

Bend Sensitive Wavelength Dependent Conventional Fiber Based Weight and Pressure Sensor

Dimpi Paul¹, Benjamin Buragohain², Rajib Biswas³

¹Assistant Professor, Department of Physics, Patharkandi College, Sribhumi, Assam, India.

²MSc, Tezpur University, Assam, India.

³Associate Professor, Department of Physics, Tezpur University, Assam, India.

Emails: paulddimpi21@gmail.com¹

Abstract

Loss of optical power in a step index multimode optical fiber due to bending has been studied for visible as well as for infrared wavelength (470-1310nm). In this piece of work, the effect of bending radius and wrapping turns on loss has been observed, with respect to the mention wavelength range. Variation of bending loss has been observed with respective change in bending radius and numbers of bending turns. The variation in the results shows a good agreement with the theory. With the help of these observations of the proposed weight and pressure sensor has been designed. This study validates that the loss is a strong function of bending radius at lower wavelength regime. Therefore, the proposed sensors have been designed at wavelength 470nm that gives better sensitivity.

Keywords: Fiber Optics; Step Index Multimode Optical Fiber (SI-MMF); Fiber Bending Loss; Fiber Turns Loss; Weight Sensor; Pressure Sensor.

1. Introduction

Optical fibers are considered to be as preferable for transmission medium that delivering high bandwidth communications signals over long distances. This is owing to very little power loss as the signal propagates along the length of the optical. But, on the other hand it is difficult to preserve the fiber's low attenuation characteristics. There are several extrinsic effects that can increase the fiber attenuation. The attenuation can come into play while bending the fiber from a straight axis during indoors and outdoors installation process. Bending can refract and escape the transmitted optical signal through the fiber cladding within the cable. This causes loss of optical power and reduces the performance of optical fibers. It is to mention that bending can also produce damage to the fiber by causing micro cracks, especially during cable installation which is known as bending loss.

Bending can increase the attenuation of an optical fiber by two mechanisms such as macro-bending loss and micro-bending loss.

- **Macro bending loss:** In optical fiber light is guided by total internal reflection at the core-cladding interface. During fiber optic

transmissions, macro-bend is large visible bend in optical fiber. A part of the propagating optical energy can leaks out due to macro bends. Thus, this is an important factor to control during transmission.

- **Micro bending loss:** In fiber optic transmissions, micro bends arise due to repetitive small scale fluctuations in the radius of curvature of the fiber axis. It arises by non-uniformities in the manufacturing or non-uniform lateral pressures created during the cabling of the fiber.

Loss during transmission may increase with bending of an optical fiber thus this factor is very important to device for designing communication systems and optical instruments and sensors [1-5]. There are several fiber optic bending sensor has been proposed. The fiber optic bending sensors could be used to measure different physical parameters such as voltage, pressure, strain, temperature, weight and so on. Micro bending has been studied by a number of researchers. But this is to mention that irregular small cracks occur during the manufacturing and stress can make these cracks bigger which may lead to micro-

bending loss. On the other hand, macro bending arises when radius of the bend is much greater than the radius of the fiber that has also been investigated by few researchers. Bending loss for various wavelengths and bending parameters viz. radius of curvature and wrapping turns for single mode fiber have been reported earlier [1, 6-15]. In this paper, the bending loss behavior of step-index multimode fiber with wavelength has been studied. Also, we have used different radius of curvature and range of wavelength to investigate their effects on bending loss. In addition to that, effects of bending radius with a number of wrapping turns have also been investigated. Investigation has been performed to know the possibility to utilize the bending loss in sensing purpose. Moreover, till now very limited work has been done in this region that turns out to choose this range to deal with the possibilities [9-17]. In this paper the bending loss is has been observed at 470-1310nm wavelength range. Our main aim is to find the variation in the visible as well as in infrared regime. This is the reason we have chosen the whole range of wavelength stating from visible to infra-red region.

2. Experimental Setup

The schematic of each experimental setup are shown in figure 1, 2, 3 and 4. The change in bending diameter causes loss of optical power that are guided by the fiber. The losses have been observed at different wavelength of light with respect to the change in bending diameter. Each experimental setup has been designed such a way that they are of low cost and provide less error during the experiments. The proposed experimental setup consists of three basic parts: (a) source section, (b) fiber section and (c) the detector section. These three systems have been explained in section 2.5.

2.1. Experimental Setup for Fiber Bending Loss

The light from an optical source falls on one end of the optical fiber and in the other end an optical detector is attached to detect the output light. For wavelength 470nm, 573nm, 589nm and 623nm we have used a light dependent resistor (LDR) to detect the output light. A multi-meter is connected across the LDR to measure the voltage across the detector

(i.e., LDR). For wavelength 850nm, 980nm and 1310nm we have used an optical power-meter to detect and measure the output. The fiber bending is changed manually using a meter scale. The light coupler has also been used here to get maximum coupling of light with the fiber.

