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Hard Disk Media Scratch Detection by Laser Scanning

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Abstract— In this article, the Hard Disk Drive (HDD) media scratch detection by using optical laser reflection scanning techniques is proposed. Which an one beam of laser is emitted toward HDD media that it is simultaneously rotating and moving back and forth, with this action, the HDD media surface scanning is obtained and the reflected laser beam is received by Light Dependence Resistor(LDR). This system composed of a differentiator circuit; an instrumentation amplifier and a power line (50Hz) reject circuit. If the periodic impulse signal reveal on an oscilloscope, it mean that, this HDD media have scratch. By varying distance and incident angle it is found that optimum distance and incident angle for this proposed system are 30.00mm and 45° degree, respectively. The experimental result show that this proposed system can inspect media scratch.

Keywords- hard disk media; scratch detection; laser scanning.

I. INTRODUCTION

In the present, hard disk drive is the one of important data recording devices which it is well known and widely used for data recording because it is high capacity and fast read-write process. The value of hard disk drive industry is therefore in the first order of data recording industries. Generally, hard disk drive is composed of three important parts, the first one is the media which is a resident of data, the second one is a read-write head, which is a device that read or write data on media and the last one is a control part, which manipulate the operation of hard disk drive such as head moving control and spindle motor rotating control etc. For the important one of hard disk drive manufacture problem is the incomplete media such as non uniform surface, surface contamination and surface scratch etc, which they caused to be a big loss and the one of big problem of incomplete hard disk drive media is scratch on media which lead to be a bad sector on media. So, if media scratch is detected and rejected before it is integrated to be a complete hard disk drive, the loss of time and material are more reduced. Because of media scratch is very small and hard inspected or observed by vision because the media is a good reflection. So, it challenge to find accurately and practically media scratch detection method. From our investigation, we found that the media scratch is not only problem for the hard disk drive media but also movies film. AD 1997, T. Hirose et al. [1] has proposed analysis technique of the surface by shooting X-ray to media and crystal structure is analyzed by grazing incidence X-ray diffractions using synchrotron radiations.

AD 1998, C.Winnewisser et al. [2, 3] used surface analysis processes by employing cameras that can separate element of light in the rang of high frequency (THz).

AD 2006, Geng et al. [4] employed analysis of the surface plate of media based on changing in a wave of high frequency components of the reflected laser light.

AD 2007, Toshi Kasai et al. [5] utilized a laser-assisted optical surface analyzer and dark field microscope (DFM) techniques for detection defect Chemical Mechanical Planarization (CMP) slurry development in rigid disk polishing. This approach is based on two laser sources point out to the same point on surface and CCD camera is used for detecting scattering light which it is more suitable for analyzing surface than detecting scratch. And it's system is also complex.

AD 2008, Seung-Kynpark et al. [6] have presented analysis of the surface on media disc based on changing of reflected wave of laser light. In this same year Y. Todtong et al. [7] offers observation of scratch on magnetic media by using thermal infrared camera. It is difficult method because the thermal infrared camera must be taken at right angle to media in addition the thermal infrared camera is more expensive.

All of these methods have been proposed as mention above; they will be difficult to create an apparatus to detect scratches on hard disk drive media in short time and their system are also complex. Moreover, all of these methods as mention above is difficult to practical in industry or mass product. In this article, we propose the hard disk drive media scratch detection by emitting the one red laser beam to incident media that is rotating and moving back and forth, simultaneously. Its reflection beam is received by LDR and output signal is employed for inspecting media scratch. Because of media is simultaneously rotated and moved back and forth. Therefore all of media surface is inspected. For this proposed inspection system is composed of, a differentiator, an instrumentation amplifier, a power 50Hz line cancellation circuit, therefore this our systems is smaller, economic and practical for mass inspection. Moreover, the optimal angle of reflection and the space between laser source and media, and space between LDR and media have also been studied.

