ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
Vol. 2, Issue 5, May 2013

Study of Characterization of Intensity Modulated Fiber Optic Sensor

C. Venkatasubbaiah[1], V. Sreeharibabu[2], A. Jayanth Kumar[3], S.Chandralingam[4].

Asst. Prof., Department of Physics, Vardhaman College of Engineering, Hyderabad, AP, India[1]

Asst. Prof., Department of Physics, Guru NanakInstitutions Technical Campus, Hyderabad, AP ,India[2]

Professor, Department of Physics, Institute of Aeronautical Engineering, Dundigal, Hyderabad, AP, India[3]

Professor., Department of Physics, JNTUH College of Engineering, Hyderabad, Andhra Pradesh, India[4]

Abstract: Fiber optic sensors are playing important role in the field of sensors. This is due to spontaneous response and ease in handling. Hence, it is proposed to study the Characterization of Intensity Modulated Fiber Optic Sensor. In the present paper, we have made use of a plastic optical fiber operated at 820nm and 850nm. A small portion of cladding has been removed in the middle of the optical fiber and the bare core is exposed in guiding liquid of various concentrations of common salt and sugar solutions. One end of the fiber is connected to the source and the other end to a power meter. The output power at the second end of the fiber is measured. The relation between refractive index of guiding liquid (which varies with concentration) and the output power, power loss, V-number, modal dispersion etc. are studied.

Keywords: Intensity modulated fiber optic sensor, variation of output power with change in refractive index, power loss, V-number, modal dispersion

I. INTRODUCTION

Fiber optic sensors represent a technology that has revolutionized a multiple sensing applications [1-5]. The property of being non-electrical, small in size, rugged and immune to electromagnetic interference enhanced the use of optical fibers in sensing applications in the field of science, engineering and technology. These sensors can be used to sense the physical properties like temperature[6-7], liquid level[8-9],radiation, strain, refractive index[10], vibration, concentration of liquid[11], chemical analysis[12] etc.

In the present experiment,3cm claddinghas been removedin the middle of 1m plastic fiber (200/230µm) along its length. The portion where cladding has been removed called 'sensing region'is exposed in guiding liquid of various concentrations of common salt and sugar solutions. The output power at each concentration of guiding liquid for operating wavelengths of 820nm and 850nm is measured. Various properties like power loss, V-number, modal dispersion have been studied.

II. EXPERIMENTAL METHOD

A)*Preparation of Guiding Liquid:*The guiding liquids used in this experiment are common salt solution and sugar solution with various concentrations. Common salt solution is prepared by dissolving 1g, 2g, 3g, 4g, 5g, 6g, 7g, and 8gof powdered common salt in 25ml of distilled water separately.Corresponding refractive index at each concentration is measured using Abbe's refractometer. Similarly, sugar solution used as guiding liquid is prepared by dissolving 1g, 2g, 3g, 4g, 5g, 6g, 7g and 8g of sugar in 25ml of distilled water separately. Corresponding refractive index at each concentration is measured using Abbe's
refractometer. The relation between concentrations of common salt and sugar solutions with refractive index are graphically illustrated in figure (1).

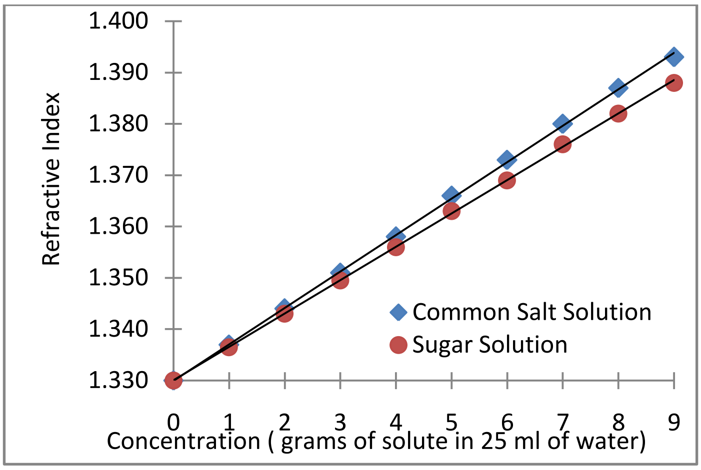


Fig (1): Graph indicating the relation between concentration andrefractive indexofcommon salt solution and sugar solutions