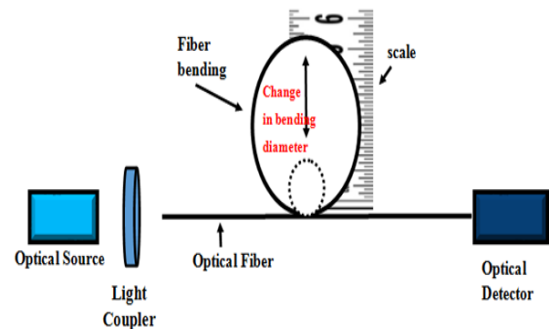


Figure 1 Experimental Setup for Optical Fiber Bending Loss

2.2. Experimental Setup for Fiber Turns Loss

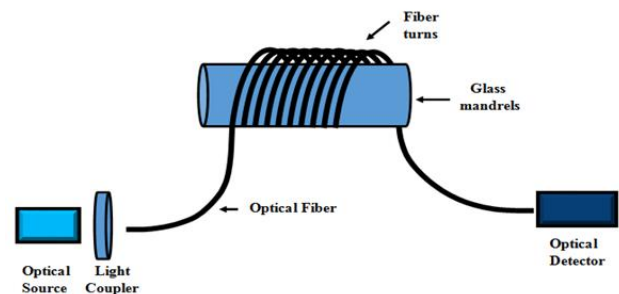


Figure 2 Experimental Setup for Fiber Turns Loss

Figure 2 shows the experimental setup for the measurements of optical fiber turns loss for different wavelength of light. We used optical source of wavelength ranging from 470-1310nm. For all the mentioned optical sources we have made one to ten turns and observed the corresponding output. The turns have been made by wrapping the fiber on glass mandrel. The glass mandrel has diameter 20mm, 25mm and 30mm. For 1310nm wavelength we have used all the aforementioned three mandrel and for the other wavelengths we have the glass mandrel of diameter 25mm.

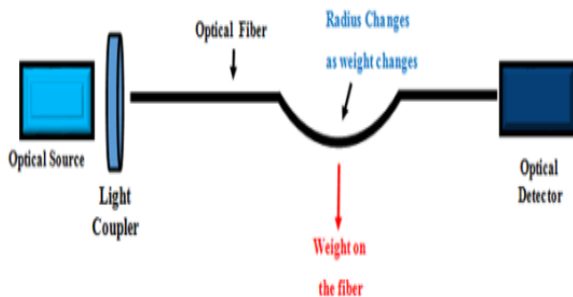


Figure 3 Experimental Setup for Weight Sensor

2.3. Figure 3 Experimental Setup for Step Index Multimode Optical Fiber Weight Sensor

Figure 3 illustrates the experimental set up for the weight sensing using a PMMA step-index multimode fiber (SI-MMF). After the exploration of bending loss behavior of the given optical fiber at different wavelength range, we have additionally made the setup to observe the sensing of the system with respect to change in weight as well. Since PMMA material works efficiently in the visible wavelength, thus the weight sensing property of the fiber has been observed using the optical source of 470nm. The bending radius of the fiber is maintained between 15mm and 25mm to measure the weight. Several weights between 1-100 grams have been used for during the experiment.

2.4. Experimental Setup for Pressure Sensor

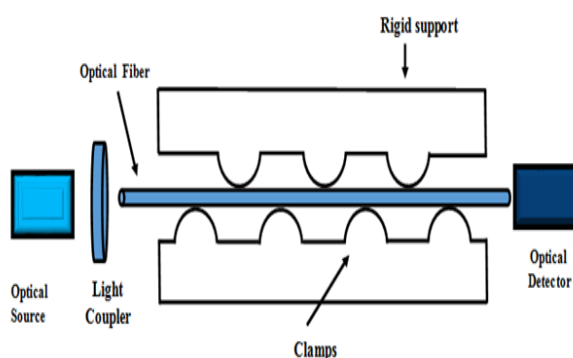


Figure 4 Experimental Setup of Optical Fiber Pressure Sensor

Figure 4 shows the experimental setup of the pressure sensor using a PMMA step-index multimode

optical fiber. If pressure is applied on the rigid surface of the setup the radius of the fiber would change and thereby the corresponding output varies. The change in the fiber bend radius would be different for different pressure. In this experiment we have used different weight to apply pressure on the fiber. Then we have converted these weights to pressure by calculating the area of contact of the fiber with the clamps.

2.5. The Complete Experimental Setup in Details

2.5.1. Light Source

In this experiment we have used LED of different wavelength as the source of light. We used LEDs with central wavelength 470-1310nm respectively. Visible as well infrared wavelength has been taken into consideration as these different sources of wavelengths that give different mode of light propagation through the optical fiber. The source circuit is shown in figure 5. The voltage and the resistance in the circuit have been applied according to the LED datasheet.

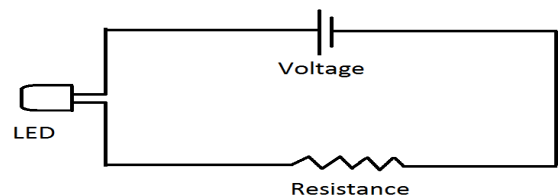


Figure 5 The Light Source Circuit

2.5.2. Fiber Section

The optical fiber used in this experiment is a step index multimode optical fiber. This is a plastic fiber having *Poly Methyl Meth Acrylate* (PMMA) and *Fluorinated Polymers* as core and cladding materials respectively. The refractive index of the core and cladding are nearly ~ 1.492 and 1.426 respectively. The numerical aperture of the given fiber is 0.5 . The core diameter of the fiber is 980 microns and cladding diameter is 1000 microns and the fiber attenuation is less than 0.2 dB/m. A convex lens has been placed between the axis of the source and fiber to get maximum light coupling. The remaining end of the fiber is attached to a detector. The light coupling is shown in figure 6.

