Thermal Distortions of Low Frequency Signals Through Multimode Optical Fiber in Dry Salt Surroundings

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ABSTRACT

Multimode optical fiber is kept in dry common salt surrounding above room temperature. Low frequency signal (500Hz) is passed through the optical fiber using laser diode (635 nm). Temperature is raised up to 86.5^{0}C in cyclic manners. Signal at other end is analyzed using Digital Storage Oscilloscope both for its wave form and Fast Fourier Transform to study effects of applied conditions. Results were analyzed on the basis of existing theories.

Keywords: *Optical Fiber, Thermal Distortions, Laser, Low Frequency Signals.*

I. INTRODUCTION

With continuously increasing use of communication using optical fiber, it has become very important to protect the fidelity of the data to very high level. Data of X-Ray computed tomography (CT scan) sent to a doctor sitting at a faraway place has to be absolutely perfect for correct diagnostic. Even in micro CT scan, data from the camera passes through optical fiber to the CCD camera should maintain its truthiness. This data is in digital form and less likely to distort easily in normal course. However thermal fluctuations in optical fiber can generate distortions in the signal [1, 2]. This data is in digital form and less likely to distort easily in normal course. However thermal fluctuations in optical fiber can generate distortions in the signal. Most common cause of degradation of an optical fiber based circuit is it's surrounding [3]. Optical fiber has to face various chemicals and adverse temperature fluctuations in real surroundings. With aim of understanding the degradations caused by adverse surroundings, present study was planned. With continuously expanding optical fiber network and moving towards deploying the fiber links to the subscriber's home, power loading of optical fiber has increased many folds. High power propagation can lead to the thermal heating of the fiber. It can some time leads to the fiber fuse effect. [4]. Maximum power required to extinguish the optical discharge propagation is found to be near 1.39 Watt. [5]. It was also found that critical bending diameter for single mode fiber with high power signal is 20 mm. [5]. External atmosphere also plays an important in aging or deterioration of optical fiber. I was found that onset of an aging knee in moisture in some of optical fibers [6]. Study of effects of atmospheric conditions, are extremely important in medical applications [7].

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II. EXPERIMENTAL

In this study, commonly available multimode optical fiber (provided by OSAW Ambala, India) is used in the study. It is a germanium doped silica glass as core material and has polymer cladding material with black polyethylene as sheath material. Semiconductor laser diode (Fig. 1a) was employed to get laser signal (Red). Laser diode was powered by function generator (Fig.1b). Semiconductor laser diode was used because we got more stable signal. Fiber was placed on chunks (Fig.1c) to give fine adjustment and to place optical fiber without any disturbance, two chunks were employed in the task first was at the signal receiving end and second was at the end of transmission channel.

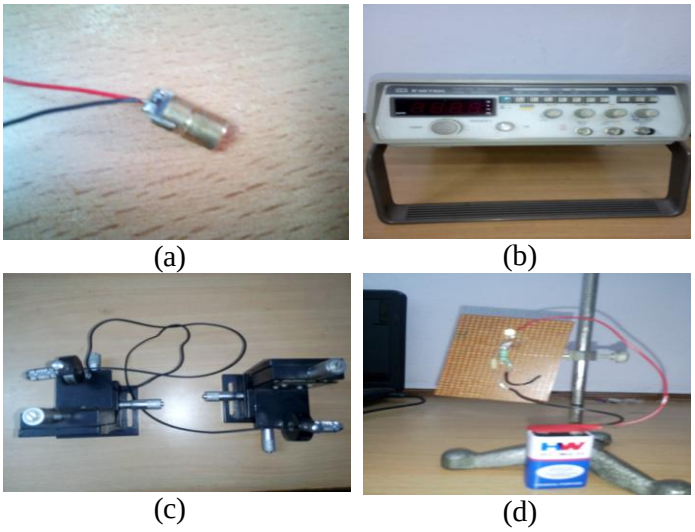

Fig. 1 (A) Laser Diode (B) Function Generator (C) Chunks (D) Detector Assembly

Square wave signal (500Hz) coming out of function generator was given to semiconductor laser diode as a power supply. As a result of it, diode starts emitting square wave of same frequency Multimode step index optical fiber was taken and fixed it on chunks to make it stable. X-Y-Z screws on the chunks helps to give movement to the optical fiber whenever required for adjustment. Optical fiber coming out of chunks was pointed towards the laser diode. It is adjusted for maximum intensity. Detector assembly was used to detect the signal from the end of transmission channel. Detector converts the light signal into electrical , phototransistor was used for this task. Optical fiber (Fig.2) is passed through an oven whose temperature is controlled by PID controller. Pure NaCl salt is kept in the surrounding. Electrical signal is recorded by Digital Storage Oscilloscope.