B) *Power launched into thefiber:*A multimode plastic fiber of length 1m is used in the present experiment. One end of the fiber is connected to a source of operating wavelength 820nm and the other endto a power meter with suitable connectors. The output power for the operating wavelength of 820nm is measured in dBm. This output power is considered as 'power launched into the fiber at 820nm'since the power lost in 1m fiber is negligible. Now the source is turned on to operating wavelength 850nm and the output power is measured in dBm and noted as 'power launched in to the fiber at 850nm'.

C) *Preparation of fiber for experimental work:*Now, 3cm outer plastic jacket has been removed in the middle of 1m fiber, using stripper. The fiber where outer jacket has been removed is immersed in benzene and heated up to 60˚C for about 25minutes. The plastic clad peels off automatically.The bare core where cladding has been removed is washed gently with distilled water and dried for about 30 minutes. The fiber thus prepared is ready to use in the experimental work.

D) *Procedure:*The core where the cladding has been removed is considered as sensing region. One end of the fiber is connected to the source ofoperating wavelength 820nm and the other end to power-meter. The sensing region is totally immersed in guiding liquid of 1g powdered common salt dissolved in 25ml of distilled water as shown in the experimental arrangementfigure (2).

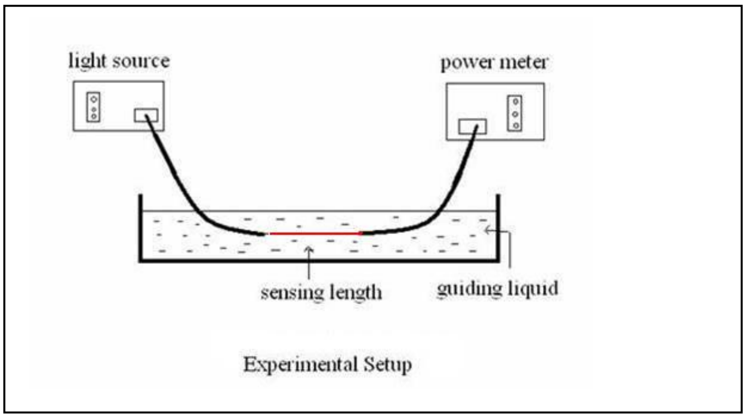


Fig (2): Experimental setup

The output power observed in the power meter is noted.The experiment is repeated with guiding solutions prepared by dissolving 2g, 3g, 4g, 5g, 6g, 7g, and 8gpowdered common salt in 25 ml of distilled water. The output power at each concentration is measured. The experiment is repeated with operating wavelength of 850nm for all concentrations.Theoutput power is measured at each concentration. The variation of output power with refractive index of guiding liquid at operating wavelengths 820nm&850nm are illustrated in figure (3).

