DEVELOPMENT OF A FIBER OPTIC THREE- DIMENTIONAL VIBRATION MEASURING SYSTEM

M. Rehman[1], M. Rizal Arshad[2] and Mohammad Ariff Bin Mohammad[3]

[1] *USM Robotics Research Group, School of Electrical and Electronic EngineeringUniversiti Sains Malaysia, Engineering Campus, 14300 Nibong Tebal, Seberang Perai Selatan, Pulau Pinang, MalaysiaTel: +604-5937788 ext. 6009, Fax: +604-5941023, E-mail: mahfoozur@eng.usm.my*

[2] *USM Robotics Research Group, School of Electrical and Electronic EngineeringUniversiti Sains Malaysia, Engineering Campus, 14300 Nibong Tebal, Seberang Perai Selatan, Pulau Pinang, MalaysiaTel: +604-5937788 ext. 6009, Fax: +604-5941023, E-mail: rizal@eng.usm.my*

[3] *Mechatronic Section, School of Electrical and Electronic EngineeringUniversiti Sains Malaysia, Engineering Campus 14300 Nibong Tebal, Seberang Perai Selatan, Pulau Pinang, MalaysiaTel: +604-5937788 ext. 6003, Fax: +604-5941023, E-mail: fredzuano@yahoo.com*

Abstract

This paper deals with the development of a three-dimensional vibration measuring system. It consists of three units of the basic sensor which are connected in such a way that each will sense the vibrations in the respective axis. These three signals can be combined to gather to display the over all vibrations in the system. On the other hand they may be observed separately to analyze the vibrations in a very simple manner. The design, fabrication and test results of basic sensor are included in this paper. It is small in size and related data acquisition system is so small that it may be used as a mobile device to measure vibrations on the spot. A proto-type model is fabricated and tested in the laboratory and is used in the measurement of vibrations of ROV under water vehicle.

Keywords:

Fiber optic technique; Vibration measurement; Sensors;

Introduction

Fiber optic techniques have been extensively used in the field of Opto-Mechatronics for the measurement and control of a number of physical quantities It is equally effective in the remote measurement of different quantities An optical fiber is a glass or plastic fiber designed to guide light along its length by confining as much light as possible in a propagating form. In fibers with large core diameter, the confinement is based on total internal reflection. In smaller diameter core fibers, (widely used for most communication links longer than 200 meters) the confinement relies on establishing a waveguide. Fiber optics is the overlap of applied science and engineering [1]. Optical fibers are widely used in fiber-optic communication, which permits the transmission of signal over longer distances and at higher data rates with least attenuation than other forms of wired and wireless communications. They are also used to form sensors, and in a variety of other applications. It has been used as sensors to measure strain, temperature, pressure and other parameters. The small size and the fact that very little electrical power is needed at the remote location gives the fiber optic sensor advantages over conventional electrical sensors in certain applications. Optical fibers are used as hydrophones for seismic or SONAR applications. Hydrophone systems with more than 100 sensors per fiber cable have been developed. Hydrophone sensor systems are used by the oil industry as well as navy of some countries. The German company Sennheiser developed a microphone working with a laser and optical fiber [2].Measurement of vibration is also a very important work because it is directly connected with the comfort of the human being. Vibrations as well as noise both are the cause of irritation and should be avoided, as far as possible, in the designed comfortable system. In this project we have proposed the design of a low cost device which can measure the vibrations, in three dimentions.er of accuracy.

Approach and Methods

Figure 1 shows the circuit diagram of the proposed system. Vibrations are recorded, using the light intensity modulation technique. Basically, the transmitter produces a light of constant intensity and employs LED light source. This light will be launched into optical fiber, efficiently. If proper care is not paid, major portion of the light, will be lost. Hence multimode fiber, made of plastic, whose both ends have been polished nicely, is used. Light entered inside the fiber travels, with least attenuation and reaches the polished surface of the vibration sensing aluminum cup

[3]. If surface is nicely polished and uniform, major portion of light falling on the surface will be reflected whose appreciable part will be launched into the second identical fiber which will take it to the receiver portion which is based on photo diode. Light reaching the photo diode is converted into current and afterwards it is converted into voltage with the help of current to voltage converter