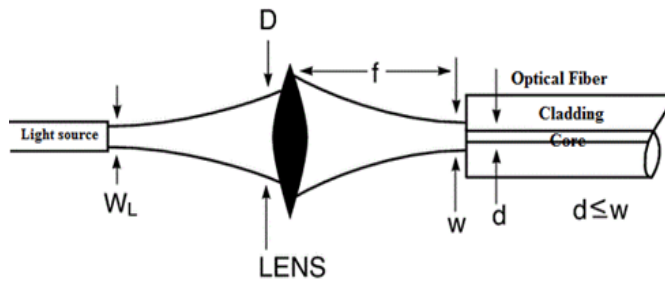


Figure 6 Light Coupling with Optical Fiber

2.5.3. Receiver Section

A receiver is a device that receives inputs and converts the information to a usable form. Here we have used light dependent resistance (LDR) and optical power meter as receiver. The LDR worked as a transducer in this piece of work. The light passing through the optical fiber is detected by the LDR and the power meter which has been converted into voltage.

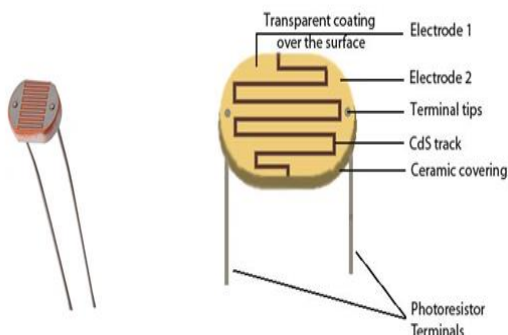


Figure 7 Light Dependent Resistor

A light dependent resistor (LDR) is a light-controlled variable resistor in which the resistance decreases with increasing incident light intensity. In dark, a LDR provides high resistance such as few mega ohms (MΩ) whereas in the light its resistance can drop to a few hundred ohms. Thus, the change in light intensity output of the optical fiber can change and can be detected by the LDR. Figure 7 shows a 4mm LDR. The response time of the LDR for increasing and decreasing light intensity is ~30millisecond. During experimentation a resistance of 4.7 MΩ has connected in series with the LDR, in the receiver circuit. To measure the output power at infrared region an optical power meter has been used. An optical power meter is a device which is used to

measure the power in an optical signal. Here, the unit of optical power meter is in dBm. The power meter is shown in figure 8. The input signal goes to the photodiode and the received signal from the photodiode is scaled and converted by means of the conversion circuit. The signal then enters the analog to digital converter (ADC) and comparator.

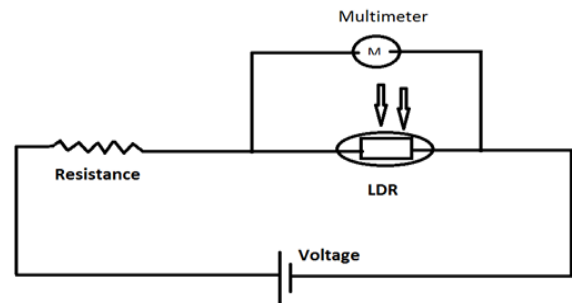


Figure 8 The LDR Receiver Circuit

ADC helps to convert the signal to discrete digital numbers that are interpreted by the control unit. Comparator amplifies and limits low-frequency waveform envelope which enters the control unit for detection and determination of low frequency modulation of an optical signal. The signal enters the low frequency amplifier after being processed by the comparator, where it is amplified. The control unit receives the user commands from the keypad and processes the data and thereby displays them on the LCD. The non-volatile memory stores the calibration coefficients set by manufacturer, settings and service information. The Power supply unit forms the required voltages either from batteries or from an external power source. Figure 9 shows the block diagram of an optical power meter.

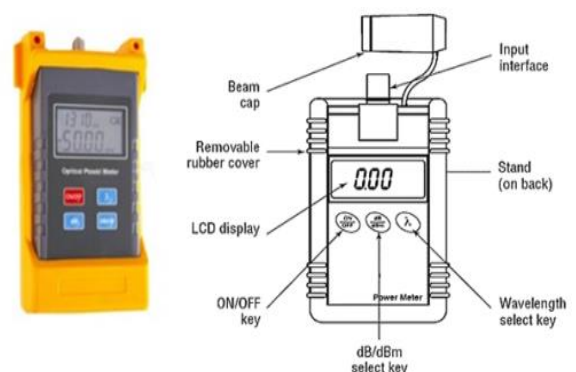


Figure 9 Optical Power Meter

3. Results and Analysis

3.1. Results

To investigate the bending loss and its variation with different wavelength, this piece of work has been carried out in different segments. At first, the effect of bending radius with wavelength has been checked and then later on the influence of wrapping turn number with wavelength has investigated. Before applying bending to the optical fiber, the transmitted optical power has been measured for

3.1.1. Fiber Bending Loss

the straight fiber. The experimental observation was repeated several times for suitable results. During repeated experimentation almost same types of results have been observed. The experimental data found from this experiment is given in the next segment. Analysis has been made for the obtained observations.

