Optical Sensor Using ExpEyes Junior Kit

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Abstract: Fiber optic sensor technology offers the possibility of sensing different parameters like strain, temperature and pressure in harsh environment and remote locations. These kinds of sensors modulate some features of the light wave such as intensity, phase and wavelength in an optical fiber or use optical fiber as a medium for transmitting the measurement information. The advantages of fiber optic sensors in contrast to conventional electrical ones make them popular in different applications and now a day they consider as a key component in improving industrial processes, quality control systems, medical diagnostics, and preventing and controlling general process abnormalities. In this paper we represent a displacement sensor by performing an experiment using expEYES junior kit.

I. INTRODUCTION

Over the past twenty years two major product revolutions have taken place due to the growth of the optoelectronics and fibre optic communications industries. The optoelectronics industry has brought about such products as compact disc players, bar code scanners and laser pointers. The fibre optic communication industry has literally revolutionized the telecommunication industry by providing higher performance, more reliable telecommunication links with ever decreasing bandwidth cost. This revolution is bringing about the benefits of high volume production to component users and a true information superhighway built of glass.

In parallel with these developments fibre optic sensor [1-6] technology has been a major user of technology associated with the optoelectronic and fibre optic communication industry. Many of the components associated with these industries were often developed for fibre optic sensor applications. Fibre optic sensor technology in turn has often been driven by the development and subsequent mass production of components to support these industries. As component prices have fallen and quality improvements have been made, the ability of fibre optic sensors to displace traditional sensors for rotation, acceleration, electric and magnetic field measurement, temperature, pressure, acoustics, vibration, linear and angular position, strain, humidity, viscosity, chemical measurements and a host of other sensor applications, has been enhanced.

The technology and applications of optical fibers have progressed very rapidly in recent years. Optical fiber, being a physical medium, is subjected to perturbation of one kind or the other at all times. It therefore experiences geometrical (size, shape) and optical (refractive index, mode conversion) changes to a larger or lesser extent depending upon the nature and the magnitude of the perturbation. In communication applications one tries to minimize such effects so that signal transmission and reception is reliable. On the other hand in fiber optic sensing, the response to external influence is deliberately enhanced so that the resulting change in optical radiation can be used as a measure of the external perturbation. In communication, the signal passing through a fiber is already modulated, while in sensing the fiber acts as a modulator. It also serves as a transducer and converts the parameters like temperature, stress, strain, rotation or electric and magnetic currents into a corresponding change in the optical radiation. Since light is characterized by amplitude (intensity), phase, frequency and polarization, any one or more of these parameters may undergo a change. The usefulness of the fiber optic sensor therefore depends upon the magnitude of this change and our ability to measure and quantify the same reliably and accurately.

Optical fiber-based sensor technology offers the possibility of developing a variety of physical sensors for a wide range of physical parameters. Compared to conventional transducers; optical fiber sensors show very high performances in their response to many physical parameters such as displacement, pressure, temperature and electric field. Recently, high precision fiber displacement sensors have received significant attention for applications ranging from industrial to medical fields that include reverse engineering and micro-assembly (Laurence et al., 1998; Shimamoto & Tanaka, 2001); Spooncer et al., 1992; Murphy et al., 1991). This is attributed to their inherent advantages such as simplicity, small size, mobility, wide frequency capability, extremely low detection limit and non-contact properties. One of the interesting and important methods of displacement measurement is based on interferometer technique (Bergamin et al., 1993). However, this technique is quite complicated although it can provide very good sensitivity. Alternatively, an intensity modulation technique can be used in conjunction with a multimode fiber as the probe. The multimode fiber probes are preferred because of their coupling ability, large core radius and high numerical aperture, which allow the probe to receive a significant amount of the reflected or transmitted light from a target (Yasin et al., 2009; Yasin et al., 2010; Murphy et al., 1994). For future applications, there is a need for better resolution, longer range, better linearity, simple construction and low cost unit. Fiber-optic displacement sensors (FODS) are demonstrated using an intensity modulation technique. This technique is one of the simplest techniques for the displacement measurement, which is based on comparing the transmitted light intensity against that of the launch light to provide information on the displacement between the probe and the target.

In this paper we perform an experiment of displacement sensor by using expEYES junior kit. A photo transistor is used to convert optical signal into electrical signal. Here we use different colours of LEDS as a light source. Light emitting from the LED falls on the photo transistor. The intensity of light falling on the LED can be changed. We use an optical fiber as a guided media between the LED and phototransistor. The optical fiber may be plastic fiber or silica glass fiber. The sensor performances are investigated for various LED sources, different probes types and arrangements and different target. The theoretical analysis of this experiment is discussed later.

