Automatic Scratch Detector for Magnetic Disk

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Abstract. *The development of an automatic scratch detector for a magnetic disk aims to detect scratches on magnetic disk surface at the micrometer level. In hard disk manufacturing industry, it is vital to focus on hard disk quality checking. [Every piece is scrutinized, especially a magnetic disk inspected for scratches. They are occurred during industrial manufacturing processes and by read/write head devices. It may affect data storage performance of magnetic disk.] In this study, scratch detector is operated by reflective method, using the principle of laser reflection (Laser). The beam is sent to disk surface and reflected to photo diode, which is a light receiver. It is found that when the intensity of laser beam received by photo diode reflect on scratched and non-scratched area differently. Light intensity is decreased when it reflects on scratched area. The signal amplitude is between 2.1 - 4.3 volts. It is indicated that the magnetic disk surface is scratched. Finally, it revealed that width of scratch magnetic disk measured by Stereo Microscope (SM) was 30 micrometers in a micrometer scale.*

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1. Introduction

The hard disk manufacturing industry is attentive to quality inspection of hard disk. Every piece of equipment will be checked for quality, especially the magnetic disk. It is inspected for scratches occurred during industrial manufacturing processed and by read/write head devices [1]. Check for scratches on the magnetic disk surface before installing hard disk, therefore, is essential. It may affect the magnetic disk's data storage performance.

Currently, there are several methods used to detect scratches on a surface. Each method includes people to detect scratches on the magnetic disk surface. For example, using and infrared camera to differentiate heat detected on the surface of a magnetic disk by a method of supplying electric current on magnetic disk surface [1]. Electron microscopy adopts an electron beam to scan the surface [2], this method uses a very complicated and expensive device. In this research, a scratch detector is developed by using reflection method at 780 mm wavelength for searching for scratches on a magnetic disk [3]. Due to the fact that light will reflect well on shiny and smooth surface, affecting the dense intensity of reflected light. However, if the surface is rough and less glossy, the reflected light tends to be scattered with lesser intensity. To reduce costs in production process, therefore, deduction the use of complex and expensive equipment is compulsory [4]. A scratch detector for magnetic disk is developed.

2. Materials and Methods

2.1 The Scratch Detection Method on Magnetic Disk

The surface characteristics of the material are important for refection of smooth surface objects. Thus, the angle of energy reflection is equal to the angle of incidence, which is characteristic of specula reflection. When an object surface is rough, the energy reflection will be disorganized, called "diffuse reflection". However, most objects are blended between these two characteristics, as shown in Fig.1.

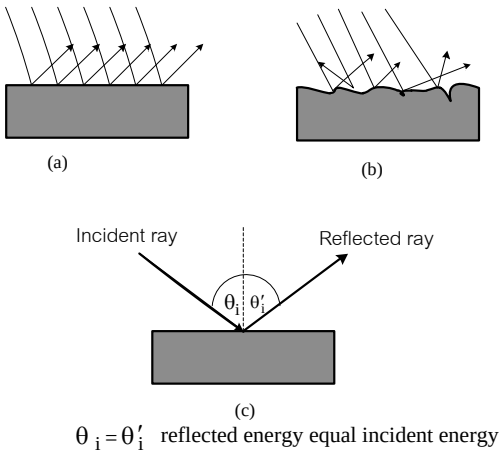


Fig. 1 Energy reflection characteristics of smooth and rough object surface [5].

This is because the surface is glossy, the light reflection of scratched area and smooth surface are different. The reflected energy (θ_i') is equal to the incident energy (θ_i) [6].

$$\theta_i = \theta_i' \quad (1)$$

From Fig. 2, it shows that a scratch detection system consists of the CD pick-up head with red laser light at a wavelength of 780 nm. The CD pick-up heads role is to transmit light and the photodiode helps to receiving the reflected light. The magnetic disk is 2.5 inches with scratches on surface of the disk installed on the spindle motor. The installation of magnetic disk must be in horizontal position with a perpendicular direction to the CD pick-up head, so that the laser beam is directly on a disk and accurately reflected to photodiode [7].