Table 1 Bending Loss for Each Bending Diameter (wavelength 470nm to 623nm)

Bending Diameter (cm)	Normalize bending loss	Bending Diameter (cm)	Normalize bending loss	Bending Diameter (cm)	Normalize bending loss	Bending Diameter (cm)	Normalize bending loss
470nm		573nm		589nm		623nm	
8	1	8	1	8	1.00060478	8	1
7	1.00062578	7	1.00120956	7	1.00181433	7	1
6	1.00250313	5.5	1.00241911	5.5	1.0027215	6	1.000300481
5	1.00406758	4.8	1.00332628	4.8	1.00302389	5	1.001201923
4	1.00563204	4	1.00453583	4	1.00423344	4	1.002103365
3.5	1.00750939	3.5	1.00604778	3.5	1.005443	3.7	1.002704327
3.2	1.01001252	3.2	1.00846689	3.2	1.00695494	3.4	1.003605769
3	1.01251564	3	1.01118839	3	1.00907167	3.2	1.004507212
2.9	1.01501877	2.9	1.01330511	2.9	1.010886	3	1.006310096
2.8	1.01814768	2.8	1.01572422	2.7	1.01572422	2.9	1.008112981
2.7	1.02252816	2.7	1.0190505	2.6	1.0190505	2.8	1.009615385
2.6	1.02722153	2.6	1.02328394	2.5	1.02237678	2.7	1.012019231
2.5	1.03254068	2.5	1.02751739	2.3	1.03296039	2.6	1.015024038
2.4	1.03817272	2.4	1.03326278	2.2	1.03991533	2.5	1.018629808
2.3	1.04536921	2.3	1.03961294	2.1	1.04747505	2.4	1.022235577
2.2	1.05350438	2.2	1.04596311	2	1.05503477	2.3	1.026742788
2.1	1.06195244	2.1	1.05443	1.9	1.06350166	2.2	1.031550481
2	1.0704005	2	1.06350166	1.8	1.07227094	2.1	1.038461538
1.9	1.08166458	1.9	1.07136377	1.7	1.08043544	2	1.044471154
1.8	1.09230288	1.8	1.07983066	1.6	1.09011188	1.9	1.051382212
1.7	1.10262829	1.7	1.08920472	1.5	1.10009072	1.8	1.05859375
1.6	1.11357947	1.6	1.09888116			1.7	1.065805288
1.5	1.12421777	1.5	1.10795283			1.6	1.074519231
						1.5	1.084134615

Table 2 Bending loss for Each Bending Diameter (wavelength 850nm to 1310nm)

Bending Diameter (cm)	Normalize bending loss	Bending Diameter (cm)	Normalize bending loss	Bending Diameter (cm)	Normalize bending loss
850nm		980nm		1310nm	
8	1	8	1	8	1
7	1	7	1	7	1
6	1	6	1	6	1
5	1.000257666	5	1.000248324	5	1
4.3	1.000515331	4	1.000496648	4	1.00016592
3.8	1.000772997	3.6	1.000744971	3.5	1.00033184
3	1.001545993	3.3	1.000993295	3	1.0008296
2.8	1.002061324	3	1.001241619	2.9	1.00099552
2.7	1.002576656	2.9	1.001489943	2.8	1.00116144
2.6	1.003091987	2.8	1.001738267	2.7	1.00132736
2.5	1.003607318	2.7	1.001986591	2.6	1.0016592
2.4	1.004380314	2.6	1.002483238	2.5	1.00199104
2.3	1.005153311	2.5	1.002979886	2.4	1.0024888
2.2	1.006441639	2.4	1.003724857	2.3	1.00298656
2.1	1.007987632	2.3	1.004469829	2.2	1.003650241
2	1.009791291	2.2	1.005463124	2.1	1.004313921
1.9	1.012367946	2.1	1.006704743	2	1.005143521
1.8	1.015202267	2	1.00844301	1.9	1.005973121
1.7	1.018036589	1.9	1.010181276	1.8	1.007300481
1.6	1.02087091	1.8	1.012416191	1.7	1.008793761
1.5	1.024220562	1.7	1.015396076	1.6	1.010452962
		1.6	1.018375962	1.5	1.012941762
		1.5	1.021852496		

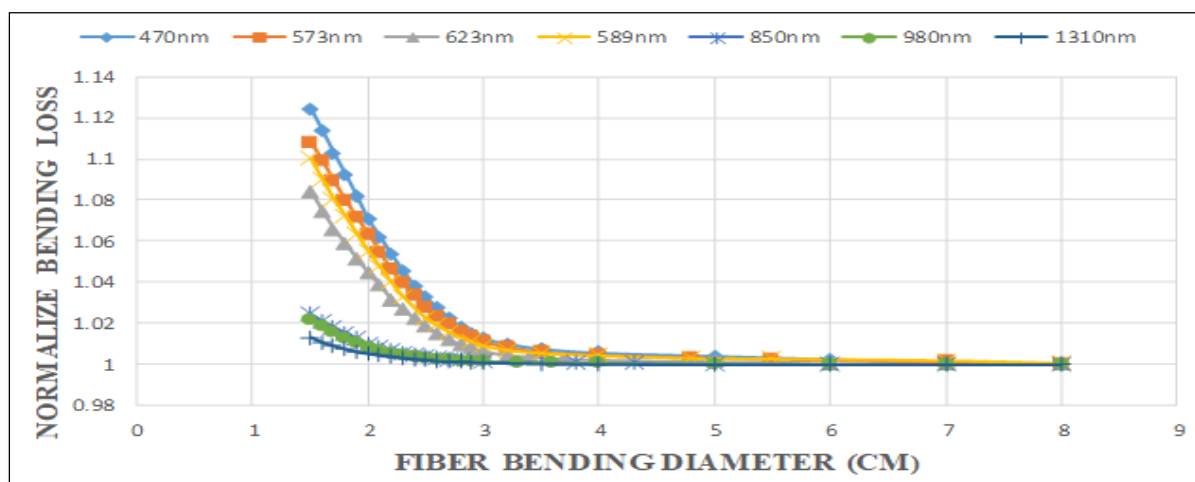


Figure 10 Fiber Bending Loss at Different Wavelength

3.1.2. Fiber Turns Loss

Table 3 Turn Loss for Each Respective Turns (*wavelength 470nm to 623nm*)