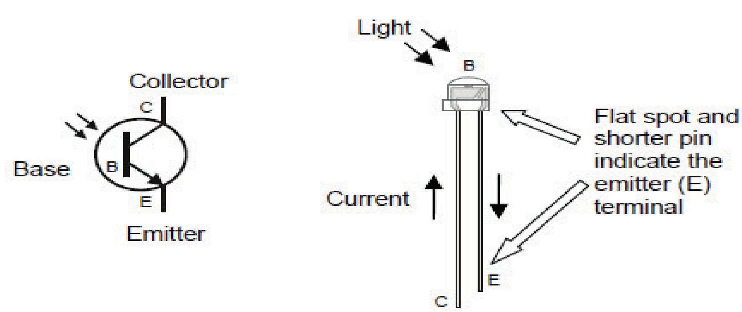
II. THEORETICAL ANALYSIS

The performed experiment can be analyzed theoretically by using expEYES junior kit. ExpEYES Junior is a modified version of expEYES released earlier. It is meant to be a tool for learning by exploration. We have tried optimizing the design to be simple, flexible, rugged and low cost. The low price makes it affordable to individuals and we hope to see students performing experiments outside the four walls of the laboratory, which closes when the bell rings. ExpEYES Junior is interfaced and powered by the USB port of the computer. For connecting external signals, it has several Input/output terminals. It can monitor and control the voltages at these terminals. In order to measure other parameters (like temperature, pressure etc.), we need to convert them in to electrical signals by using appropriate sensor elements.

Programmable Voltage Source (PVS) can be set, from software (python programming), to any value in the 0 to +5V range. The resolution is 12 bits, implies a minimum voltage step of around 1.25 mill volts. The external voltages connected to expEYES must be within the allowed limits. There are two types of analog inputs- (i) one is +5 volt range. These are denoted by A1 and A2 on the interfacing kit. (ii) Another is 0-5 volt range. These are denoted by IN1 and IN2 on the interfacing kit. The input IN1 and IN2 acts both as analog input and digital input. In digital mode any voltage less than 1 volt is treated as logic 0 (low) and any voltage greater than 2.5 volt is treated as logic 1(high). Exceeding these limits slightly will flash an error message. If the program stops responding, exit and re-connect the USB to reset the device. Larger voltages will result in permanent damage. To measure higher voltages, scale them down using resistive potential divider networks.

A transistor is like a valve that regulates the amount of electric current that passes through two of its three terminals. The third terminal controls just how much current passes through the other two. Depending on the type of transistor, the current flow can be controlled by voltage, current, or in the case of the phototransistor, by light.

The drawing below shows the schematic and part drawing of the phototransistor in your Robotics Shield Kit. The brightness of the light shining on the phototransistor's base (B) terminal determines how much current it will allow to pass into its collector (C) terminal, and out through its emitter (E) terminal. Brighter light results in more current; less-bright light results in less current.



The phototransistor looks a little bit like an LED. The two devices do have two similarities. First, if you connect the phototransistor in the circuit backwards, it won't work right. Second, it also has two different length pins and a flat spot on its plastic case for identifying its terminals. The longer of the two pins indicates the phototransistor's collector terminal. The shorter pin indicates the emitter, and it connects closer to a flat spot on the phototransistor's clear plastic case. The light emitted from the LED falls on the phototransistor and the phototransistor is illuminated.

III. EXPERIMENTAL ARRANGEMENT

Following Fibre-optic components are required for completing the experimental set-up: (i) 1 watt/ 3 watt LED (ii) Phototransistor (iii) Optical fibre-plastic/silica (iv) Optical bread board (v) Stand (vi) Laptop (vii) expEYES-J kit (vii) software (python programming) CD. The connecting arrangement is shown in **Fig 1** below where it can be seen that when we change the displacement from the end portion of the optical fibre to the phototransistor by screw-gauge on the optical bread board, the phototransistor output will be changed. The changing output of the phototransistor will be shown on the screen of the laptop. By using a stand we place the LED on the optical bread board. The phototransistor is placed by using another stand on the optical bread board. The optical fibre is placed between the LED and the phototransistor by using two stands. Now we can move the micrometer towards the phototransistor or away from the phototransistor and we will see the output change. The expEYES-J kit acts as an interfacing kit. The USB cable is connected between the laptop and the kit. We may use a plastic optical fiber or a silica fiber as a guided media between the LED and photo transistor in the **Figure 1** below.