In this paper, it is organized to be five sections. The introduction of purpose and literature review of the hard disk drive media scratches detection and relative works is provided in section I. In section II the reflection property of light is briefly described and the proposed hard disk drive media scratch system and their circuits are

illustrated in section III. The experimental result of each subsystem and overall system are shown in section IV. Finally, conclusion and remark is given in section V

II. REVIEW OF REFLECTION OF LIGHT

When a light ray travel in one medium and encounters a boundary with another medium, the one of the incident light is reflected. Figure 1a shows several rays of a beam of light incident on a smooth, mirror-like, reflecting surface. By assume that the incident rays are parallel to each other, as indicated in figure 1(a). The detection of a reflected ray is in the plane perpendicular to the reflecting surface that contains the incident ray. Reflection of the light from such a smooth surface is called specular reflection. If the reflected surface is rough, as shown in Figure 1b, the surface reflects the rays not as a parallel set but in various directions. Reflection from any rough surface is known as diffuse reflection. A surface behaves as a smooth surface as long as the surface variations are much smaller than the wavelength of the incident light.



Fig. 1. Schematic representation of (a) specular reflection, where the reflected rays are parallel to each other, and (b) diffuse reflection, where the reflected rays travel in random direction.

Consider a light wave travel in air and incident at an angle on a flat, smooth surface, as shown in Figure 2. The incident and reflected rays make angles θ_i and θ_i' , respectively, where the angles are measured from the normal to the rays. (The normal is a line drawn perpendicular to the surface at the point where the incident ray strikes.) Experiments and theory show that the angle of reflection equals the angle of incidence.

$$\theta_i' = \theta_i$$

This relationship is called the law of reflection [8, 9].

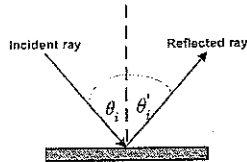


Fig. 2. According to the law of reflection, $\theta_i' = \theta_i$. The incident ray, and the normal all lie in same plane

III. SYSTEM DESCRIPTION

Generally, the surface coatings of media disc of the hard disk drive similar to the mirror that can good reflect of light. Therefore, it is very hard to take a photo of the hard disk drive media surface. For this reason,

media scratch inspection can not be achieved by taking a photo. However, by principle of light reflection we found that if a reflection surface is uniformly smooth then the light ray of reflection is uniform, it cause the signal output from light reflection detector is very small variation, on the other hand, if the reflection surface is non uniformly smooth then the light ray of reflection is non uniform, it cause the signal output from light reflection detector is drastically variation. Therefore if we assume that the media surface with and without scratch are uniform and non uniform surface, respectively, then their signal output are also different variation. From principle as mention above, in this article the hard disk drive media scratch detection system is proposed by using the beam of the red light laser shoot on media plate of the hard disk drive media which is rotating and moving back and forth and the LDR is used for photosensitive device for convert light laser intensity to electrical signal, as shown in figure 3. Which the principle of detection of scratches has three main parts as shown in figure 4 which are a differentiator circuit, an instrumentation amplifier circuit and a 50Hz band reject filter.

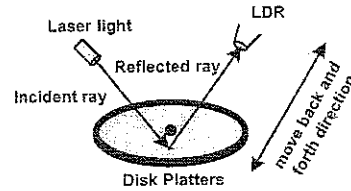


Fig. 3. the beam of the incident light from laser light source and LDR

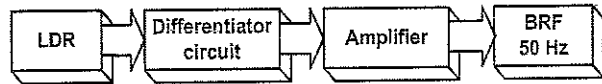


Fig. 4. the block diagram of the proposed mechanism for checking media scratches.