Number Of Turns	Normalize Output Loss	Number Of Turns	Normalize Output Loss	Number Of Turns	Normalize Output Loss	Number Of Turns	Normalize Output Loss
470nm		573nm		589nm		623nm	
0	1	0	1	0	1	0	1
1	1.03034995	1	1.02713064	1	1.02027027	1	1.017548907
2	1.06286776	2	1.0513123	2	1.04054054	2	1.033947066
3	1.09569526	3	1.07903273	3	1.0619859	3	1.053509781
4	1.12170951	4	1.10822766	4	1.08078731	4	1.071058688
5	1.15391762	5	1.13388381	5	1.09753231	5	1.084867664
6	1.18953236	6	1.15806547	6	1.12191539	6	1.102704258
7	1.21554661	7	1.18283692	7	1.13807286	7	1.1216916
8	1.25209043	8	1.21026246	8	1.15599295	8	1.140678941
9	1.27965314	9	1.24211147	9	1.17978848	9	1.153049482
10	1.30442862	10	1.26865231	10	1.2059342	10	1.171173763

Table 4 Turn loss for Each Respective Turns (*wavelength 850nm to 1310nm*)

Number Of Turns	Normalize Output Loss	Number Of Turns	Normalize Output Loss	Number Of Turns	Normalize Output Loss
850nm		980nm		1310nm	
0	1	0	1	0	1
1	1.004430545	1	1.002889477	1	1.001301236
2	1.008861089	2	1.005538165	2	1.002927781
3	1.011988533	3	1.008909222	3	1.004716981
4	1.016158457	4	1.01203949	4	1.006018217
5	1.01876466	5	1.014206598	5	1.007644763
6	1.023977065	6	1.017096075	6	1.00862069
7	1.02840761	7	1.020226342	7	1.010409889
8	1.031535053	8	1.023597399	8	1.011711126
9	1.034662497	9	1.025523718	9	1.013500325
10	1.040135523	10	1.028894775	10	1.014801561

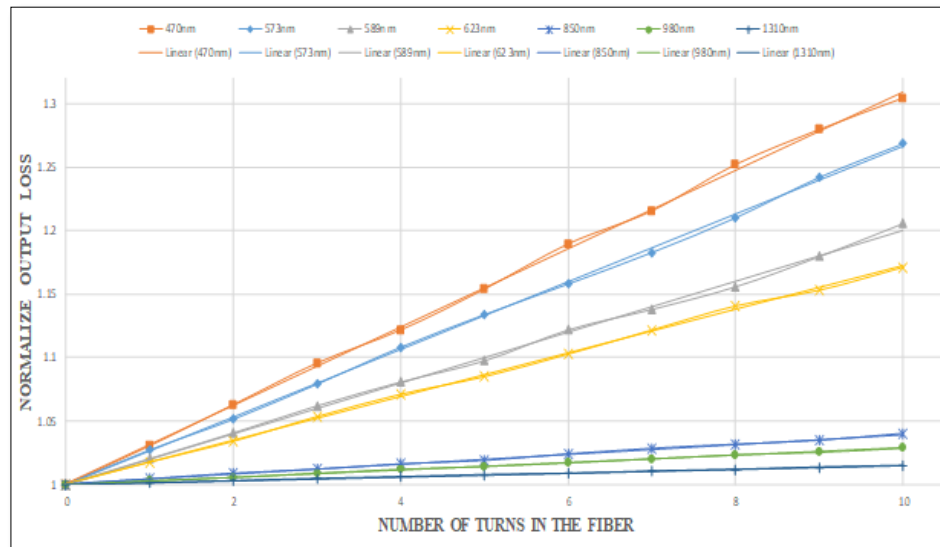


Figure 11 Fiber Turns Loss at Different Wavelength

3.1.3. Fiber Turns Loss at 1310nm for Different Diameter of The Turns

Table 5 Turn Loss for Each Respective Turns (at wavelength 1310nm)

Number Of Turns	Normalize Output Loss	Number Of Turns	Normalize Output Loss	Number Of Turns	Normalize Output Loss
1310nm		1310nm		1310nm	
20mm (turns Diameter)		25mm (turns Diameter)		30mm (turns Diameter)	
0	1	0	1	0	1
1	1.00535207	1	1.00249294	1	1.00129955
2	1.0122094	2	1.00531826	2	1.00243665
3	1.01789597	3	1.00648164	3	1.00324886
4	1.02174277	4	1.01013794	4	1.00503574
5	1.02742934	5	1.01279707	5	1.00584795
6	1.03144339	6	1.01396045	6	1.00747238
7	1.03763171	7	1.01695197	7	1.00812216
8	1.0449908	8	1.01811534	8	1.00958415
9	1.05017561	9	1.02027588	9	1.01072125
10	1.05502592	10	1.0235998	10	1.01185835