Fig.2 Optical Fiber Before and after Heat Treatment

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III. RESULTS AND DISCUSSIONS

Temperature of the fiber is slowly raised from room temperature to 86.4^{0}C. Then it is cooled to nearly 50^{0}C. Further it is raised to 86.4^{0}C. It is found that:

1. Amplitude of the signal decreases on heating and remains low even after cooling. This clearly shows that the damage done to the optical fiber is irreversible. (Fig.3)

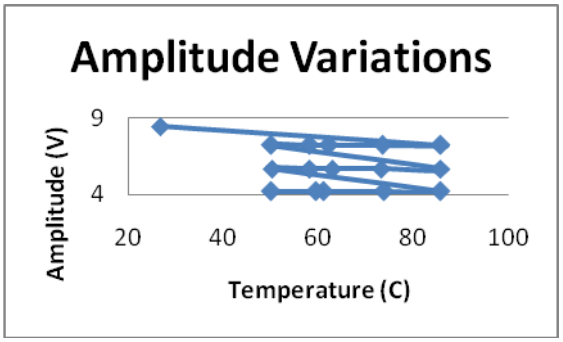

Fig. 3 Amplitude Decreases with Increase in Temperature

2. Signal Shape changes at increased temperature. However the rise time and fall time almost remains same. (Fig.4)

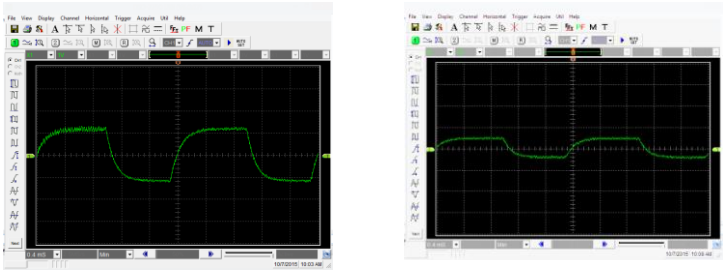

Fig: 4 Signal Shape before and after Heat Treatment (One Cycle)

3. Fast Fourier Transform is recorded for the signal. These almost remain the same, except for decrease in amplitude. This clearly indicates that the signal composition is almost unaffected by the heat treatment. (Fig.: 5)

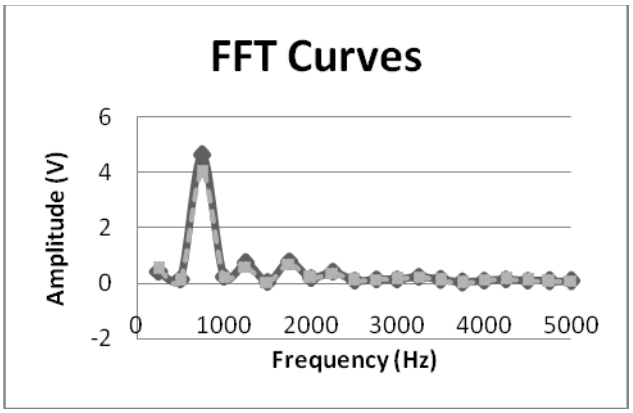

Fig. 5 Fast Fourier Transform before (Dark Line) and after (Dotted Line) Heat Treatment

4. Surface of the optical fiber shows some reaction with sodium chloride salts. When temperature is raised above 100^{0}C, it is found that sheath material soften to the extent that fiber sticks to each other.

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Optical signal propagating in step index multimode optical fiber at high temperature undergoes significant signal distortion due to following reasons.

(1) Variation of refractive index of core and cladding leads to the leakage of signal at certain bends (especially sharp bends).