The block diagram of overall circuits that employed in the proposed system is shown in Fig 4. When a light ray travel in one media encounters a boundary with another medium, an one part of the incident light is reflected into LDR. The resistance of LDR varies accordingly the intensity of light that strike it and gives output that is the level of voltage. When media scratch is found, it cause the direction of the reflected ray changes, the result is a voltage output drop of LDR is also changed. When it passed into a differentiator circuit, the differentiate levels of output voltage is drastically change and it sent to an instrumentation amplifier circuit to amplify the signal as shown in Fig.5 – Fig.6, respectively. Then, that the 50 Hz AC power line noise are removed by using the band reject filter 50 Hz is illustrated in Fig.7

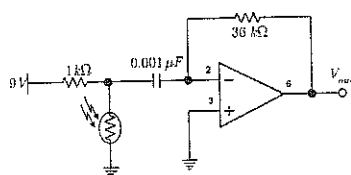


Fig. 5 Circuit diagram of a differentiator

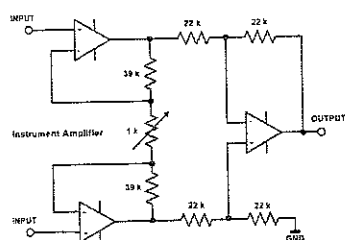


Fig. 6. Circuit diagram of an instrumentation amplifier

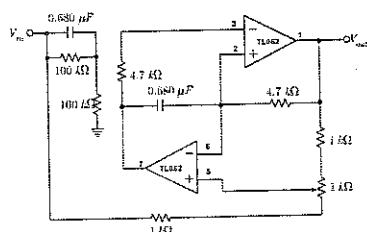


Fig. 7. the circuit of band reject filter 50 Hz

In addition, this article studies the optimum angle of reflection and distance by varying the distance and incident angle of a laser light, as shown in Fig.8. The optimum angle of reflection and distance are therefore obtained.

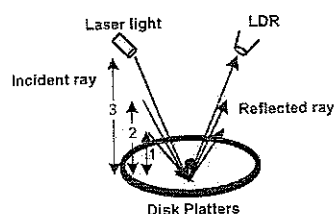


Fig.8. show the distance varying for experiment.

Fig.8 illustrates distance between the laser and media hard disk plate. There are three range of distance for studying which are 1 cm (centimeter), 2 cm and 3 cm.

IV. EXPERIMENTAL RESULT

To examine the proposed concept, the experiment is set up by using a differentiator as shown in Fig.5. The result of the differentiator circuit is illustrated in Fig.9. It is fed by square wave as an input signal that is indicated on upper trace. Its result output is an impulse train which is shown on bottom trace in Fig.9. The instrumentation

amplifier characteristic as shown in Fig.10 which its gain about 37.43 dB and frequency response of 50 Hz rejected network shown in Fig.11.

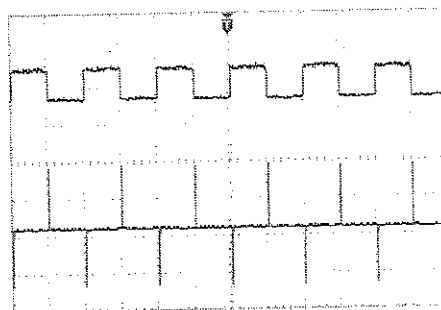


Fig. 9 The result of the test differentiator circuit

The frequency response of the instrumentation amplifier circuit and the band reject filter 50 Hz are illustrated in Fig.10, Fig.11, respectively.

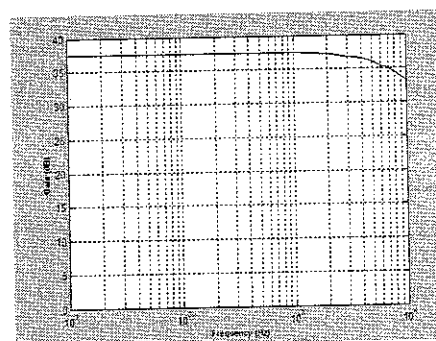


Fig. 10. The frequency response of the instrumentation amplifier circuit

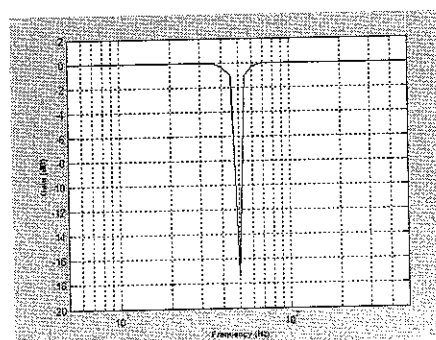


Fig. 11. The frequency response the band reject filter 50 Hz.