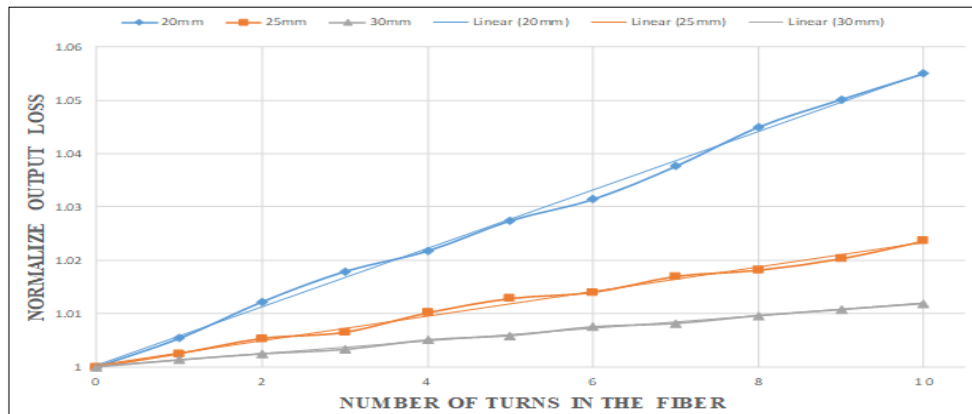


Figure 12 Fiber Turns Loss for Different Bending Diameter at 1310nm

3.1.4. Step Index Multimode Optical Fiber Weight Sensor

Table 6 Different Losses for Different Weight (gm)

Change in Weight (gm)	Normalize Output (Loss)	Change in Weight (gm)	Normalize Output (Loss)	Change in Weight (gm)	Normalize Output (Loss)	Change in Weight (gm)	Normalize Output (Loss)
1	1	19	1.025442	37	1.047161	55	1.071052
2	1.000621	20	1.026063	38	1.049023	56	1.071672
3	1.002482	21	1.026993	39	1.049643	57	1.073534
4	1.003413	22	1.029165	40	1.051195	58	1.074155
5	1.006516	23	1.029786	41	1.053056	59	1.074775
6	1.007757	24	1.030717	42	1.053677	60	1.076947
7	1.008688	25	1.032889	43	1.055228	61	1.078498
8	1.010859	26	1.033819	44	1.055849	62	1.08005
9	1.01148	27	1.03475	45	1.05771	63	1.08067
10	1.013031	28	1.036612	46	1.059572	64	1.082842
11	1.014272	29	1.037232	47	1.060192	65	1.084083
12	1.015514	30	1.038784	48	1.060813	66	1.084704
13	1.016134	31	1.040335	49	1.062675	67	1.086876
14	1.017996	32	1.040956	50	1.063605	68	1.087496
15	1.019237	33	1.042817	51	1.064846	69	1.089668
16	1.021719	34	1.043438	52	1.065777	70	1.090599
17	1.02265	35	1.044989	53	1.067949		
18	1.023581	36	1.04654	54	1.06888		

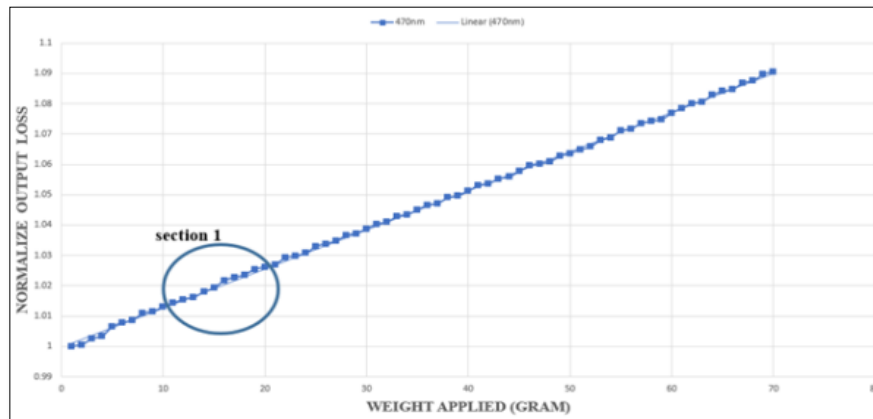


Figure 13 Step Index Optical Fiber Weight Sensor

3.1.4.1. Zoom View of Section 1

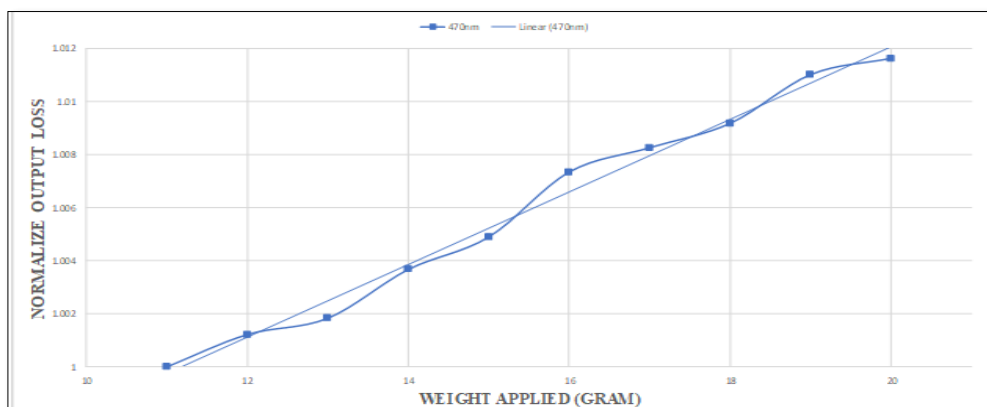


Figure 14 Zoom View of Figure 4 Step Index Optical Fiber Weight Sensor

3.1.5. Step Index Multimode Optical Fiber Pressure Sensor

Table 7 Different Power for Different Pressure (bar)

Weight Applied per Square cm area	Pressure	Output voltage	Output power	Normalize output
(kg)	(bar)	(mv)	(dBm)	
0	0	971	-36.97	1
0.5	0.49	966	-37.02	1.00135245
1	0.98	955	-37.12	1.00405734
1.5	1.47	939	-37.27	1.00811469
2	1.96	923	-37.42	1.01217203
2.2	2.16	899	-37.64	1.0181228
2.5	2.45	865	-37.98	1.02731945