(2) Uneven thermal expansion leads to the formation of micro and macro cracks in the fiber. These cracks are the sites for the internal trapping of the signal which leads to

- Additional reflection of the signal
- And time delay due to multiple reflection

According to Paulo Andre etal. [5] Damage in optical fiber coating is due to optical power loss in the bent section. This induces the temperature increase of the coating, resulting in an oxidation of the sheath layer (acrylate).

Loss in optical power from the optical fiber core is dependent on two parameters

- Power loss due to bend (α_{bend})
- Power loss due to length.

With rise in temperature refractive index of glass normally increases above 20^0C. [8]. Rise in temperature also affects the refractive index of cladding material [Fig.6]. Depending on the nature of core and cladding there may be increase or decrease in the numerical aperture of the optical fiber. However the change in refractive index of core material causes the change in dispersion of the signal. From the fast Fourier transform analysis it is quite clear that, such variations are not very effective.

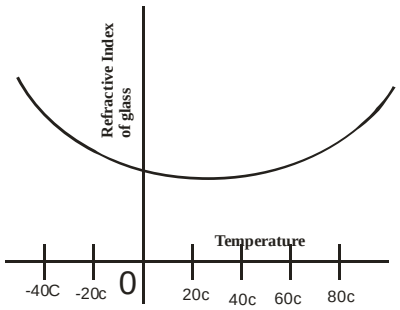

Fig.6 Variation of Refractive Index of Glass with Temperature

However, the increase in temperature is responsible for:

- Increase in number of micro-cracks [Fig.7] and
- Enlargement of existing cracks.

Both of these are responsible of signal trapping and hence responsible for decrease in signal amplitude.

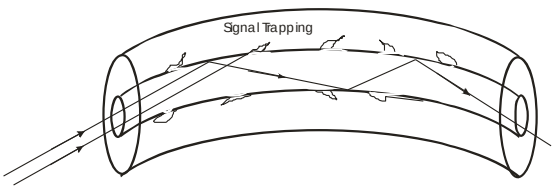

Fig. 7 Micro-Cracks are Responsible for Signal Trapping

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Creation of micro-cracks develops in fiber due to different thermal expansions of core, cladding and sheath material.

Optical fibre shows rupturing of sheath from various places after heat treatment. [Fig 2b]

IV. CONCLUSIONS

Rise of temperature of the fiber up to 85-86^{0}C attenuates the signal to 10-15%; however the composition of the signal, rise and fall time is not affected. Repeated rise of temperature creates permanent damage to the fiber.

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REFERENCES

[1] Gabriele Chiesura,Geert Luyckx, Eli Voet,Nicolas Lammens,Wim Van Paepegem, JorisDegrieck, Manuel Dierick, Luc Van Hoorebeke, Pieter Vanderniepen, Sanne Sulejmani, Camille Sonnenfeld, Thomas Geernaert and Francis Berghmans "A Micro-Computed Tomography Technique to Study Quality of Fiber Optics Embeded in Composite Materials" Sensors (Basel). 2015 May; 15(5): 10852–10871.

[2] Christopher C. Davis "Laser and Electro- optics: Fundamentals and Engineering" 2014, Isbn-0521860296, google.co.in/books

[3] "Preventive Maintenance for Fiber-Optic Connectivity" Cabling Instalation and Maintenance Magzine (1 july 2008) www. Cableinstall.com

[4] Kashyap, R and K.J.Blow (1988) "Observation of Catastrophic Self-Propelled Self-Focusing in Optical Fibers" Electronic Letters Vol 24, No. 1 pp 47-49,IssN:0013-5194.

[5] P. Andre, A. Rocha,F. Domingues and M. Facao "Thermal Effects in Optical Fiber" (2011) ISBN: 978-953-307-569-3, Intech.

[6] E.A. Lindholm, Jie Li, A.Hokansson, B Slyman and D. Burgess. "Aging Behaviour of Optical Fibers in Aqueous Environments" (2004) Proc. SPIE 5465,25-32.

[7] A.A. Stolov, B.E.Slyman,D.T.Burgess, A.S. Hokansson, J.Li and R.S.Allen. "Effects of Sterlization Methods on Key Properties of Specialty Optical Fiber Used in Medical Devices" (2013) Proc. SPIE digitallibrary.org

[8] Tie-19: "Temperature Coefficient of theRefractive Index" (2006) Page 1-12 Advance Optics Technical Information Lightmachinery.com.