The result of scratches inspection on media plate of hard disk drive is shown in Fig.12.

Which Fig.12 illustrates the result of scratch inspection which the frequency computation of output signal is obtained and it equals to frequency rotation of hard disk drive. From Fig.12, the result shown frequency about 71.43 Hz refer to the one minute that hard disk rotate around $71.43 \times 60 = 4285.8$ cycles. For this here, the number of hard disk round speed is 4,200 cycles/minute.

The result of experimental study an appropriate distance between the laser source and media hard disk plate are set up with three distances which are 1 cm, 2 cm and 3 cm as shown in Fig 13, 14 and 15, respectively.

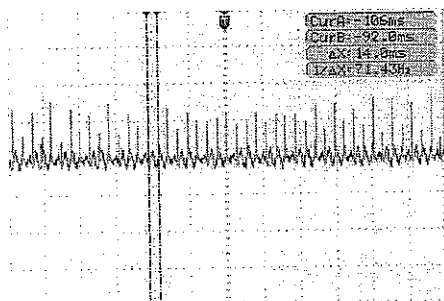


Figure 12 The result of the scratch test on media plate of hard disk drive.

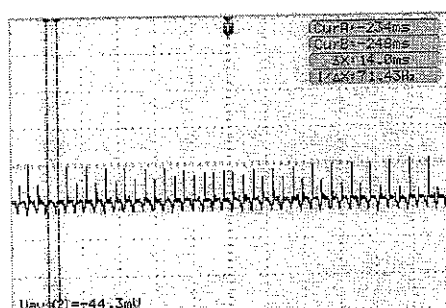


Fig.13. the result of scratch test on media plate of hard disk drive in distance 1 cm

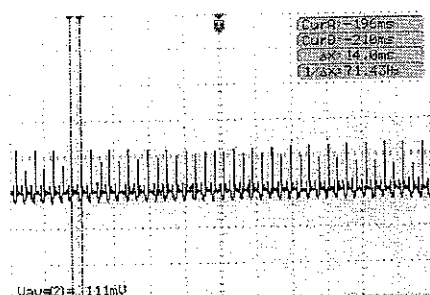


Fig. 14. the result of scratch test on media plate of hard disk drive in distance 2 cm

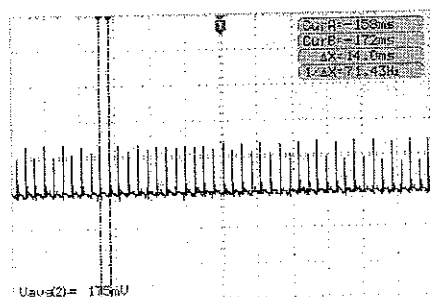


Fig. 15. the result of scratch test on media plate of hard disk drive in distance 3 cm.

V. CONCLUSION

In this article, the system employed to detect the scratch with optical laser reflection scanning is proposed. This system composed of a differentiator circuit, an instrumentation amplifier and a power line (50 Hz) rejected network, as shown in Fig. 4. The laser beam is emitted toward hard disk drive media that it is simultaneously rotating and moving back and forth. This action equivalent to the hard disk drive media surface scanning. For converting light intensity to electrical signal, the reflected laser beam is received by LDR. The obtained signal is displayed on oscilloscope. The characteristic of a signal is periodic impulse show that this hard disk drive media have scratch.

By rule of thumb we found the optimum angle and distance is 45° degree and 0.03 m, respectively which it notes that the optimum distance has to be far from media because the resistance of LDR is inverse proportion to the light intensity. However, Because of out put of LDR circuit is a voltage divider of constant voltage source. So, when high light intensity, the output voltage is small and low light intensity the output voltage is large which it is accordingly with result in Fig.13-15. Future work, a further study of this system can detect minimum scratch and fabricate additional system in order to use output voltage from system to create a media surface.

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