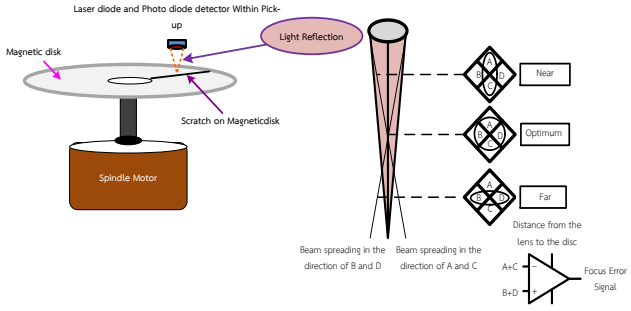


Fig. 2 Scratch detection system using CD pick-up head [8], [9]

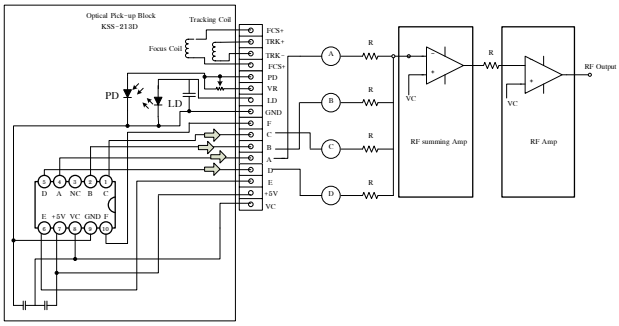
2.2 Amplifier Circuit Design from CD Pick-up Head

Scratch detection system is designed by light reflection method of CD pick-up head. Industrial equipment was applied to develop the system by using CD pick-up head model KSS-213C, connected to the IC device (Integrated Circuit: IC). The IC circuit is designed to join and amplify signal received from the CD pick-up head. Then the obtained RF signal is analyzed for transforming an output waveform, while there are scratches and non-scratches [9].

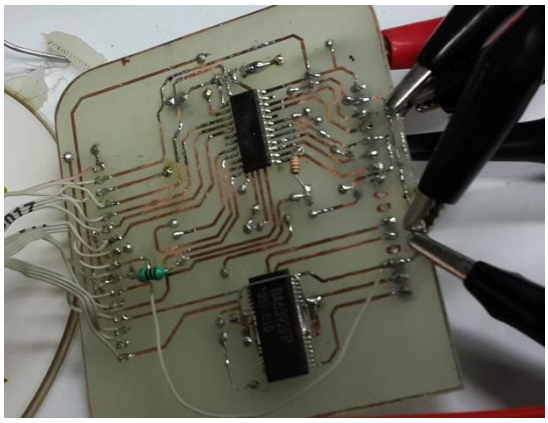
From Fig. 3 (a), the light reflected to the 4-quadrant photodiode converts from light signal into a small electric current signal. Then the signal is amplified into higher one. The signal is combined before sending to the RF Summing Amplifier circuit and RF Amplifier circuit, so that signal strength increases. Then the RF signal from measuring by oscilloscope instrument is analyzed. Characteristics of amplitude signal will change its shape in scratch and non-scratch area. The Printed Circuit Board (PCB) of the operational amplifier is as follows: Fig. 3 (b).

2.3 Automatic scratch detection

The automatic scratch detection system is designed to control CD pick-up head. The speed control of disk rotation is controlled by microcontroller with speed of 1,500 rpm for 5 rounds. It leads to finding the effectiveness of scratch detects machine. It can measure from RF output and repeated measurement experiments for accurate results, shown in Fig. 4.



(a)



(b)

Fig. 3 Internal circuit of CD pick-up head (a) RF signal summing circuit and RF signal amplifier (b) practical equivalent circuit.