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

Vol. 2, Issue 5, May 2013

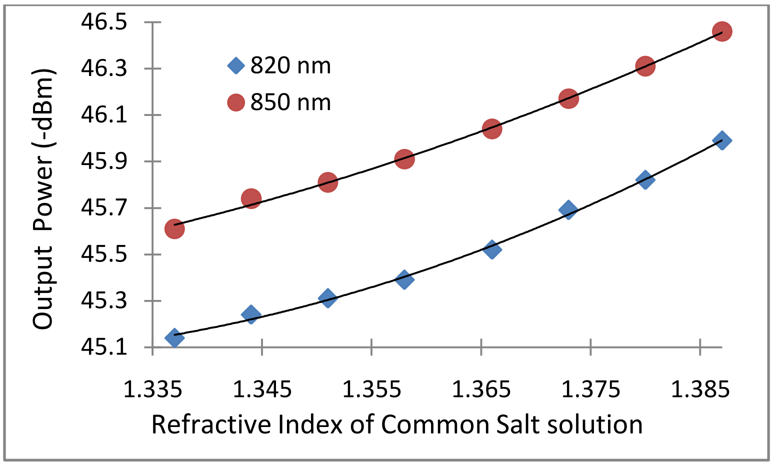
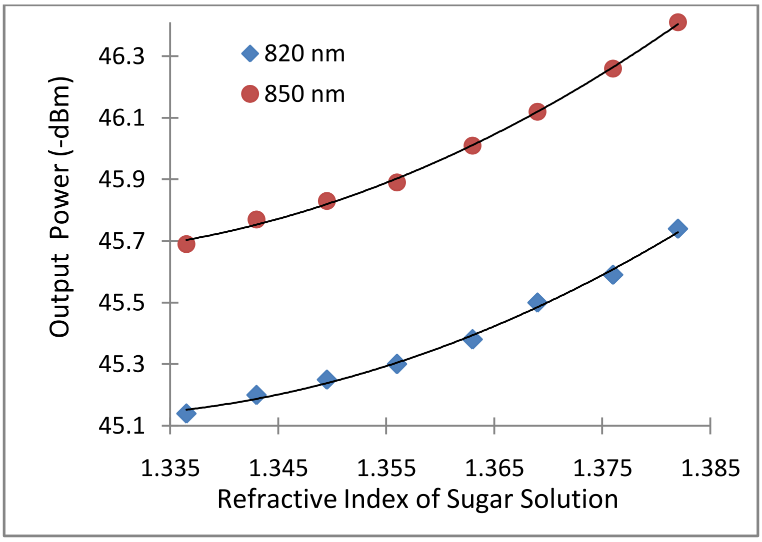


Fig.3. Graph showing variation of output power with refractive index of guiding liquid common salt solution at operating wavelengths 820nm & 850nm

Now the guiding liquid surrounding the sensing region is replaced by sugar solution. The fiber is switched onto operating wavelength of 820nm. The output power is measured at various concentrations of sugar solution prepared by dissolving 1g, 2g, 3g, 4g, 5g, 6g, 7g, and 8g of sugar in 25ml of distilled water. Now the source is switched onto operating wavelength 850nm. The experiment is repeated for all concentrations of sugar solution as guiding liquid and the output power is measured at each concentration. The relation between refractive index of sugar solutionused as guiding liquid and corresponding output power is graphically represented in figure (4).



Fig(4): Graph showing the relationship between refractive index and output power at operating wavelengths 820nm and 850nm for guiding liquid of Sugar solution

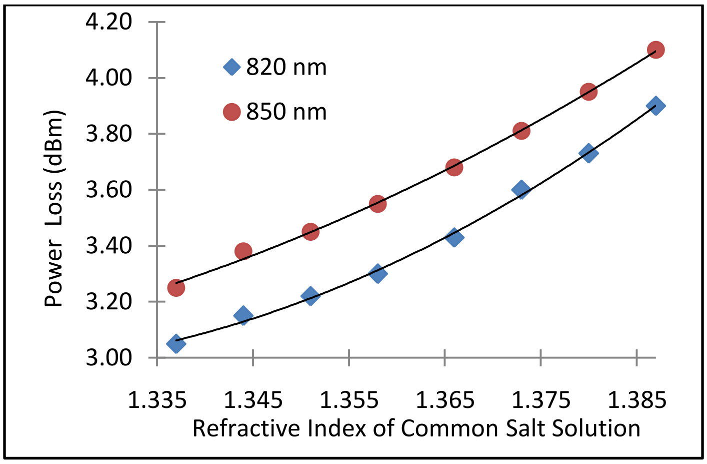
The power loss at each concentration for both the guiding liquids can be calculated using the following relation.

$$\text{Power Loss} = \left\{ \begin{array}{c} \text{Power Launched} \\ \text{in to the fiber} \end{array} \right\} - \left\{ \begin{array}{c} \text{Output Power measured at} \\ \text{the second end of the fiber} \end{array} \right\}$$

