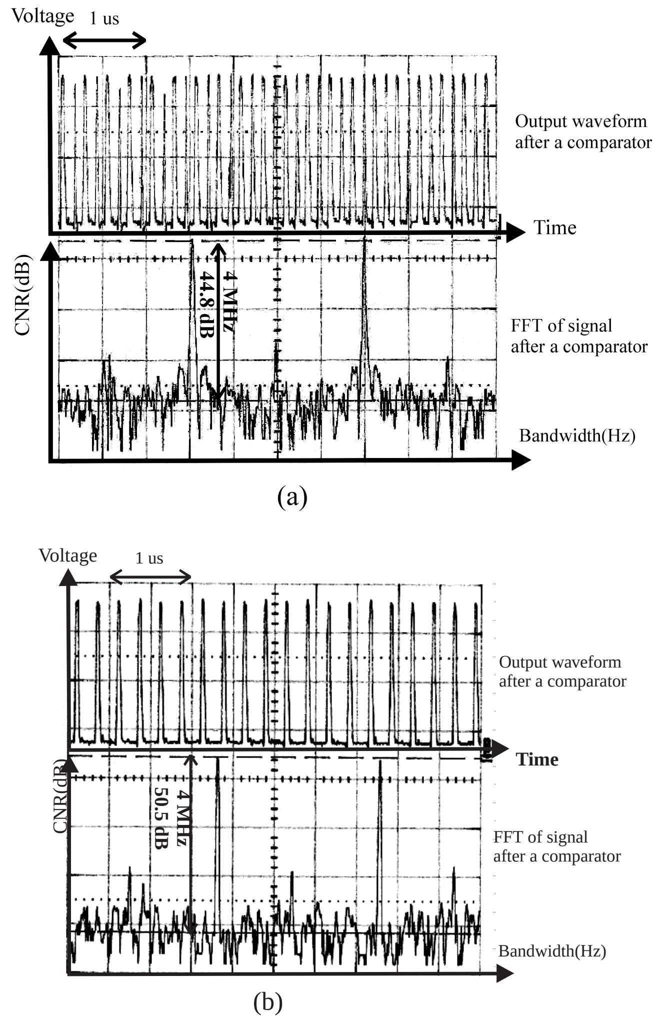

Fig. 6. 0.6 um marks signal and CNR value after a comparator by (a)nonsynchronous and (b) synchronous trigger process.

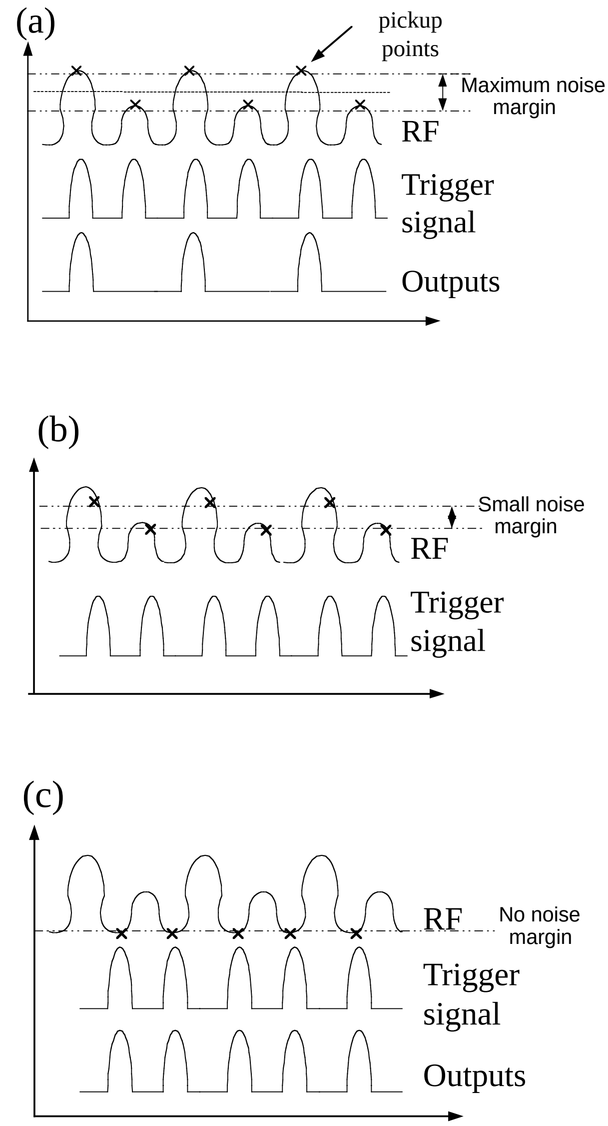

Fig. 7. (a) Synchronous (b) Nonsynchronous (small shift) (c) Nonsynchronous (large shift) process.