Figure1

The schematic block diagram is shown below by **Figure2.**

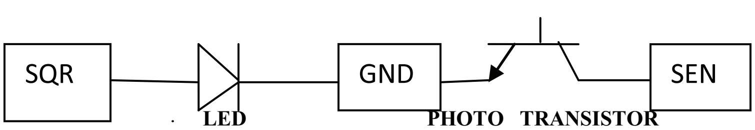


Figure2

In the above block diagram it is shown that the positive terminal of the LED is connected to the squire voltage (SQR) and the negative terminal is connected to the ground of the kit. The collector part of the phototransistor is connected to the sensor (SEN) and the emitter is connected to the ground of the kit. The frequency of the squire voltage is set to 1000 Hz. Now we move the micrometer or screw gauge and we will see the phototransistor output on the laptop at different position of the micrometer. The experimental result for different position of micrometer is discussed below-

IV. EXPERIMENTAL RESULT

Distance of the photo transistor from the optical fiber (µm)	Time (ms)	Intensity (V)
0.00	0.004	4.493
	0.500	3.937
	1.044	4.054
	1.500	3.926
	1.996	4.556
4.50	0.004	4.592
	0.500	4.371
	0.996	4.614
	1.484	4.100
	1.996	4.619
10.50	0.004	4.619
	0.005	4.619
	0.996	4.619
	1.500	4.619
	1.996	4.619

The following **Figur3**, **Figure4** and **Figure5** show the resulting graphs related the above result. **Figure3** Shows the result when the phototransistor lies at the nearest position of the optical fiber. **Figure4** shows the result when the phototransistor lies at a certain distance from the optical fiber. **Figure5** shows the result when the phototransistor lies at the maximum distance from the optical fiber. **Figure3** shows the result when the distance between the phototransistor and the optical fiber is 0.0 µm. **Figure4** shows the result when the distance between the phototransistor and the optical fiber is 4.5µm. **Figure5** shows the result when the distance between the phototransistor and the optical fiber is 10.50µm. In the following graphs the squire waveform shows the LED output and the red waveform above the squire waveform shows the phototransistor output.