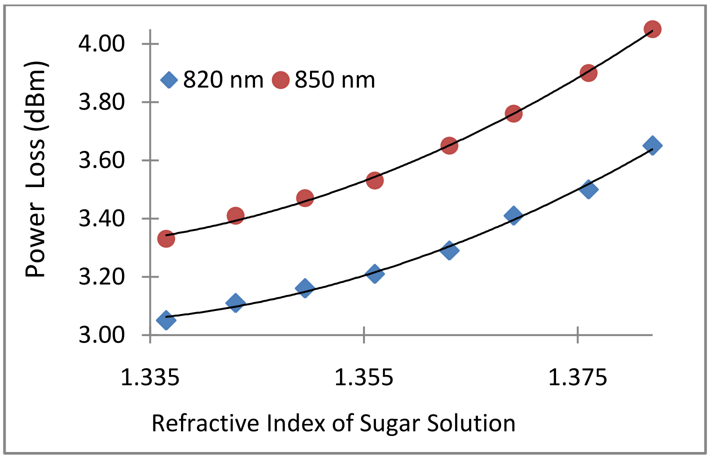
ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
Vol. 2, Issue 5, May 2013

The variation in power loss with refractive index of both the guiding liquids at operating wavelengths 820nm and 850nm are shown in figures (5) and (6).



Fig(5): Graph showing the relationship between refractive index and power loss atoperating wavelengths 820nm and 850nm for guiding liquid of common salt solution



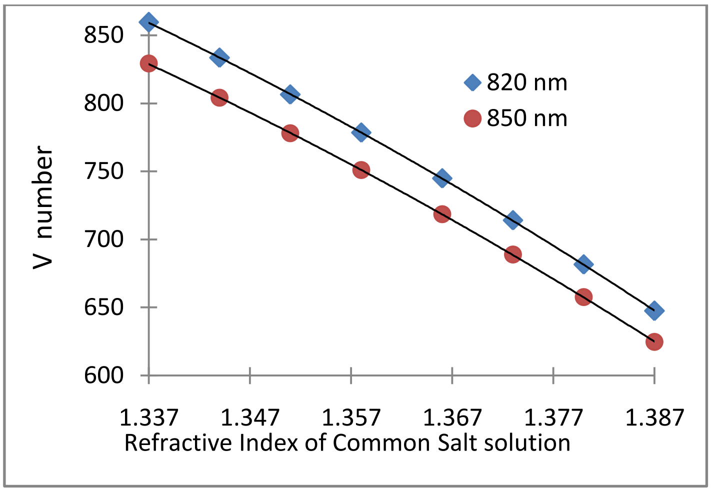
Fig(6): Graph showing the relationship between refractive index and power lossat operating wavelengths 820nm and 850nm for guiding liquid of sugar solution

The cutoff wavelength is an important parameter to understand the number of waves transmitted as guided waves in the optical fiber. This phenomenon can be represented in terms of normalized frequency 'V'. This important parameter connected with cut-off condition [13] is given by;

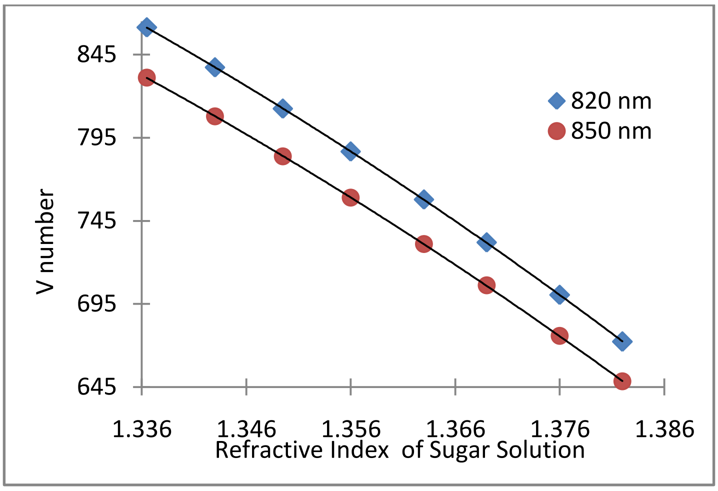
$$V = \frac{2\pi a}{\lambda} \sqrt{n_1^2 - n_2^2} \text{ .... (1)}$$