2.7	2.65	841	-38.23	1.03408169
2.8	2.75	812	-38.53	1.04219638
3	2.94	746	-39.26	1.06194212
3.05	2.99	730	-39.45	1.06708142

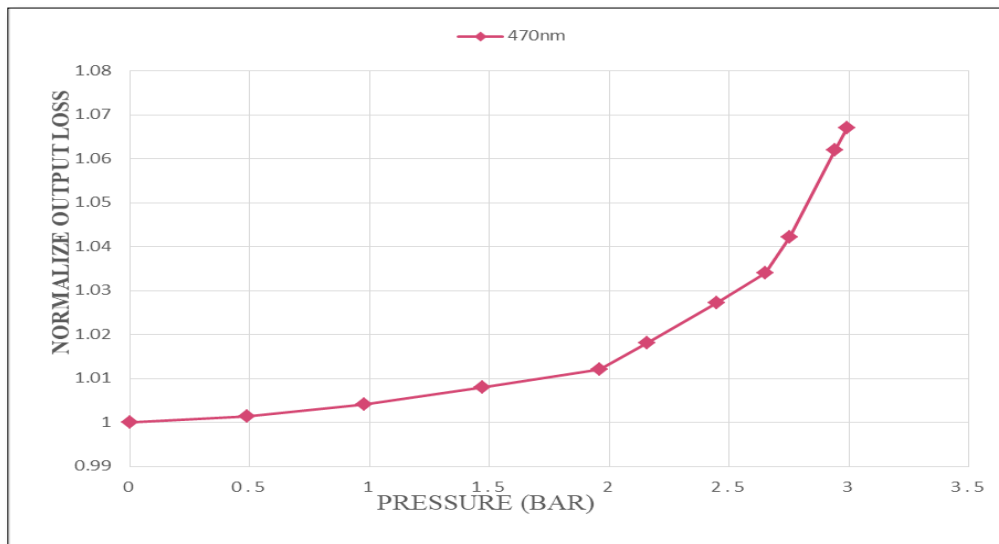


Figure 15 Step Index Optical Fiber Pressure Sensor

4. Analysis of Experimental Data and Curve

4.1. Fiber Bending Loss

Data from table:1 and table:2 are plotted and the curve obtained are shown in figure 10. The curve is plotted for bending loss vs. fiber bending diameter. It is observed that the optical fiber loss power exponentially with decreasing bending radius. In the bending loss formula the loss is an exponential function of radius of curvature of the fiber. Therefore, the fiber loss power exponentially. It is also observed that the curve shows a higher decay rate at lower bending radius. This can be explained as the multimode fiber without bending has support a large number of modes. When we start to decrease the bending radius the number of modes through the fiber also starts to decrease. For any optical fiber, the mode field is distributed not only in the core, but also in the cladding of the fiber as well. When we make a curvature in the fiber, then different part of the modes must travel at different speed to maintain the mode field during transmission. It is to be noted that complete transmission of wave is not possible and

hence few modes may have been lost through radiation. As the radius of curvature increases, a greater number of modes losses from the fiber and this explain the curve obtained. Theory shows that below critical radius of the curvature loss increases rapidly which is because of propagation characteristic of the fiber material. From figure 11 it is also observed that bending loss of the fiber decreased as the operating wavelength is increased. The order of bending loss obtained is during the experimentation: loss470nm > loss573nm > loss589nm > loss623nm > loss850nm > loss980nm > loss1310nm. This loss can be explained using the exponential term present in bending loss coefficient α . The exponential term is negative and so it gives higher value for lower wavelength and lower value at higher wavelength respectively. Thus, the bending loss decreases with increasing in wavelength. From the experimental it has been observed that the power loss of the fiber at different wavelength for the bending diameter of 15mm are obtained as wavelength and shown in Table 7.

Table 8 Wavelength

Power Loss	Wavelength
3.97dB	470nm
3.57dB	573nm
3.29dB	589nm
2.80dB	623nm
0.94dB	850nm
0.88dB	980nm
0.78dB.	1310nm

4.2.Fiber Turns Loss

Plotting the obtained results from table 3 and table 4 gives the curve as shown in figure 12. Here it has been observed that the fiber turns are made on a glass mandrel of 25mm diameter, Table 8.

Table 9 Wavelength

Power Loss	Wavelength
9.83dB	470nm
9.11dB	573nm
7.01dB	589nm
5.95dB	623nm
1.54dB	850nm
1.20dB	980nm
0.91dB.	1310nm

LED's with central wavelength 470nm, 573nm, 589nm, 623nm, 850nm, 980nm and 1310nm has been used to investigate the fiber turns loss. The turn loss increases linearly with increase in turn number. This is supported by the turn loss equation (Turns loss = $8.686\alpha LN$), where turn loss is a linear function of number of turns (where, N = number of turns in the

optical fiber, α =bending loss coefficient and L=fiber length). The deviation of data point from the theoretical value is due to the experimental error. The power loss at different wavelength for the ten turns of the fiber at a bending diameter are obtained, shown in Table 8.

4.3.Influence of Wrapping Turns at 1310 nm for Different Bend Curvature

We have observed the variation of fiber output power at wavelength 1310nm by increasing the turn number in the fiber. Also, these observations can be made for different turn diameter. The data obtained is tabulated in table 5. The plot of the data of table 5 is given in the figure 14. The loss is a linear function of turns for all the three different bending radius of curvature. The power loss at different wavelength for the ten turns of the fiber is at different fiber turn diameter are obtained, table 6, shown in Table 9.