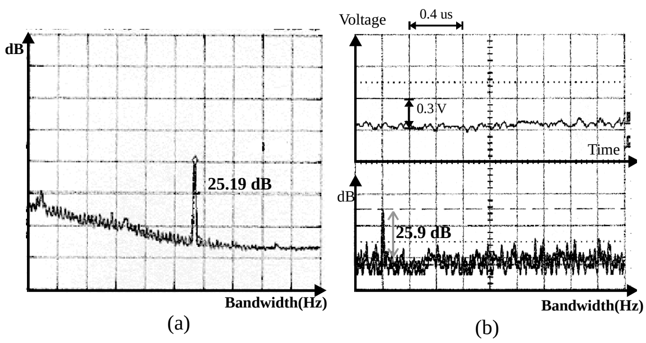

Fig. 8. DC readout estimated by (a) spectrum analyzer and (b) FFT of DSO.

not synchronized with the readout signal. The output signal is reformed by the comparator, then estimated by FFT using the digital storage oscilloscope. The output signal reaches 50.5 dB by a synchronous process, and 44.8 dB by a nonsynchronous process, respectively. The CNR of the synchronous process is 5-dB higher than that of the nonsynchronous process, suggesting that noise suppression is the main cause of the CNR increase. As shown in Fig. 8, it is indubitable that the digital output has some noise content. Since timing of the pickup is very critical to determine the state of the digital output, as the trigger signal shifts from synchronous to nonsynchronous, so does the reference level which determines the frequencies of the output signals. As a result, the number of pulses of the nonsynchronous process is twice that of the synchronous one. Thus, the timing of the pickup RF signal determines error occurrence. Assuming that the rms value of the noise is 0.2 V, the difference between two peaks voltage values should be larger than 0.2 V to prevent the error. However, once the trigger signal is shifted, the noise margin drops as shown in Fig. 7.

Taking 0.35 um effective marks for example, where the disk was spinning at 5 m/s with 7 MHz-recording frequency and 14 MHz-readout frequency, the DC and reformed signals were both investigated in order to evaluate the advantage of the synchronous process. The CNR of DC readout estimated by a spectrum analyzer and FFT of DSO were 25.2 dB and 25.9 dB, respectively, as shown in Figs. 8(a) and 8(b). The RF signal of 0.35 um by DC readout had a small amount of 7 MHz frequency content, which might be a result of the irregularity of the recorded domain or poor thermal distribution. The pulse readout RF signal processed by the compara-

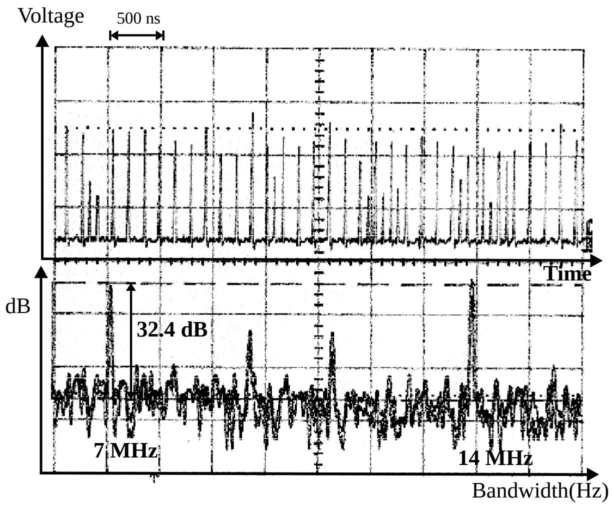

Fig. 9. Pulse signal evaluated by FFT using DSO.

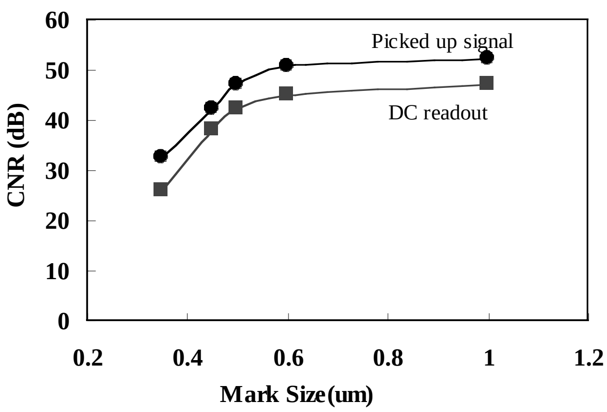

Fig. 10. CNR as a function of mark size for DC and synchronous detections.

tor was estimated by the FFT of DSO, as shown in Fig. 9. After signal processing, the signal quality was increased to 32.4 dB, a 6-dB gain with the synchronous process was estimated. Using this synchronous process to pick up the desired signal is then proceeded with and the CNR as a function of mark size for both DC and synchronous detection is shown in Fig. 10. Synchronous detection clearly shows the gain in CNR, especially at smaller marks.

5. Conclusion

The suppression of adverse effects of the light modulation on a laser pulse readout signal was considered in the detection system. The synchronized pulse readout scheme was used to perform precise timing in the detection channel so that sub-um marks on erasable optical disks could be easily resolved with much improved CNR.

Acknowledgement

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