Where, a = Radius of the core
λ = Operating wavelength
n_1 = Refractive index of core
n_2 = Refractive index of cladding (guiding liquid surrounding the sensing region)

The relation between refractive index of guiding liquid and V-number is illustrated in figures (7) and (8)



Fig(7):The relation showing variation of V-number with refractive index at operating wavelengths 820nm and 850nm for guiding liquid of common salt solution



Fig(8):The relation showing variation of V-number with refractive index atoperating wavelengths 820nm and 850nm for guiding liquid of sugar solution

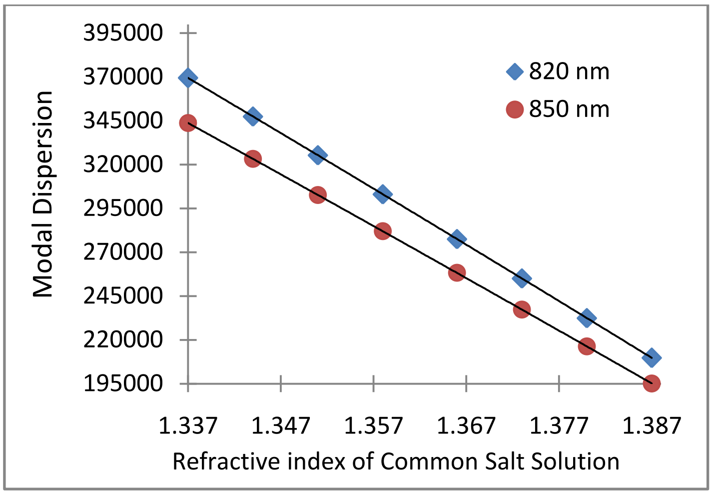
The modal dispersion of multimode step index fiber is given by

$$M = \frac{V^2}{2} = \frac{1}{2}\left(\frac{2\,\pi\,a}{\lambda}\right)^2 \sqrt{n_1^2 - n_2^2} \quad \text{............. (2)}$$

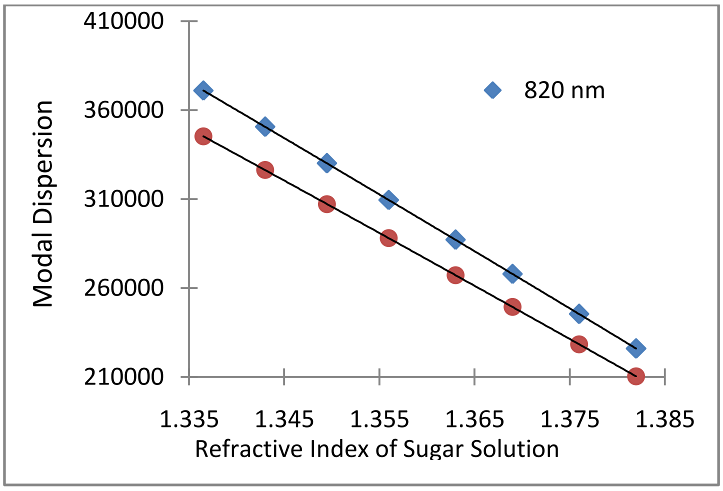
The relation between refractive index and modal dispersion at operating wavelengths 820nm and 850nm for guiding liquids common salt and sugar solutions are indicated in figures (9) and (10).

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology
Vol. 2, Issue 5, May 2013



Fig(9):The relation showing variation of Modal Dispersion with refractive index at operating wavelengths 820nm and 850nm for guiding liquid of common salt solution



Fig(10):The relation showing variation of Modal Dispersion with refractive index at operating wavelengths 820nm and 850nm for guiding liquid of sugar solution.