Table 10 Turn Diameter & Power Loss

Turn diameter	Power Loss
20mm	3.29dB
25mm	1.42dB
30mm	0.73dB

4.4.Step Index Multimode Optical Fiber Weight Sensor

We have already study the bending loss behavior of step index optical fiber at different wavelength. At lower wavelength side the loss increase more rapidly with increasing radius of curvature than the higher wavelength side. The loss is a strong function of bending radius for the lower wavelengths. Therefore, this property can be used in sensing purpose. The weight sensor proposed in here is designed at wavelength 470nm. This arrangement is capable of sensing weight from 1 gram to about 70 gram. The sensor is able to sense small change up to 1 gram. If we analyze the bending loss curve for 470 nm as shown in figure 16, we found a linear part for bending diameter at 1.5cm to 2.5cm. This linear part is utilized for designing the weight sensor. For this linear region the output power from the fiber is changed linearly with change in radius. This linear characteristic

makes the sensor easy to design and make more reliable. Some parameters of the proposed sensor are

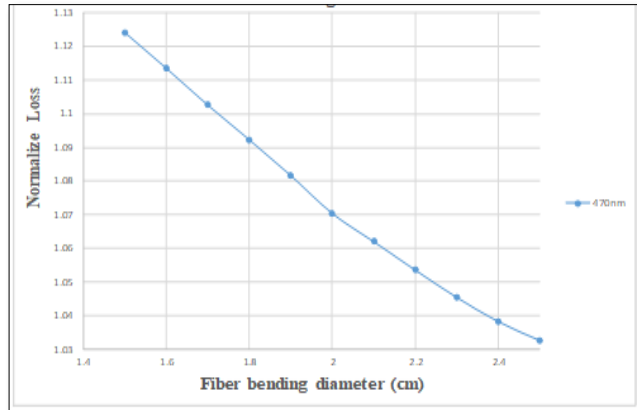


Figure 16 Step Index Optical Fiber Pressure Sensor

Range: maximum value measured: 70 grams. minimum value measured: 1 gram. Resolution: The smallest value perceptible is 1 gram. Figure 14 gives the output variation of the fiber with respect to change of weight in the fiber. The plot is almost linear. Figure 15 shows a zoom view of section 1 of figure 14. From the figure 15 it has been observed that the experimental values are almost precise to its theoretical value. The little distortion of the experimental values may be due to experimental error, Table 10.

4.5. Step Index Multimode Optical Fiber Pressure Sensor

In this project work, investigation has been made for pressure sensing using a step index multimode optical fiber. We have obtained the experimental data as shown in table 7 and the plot of is shown in figure 17. The experimental setup has been made such a way that the fiber can changed its bending radius up to 10mm. As we increase the pressure on the fiber lead to change the radius of the fiber and hence change the corresponding output power of the fiber. In this experiment the fiber gives sensing up to 3 bar. Further, investigation has been made on this pressure sensing characteristic of the fiber.

Conclusion

In this work, variation of bending loss as well as turns loss with a wide range of wavelength has been

evaluated using step index multimode fiber. Loss reduction with increase in curvature radius and turns number was obtained. Based on this study, the proposed weight sensor and the pressure sensor have been molded. We have used a PMMA fiber, as it shows good efficiency towards the visible wavelength. Also, from the bending loss investigation we have found that loss is a strong function of bending radius at lower wavelength. For these regions, we modeled a weight and a pressure sensor at wavelength 470nm. Hence, the results shows good validation towards sensing point of view utilizing the an wide range of wavelength.

References

- [1]. Ghatak, Thyagarajan — Introduction to fiber optics — Cambridge.
- [2]. Allan W. Snyder, John D. Love — Optical waveguide theory.
- [3]. IJECCCT — volume 3, issue 4 (July 2013) — Classification of fiber optical sensor.
- [4]. Fundamentals of Photonics —Bahaa E. A. Saleh, Malvin Carl Teich — ISBNs: 0-471-83965-5 (Hardback); 0-471-2-1374-8 (Electronic) — CHAPTER 8.
- [5]. Fiber Optic Sensors Technology & their applications — Shaveta Thakral, Pratima Manhas.
- [6]. Jaction — Classical Electrodynamics — third edition, Wiley.
- [7]. A Zendehnam, M Mirzaei, A Farashiani, L Horabadi Farahani - Investigation of bending loss in a single mode optical fiber.
- [8]. D Gloge - Bending loss in multimode fibers with graded core index.
- [9]. B G Plotter - Attenuation in optical fibers.
- [10]. John A Jay - An overview of macrobending and microbending of optical fibers.
- [11]. Ross T Schermer - Improved bend loss formula for optical fiber by simulation and experiment.
- [12]. J Gowar, optical communication system (Parentice - Hall International Series in opto electronics (PHI), London, 1983) p. 78.
- [13]. S C Gupta, Textbook on optical fiber communication and its application (PHI, India) p.44.



- [14]. L Faustini, G Martini - Lightwave Technology, Journal of, 1997 - ieeexplore.ieee.org - Bend loss in single-mode fibers.
- [15]. Single-mode optical fiber design with wide-band ultra low bending-loss for FTTH application - Pramod R. Watekar, Seongmin Ju, and Won-Taek Han.
- [16]. Bend loss measurements on high numerical aperture single-mode fibers as a function of wavelength and bend radius - A Harris, PF Castle - Lightwave Technology, Journal of, 1986 - ieeexplore.ieee.org. en.wikipedia.org.