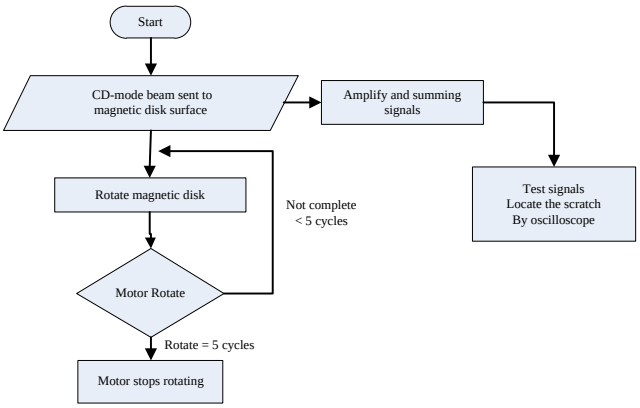


Fig. 4 System automatically detects scratch

3. Experimental Setup

3.1 Operation of Scratch Detector Machine on Magnetic Disk

The scratch detector uses the CD pick-up head of KSS-213C, as shown in Fig. 5. The component of the CD pick-up head consists of Laser diode devices, which emits light, red beam with wavelength of 780 nm for scratch detect on magnetic disk [10]. The photodiode IC receives

reflected light from the laser diode and signal amplifier. In addition, the amplifier circuit is designed using op-amps for summing and amplifies of RF signals and assembled on printed circuit board (PCB). The automatic scratch detector uses a microcontroller board of Arduino UNO for operational control. The program is designed for laser emission control and rotation control of spindle motor at 1,500 rpm. The scratch inspection technique utilizes CD pick-up head to send laser beams onto the surface of the magnetic disk. The reflected light on the non-scratched surface results in high intensity of light, but the light reflected on the scratched surface has low intensity. Thus, the intensity of light affects amplitude of RF signal, indicating whether the magnetic disk is scratched or non-scratched.

The received RF signal is analyzed for transcripting in the output waveform, while being scratched and non-scratched. The measuring signals using oscilloscope models waveAce 2012 with 40-300 MHz bandwidth and sampling rates up to 2 GS/s. The disk rotation is controlled by microcontroller models ARM Arduino [11] speed controls for disk rotation at 1,500 rpm. The disk rotation is set at 5 cycles to test the accuracy of the scratch detection. The CD pick-up head emits red laser light and the photodiode receives reflected light from magnetic disk. The magnetic disk is installed on the Spindle Motor in a perpendicular direction to the CD pick-up head. So that, laser light is delivered to the magnetic disk surface and reflected back to photodiode, as shown in Fig. 6.

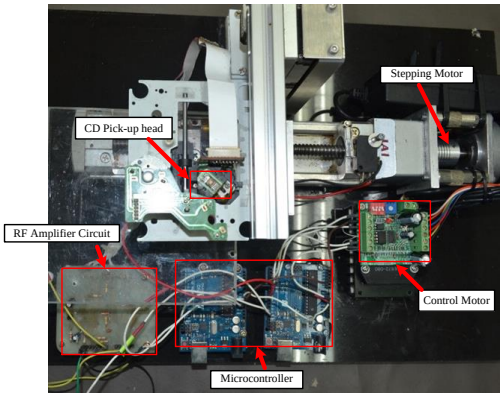


Fig. 5 Automatic scratch detector

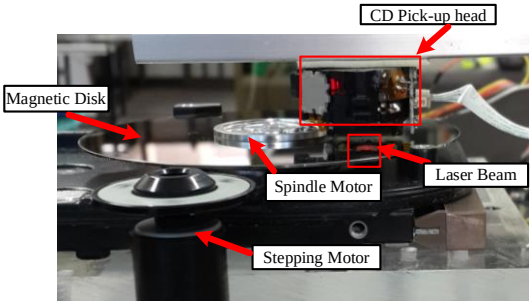


Fig. 6 Scratch detection system components

4. Results

4.1 Signal Measurement Results

The measurement of radio frequency (RF) signals adopts the oscilloscope to position detection of scratch. The microcontroller is used to control a stepping motor for rotating the magnetic disk in a circle and moves along the radial axis, as shown in Fig. 6. Signal analysis for scratch detection on the magnetic disk surface is a study of energy reflection and incident light. The reflected light to the photodiode converts light energy into electric current, enabling signal analysis of lower amplitude levels; when incident light is on the scratched area, as shown in Fig. 7.