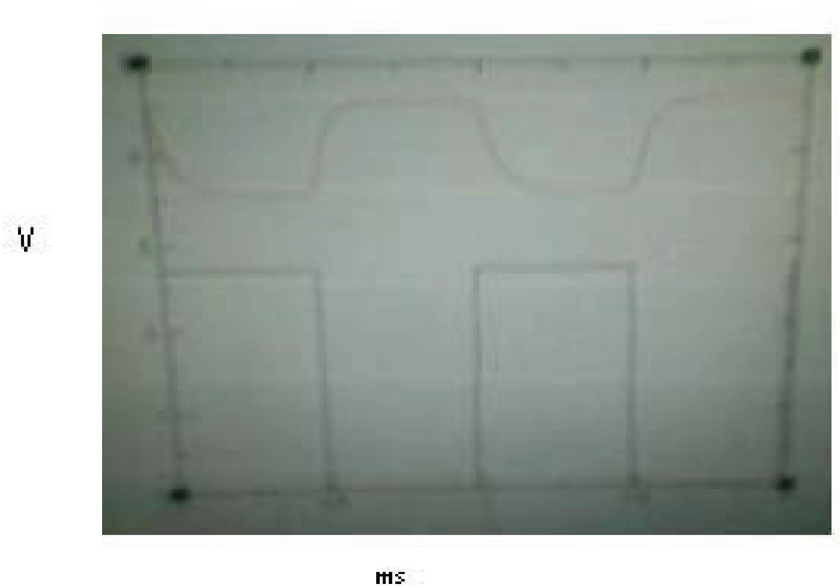


Figure3

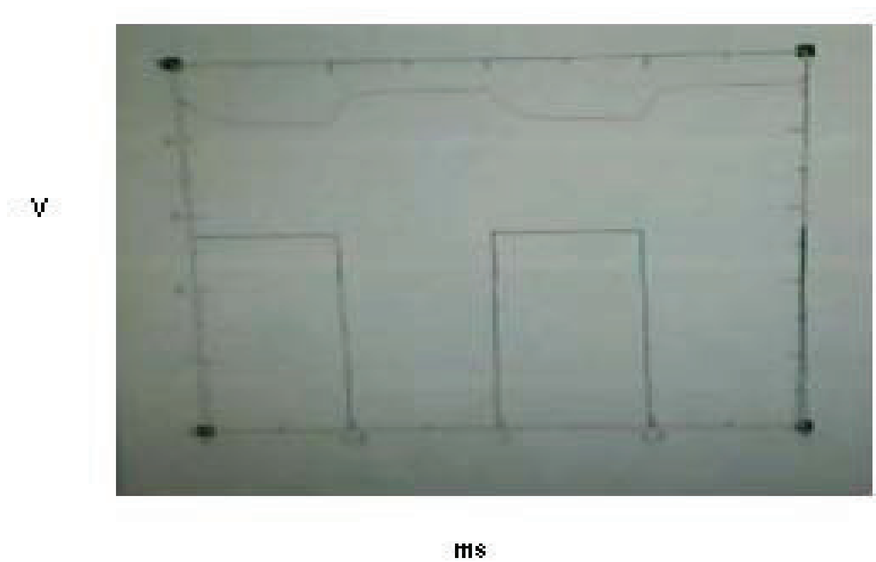


Figure4

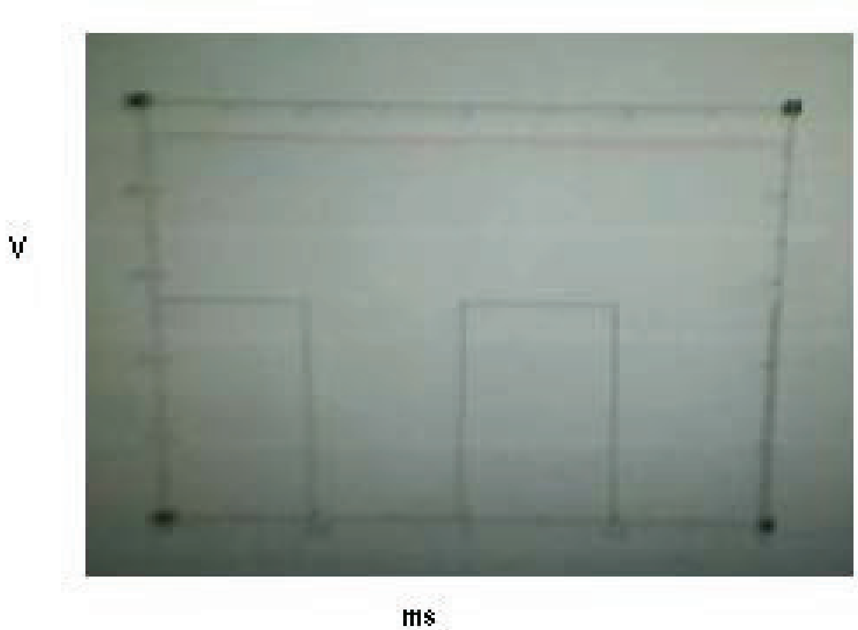


Figure5

From the above experimental results and graphs it is shown that when the distance between the end portion of the optical fiber and the phototransistor is nearest there is a response time and decay time. When the distance increases i.e. the distance is 4.5 µm the amplitude of the response time and decay time decreases, but both response time and decay time presents. When the distance is farthest there is no decay time. Only response time is present. From the experimental table and graphs it is clear that when the distance is 0.00 and 4.50 µm, among 1ms the response time is from 0.00 ms to 0.50 ms and the decay time is from 0.50 ms to 1ms.

So the response time = 0.50/1.00 x 100 = 50%

Decay time = 0.50/1.00 x 100= 50%

But at the furthest distance it is seen from the experimental result and graphs that the total time is response time. So the response time = 1.00/1.00 x100 =100%

V. CONCLUSION

The output of the photo-transistor at 1 kHz is shown in the above figures. The square trace is the voltage across the LED. When the LED is ON, phototransistor conducts and the voltage across the collector drops to .2 volts. When the LED is OFF the photo-transistor goes into cut off mode and the collector shows almost the supply voltage. The rise and fall time of the photo-transistor seems to be different. From the above experimental results and graphs we can conclude that if we increase the distance between the source and detector then the decay time will be decreased and response time will be increased. If the source is far away from the detector then there is only response time and there is no decay time. We can use this incident in different application. So the application of this incident is research worthy.

VI. ACKNOWLEDGEMENT

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