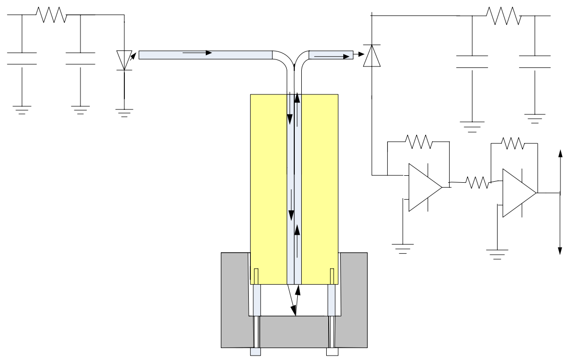


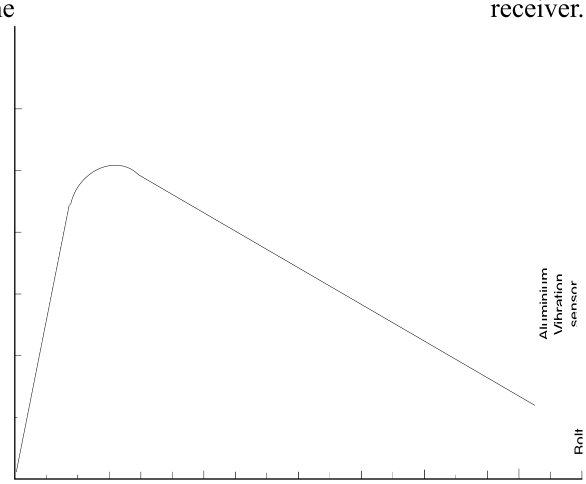
Figure 1 Circuit diagram of the proposed system

5 Volts (DC)

Optical Fiber

LED

. Output of current to voltage converter is further amplified to increase its magnitude to good level. Relationship between distance and output is represented, graphically, in Figure2. Ideally output is zero when distance between probe and surface is zero. However it will not be possible in this application due to the presence of spring. As distance increases output increase linearly due to the reception of more light by the receiver.



Aluminium Vibration sensor

Spring

Bolt

Brass handle

Figure2 Output Voltage versus Distance Characteristic

FIGURE 2 Relationship between the output voltage of the receiver and distance between surface and probe.

Linearly is maintained up to a distance of 2 to 4mm.but afterwards it starts decreasing as shown in Figure2. The later part of the characteristic may be represented by a straight line. For the measurement of vibrations, distance between probe and vibrating surface should be selected properly keeping in mind the maximum amplitude of the vibrations. When the vibration peak is expected to be with in 2-3 mm, system may be tuned in the front portion of the relationship shown in Figure 2. However, if the vibrations are expected to be more than this, system may be tuned to the tail of the graph by adjusting the length of the bolt supporting the spring. The fabricated probe is shown in Figure 3.The theoretical details are avoided to make the paper concise. The main purpose behind this design is to record the vibrations of moving systems in real time conditions. Output of the receiver may be easily interfaced with the microcontroller to record the vibrations in a memory which may be used to display the nature of vibrations in the laboratory. Further analysis may be done with the help of spectrum analyzer.

5 Volts (DC)

analyser

Spring

Figure 3 Photograph of the sensor probe with optical fiber cable.

Experimental methods and Results

Due to the presence of spring in between the fiber probe and reflecting surface, full front linear portion of the characteristic could not be utilized. However, calibration curve between 2 to 5.5mm is determined and results obtained are tabulated in TABLE-1. During experimentation supply of the LED is kept constant and relationship between distance and output voltage of the receiver is

Table I-Results obtained from the calibration of the probe

measured and tabulated in TABLE-1. It is appreciably linear but linear movement is limited to a distance of

Distance, mm	Output Voltage, Volts
2.00	0.50
2.2	1.05
2.5	1.10
3.5	2.20
4.0	2.60
5.0	3.70
5.5	3.95

2.5 mm only. However, for large amplitudes displacement has to be restricted to the second part of the curve. For this purpose size of bolt and spring has to be selected according to requirement. For practical testing, system was attached to ROV under water vehicle and output was seen on the cathode ray oscilloscope.

Conclusions

A low cost vibration recording system is presented. Due to the use of optical system, recording of high frequency signals may be much better than other techniques. The proto-type model is working satisfactorily and further improvements in the design are to be incorporated to make it suitable for recording vibrations with high degree of sensitivity and accuracy. Efforts are on to convert it into an embedded system so that it may record vibrations in the moving systems in the real time. It is also planned to fuse three probes into one to record three dimensional vibrations directly.

Acknowledgements

The authors would like to thank the school of electric and electronic engineering to provide the necessary facilities to fabricate and test the equipment.

References

[1] Francis T.S. Yu, 2002. *Fiber- Optic Sensors,* Marcel and Dekker. pp 41-47.

[2] Gowar, J., 1993.*Optical Communication Systems* 2nd edc. Hempstead UK. Prentice Hall,

[3] Doebelin, O.E.2003. *Measurement Systems, Application and Design,* Fifth Edition pp292-296.

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Author has been working in the field of Electronic Instrumentation and Sensors for nearly forty years. He completed his B.Sc Engg and M, Sc.Engg.degrees from ZH College of Engg. and Technology, AMU, Aligarh in 1966 and in 1972 respectively. He completed his PhD degree from Indian Institute of Technology Madras(INDIA)in 1981. He has published nearly 80papers in International Journals, International Conferences, National conferencesetc His main field of research is sensors with special attention on Fiber –Optic Sensors, Capacitive sensor, Ultrasonic sensors and intelligent Sensors.He has theTeaching experience of nearly forty years.

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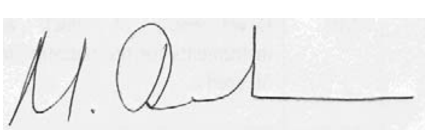
Signature: 

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