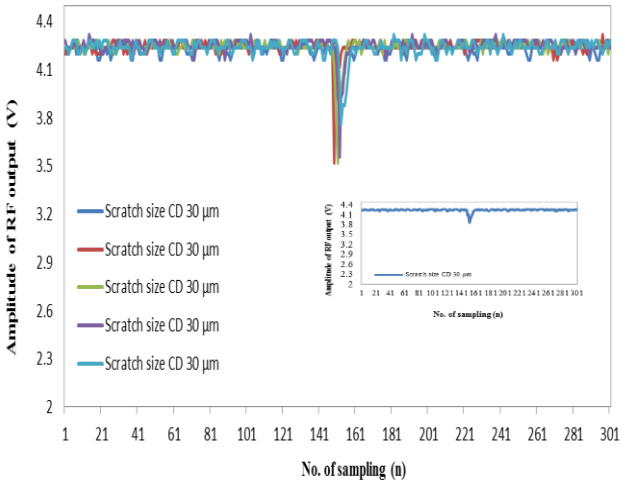


Fig. 7 Signal from scratch detection on magnetic disk surface

The result of scratch detection size 30 µm is found that the machine can detect the signal from reflection to photodiode detectors A, B, C, D. Then, the signal from the photo diode is combined and amplified. It is sent to RF output, signal measured by oscilloscope. The measurement results of output signal showed that scratch surface area, the measured signal is between 2.1 - 4.3 volts. Therefore, when analyzing the signal from measurements all 5 rounds, it was found that the signal from scratched area all 5 rounds have a lower amplitude level in position of sampling at 147 - 162. The reduced amplitude indicates the shape and width of the scratch.

4.2 Examination the Scratch Size

The size of the scratch was examined using stereo microscope [12]. The microscope is a type of camera with compound lens that produces 3D images, with high definition as a larger virtual image, as shown in Fig. 8.

The examination of scratch size employs magnification microscope with 4x - 120x [13], objects and opaque objects, the distance from the objective lens studied are 63-225 mm. It is found that the scratch size is 30 µm.

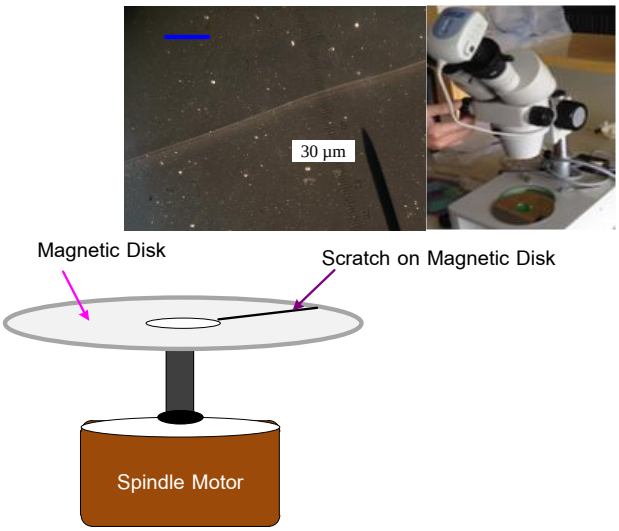


Fig. 8 Measuring scratch size on magnetic disk by using stereo microscope

5. Conclusions

This article presents the machine for detect scratch on magnetic disk by using the CD pick-up head with 780 nm wavelength laser diode. The finding indicated that scratched area has rough surface, affecting the direction of reflected light to photodiode detector. The received signal was sent to amplify the signal range. The signal was measured by an oscilloscope. The finding showed that when the disk was rotated to scratched area the amplitude level was decreased to 2.1 volts which was comparatively lower than non-scratched area with 4.3 volts. It can be identified that scratches occurred on the magnetic disk surface with lesser than 100 µm. In addition, the scratch shape can be seen on the disk surface, which can be used to determine the cause of the scratch.

Acknowledgements

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Biographies

Achinee Polsawat received a M.S.Ind.Ed. Electrical Engineering from King Mongkut's University of Technology Thonburi, Thailand, in 2005 to 2007. During Ph.D. in 2012, She worked on research with Scratch-Detection on Magnetic Disc by using Light Reflection Approach, in Electrical Engineering, Khon Kaen University, Thailand.

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