III. RESULTS AND DISCUSSIONS

1) From figure (1), we can understand that the refractive index of guiding liquid increases linearly with increase in the concentration of guidingliquid.
2) The guiding liquid (of refractive index n_2) surrounding the sensing region (bare core of refractive index n_1) acts as cladding. As refractive index of guiding liquid increases the output power at the second end of the fiber decreases at bothoperating wavelengths 820nm and 850nm. This can be conformed from figures (3)and (4).
3) The power loss increases with increase in refractive index of guiding liquid for both the wavelengths. This can be conformed from figures (5) and (6).
4) The power loss increases with increase in refractive index of guiding liquid for both the wavelengths. This can be conformed from figures (5) and (6).
5) For the same refractive index (sameconcentration), the output power decreases with increase in wavelength {from figures (3) and(4)} and is also it is observed that the power loss increases with wavelength {figures (5) and(6).
6) As refractive index of guiding liquid increases, the V-number decreases {figures (7) and(8)} for both the operating wavelengths.
7) As refractive index of guiding liquid increases the modal dispersion decreases for both the operating wavelengths {figures (9) and(10)}.

8) At same refractive index, as operating wavelength increases the V-number decreases {figures (7)and (8)}.We can also understand that the V-number decreases with increase of wavelength, since V is inversely proportional to λ from the relation (1).
9) At the same refractive index,as operating wavelength increases the modal dispersion decreases. It can be observed fromfigures (9) and (10). Wecan also understand that the modal dispersion decreases with increase of wavelength,since modal dispersion is inversely proportional to λ^2 from the relation (2).

REFERENCES

[1]. BCulshaw, A D Day and Y.Rhtsuka, "*Special issue on optical fiber sensors*", IEEE/OSAJ Light wave TechnolVol 13, No.7, 1995.

[2]. A.K.Ghatak, B.Culshaw, V.Nagarjan and B.D.Khurana, "*Trends in fiber optics and optical communications*", Viva Books (Pvt) Ltd. New Delhi, 1995.

[3]. T .G. Giallorenzi and S.Ezekiel, "*Special issue on optical fiber sensors optics news*", Vol. 15, No.11, 1989.

[4]. R.M. Measures and K.Lin, "Fiber Optic Sensors – Focus on Smart Systems", *IEEE Circuits A Devices Magazine* PP 37-46, 1992.

[5]. T.G.Giallorenzi, J.A.Bocaro, A.Dandridge and J.H. Cole, "Optical Fiber Sensors Challenge the Competition", *IEEE spectrum,* PP 44-49, 1986.

[6]. R.VenkateswaraRaju, T.R Annapurna, A.Jayanth Kumar, N.M.Gowri, T.Radha Krishna, B.S.Bellubbi and G.Nirmala, "Fiber Optic Temperature Sensor using a Plastic-Fiber", *J. Pure & App1.phy*.vol 17 No:3 PP 135-138, 2005.

[7]. R.VenkateswaraRaju, T.Radha Krishna, B.S. Bellubbi , N.M.Gowri , G.Nirmala, A.Jayanth Kumar, T.R Annapurna, " Fiber Optic Sensor Using a Glass-Fiber- Studies on the Sensitivity of other Sensor", *Journal of Pure and Applied Physics* , Vol 17, No.4, July-August,PP 173-175, 2005.

[8]. Sukkader Roy and R.C. Srivastava, "A simple intrinsic fiber optic intensity modulated liquid level sensor for Petrol tanks", *Proceedings of NSPTS-3,* PPC 16-16.6, India, 1996.

[9]. R.S.John, "Fiber Optic Liquid level and flow sensor Systems, *US patent*, 4, 3, 394.

[10]. S.Rama Krishna and Th.Kerston, "FaseroptischeWasser Wage, *German Patent* P 3236436, 1982.

[11]. Jayanthkumar, T.Radha Krishna, R.VenkateswaraRaju, N.M.Gowri, T.R.Annapurna, B.S.Bellubbi and G.Nirmala, "Intensity Modulated Fiber optic Sugar sensor – studies of Wavelength dependence", *J. Pure & Applied Physics*Vol 17 No.13, PP/19-122,May-June 2005.

[12]. G.Stewart and B. Culshaw, "Optical Waveguide Modeling and design for evanescent field Chemical Sensor", *Opt & Quantum electronics,* Vol 26, PP S 249-5259, 1984.

[13]. T .G. Giallorenzi et al., "Optical Fiber Sensor Technology", *IEEE Journal of Quantum Electronics,* Vol QE – 18, No. 4, PP.626-664.