ISSN (Print) : 2320 – 3765
ISSN (Online) : 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

Optical Fibers - A Boon for Power Transmission

Satyananda Sarangi

UG Student [Electrical Engineering], Dept. of EE, Indira Gandhi Institute of Technology, Sarang, Odisha, India

ABSTRACT: In the modern era of science & technology, the transmission of electric power at reduced costs has been a field of great emphasis. As a result, the alternate technology of optical power transmission has been one of the emerging forces in the present times. With hindrances from external electromagnetic fields reduced, more resistance to sparks and network short circuits, lighter than normally used metallic wires and a reduced corrosion level are some of the factors that have made optical power transmission more advantageous and reliable over conventional transmission. This review paper broadly highlights the aspects of transmission through optical fibers and new technologies involved. It gives a brief summary on the powering architectures of optically powered system and the key factors that affect the performance level. Lastly, the prospect of a new developing technology involving micro dispensing and dispensed optical fibers is mentioned. This technology facilitates the direct coupling of fibers and devices.

KEYWORDS: Powering Architectures, Wavelength Division Multiplex, Space Division Multiplex, Dispensed Optical fibers.

I. INTRODUCTION

A typical optical transmission system consists of three components: a source, a medium and a receiver. The source emits the light energy, which is transmitted through a suitable medium and finally received by the receiver. The efficiency of such a system depends largely on the converter devices' performance (which convert optical energy to electrical energy), losses incurred due to temperature effect & illumination and change in medium properties (attenuation). In the late 20th century, the basic fundamental concept of optical power was put forth by DeLoach. He proposed the working of a sound alerter, which made use of optical power- sound energy conversion principle. The process involved the conversion of optical to electrical energy by means of a photovoltaic detector and then this electrical energy was finally converted to sound energy by an electro-acoustic generator.

In this paper, the different multiplex architectures for the optical power transmission have been illustrated. A detailed analysis of the factors which affect the optical transmission system working has been done. Finally a new technology based on transmission by Dispensed Optical fibers has been discussed.

II. MULTIPLEX ARCHITECTURES

The multiplex architectures or technology enhance the capacity of channels in the optical fibers. For this purpose, generally two architectures are used namely Wavelength Division Multiplex (WDM) and Space Division Multiplex (SDM). When the source emits different frequencies, there is a need for both combining and separating these, which is done optically. For instance, Mizusawa put forward a system which involved four wavelengths. In the above system, the sources are placed facing the fiber separated by 125μm. All the sources and receivers are quadratically adjusted. Dielectric filters separate the emitted light. Similarly a duplex system by Takezawa consisted of two sources, a 830 nm source and a 660 nm source sending signals of 6 MHz and 10 kHz respectively.

WAVELENGTH DIVISION MULTIPLEX

The Wavelength Division Multiplex (WDM) is a method in which several signals are combined with laser beams at wavelengths in the infrared region of the electromagnetic spectrum. Each of the laser beams is defined by a unique set of signals.

ISSN (Print) : 2320 – 3765
ISSN (Online) : 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

The main advantage of WDM is that the effective bandwidth of the system increases by many folds .But it suffers from the disadvantage that it is very costly due to presence of multiple fibers bundled together. This cost factor is taken care of by using the erbium amplifier. Taking into consideration the system set up by Liu and his workers, a 40 mW AlGaAs laser of wavelength 820 nm and an InGaAsP laser of wavelength of 1300 nm serve as the power supplier and data transmitter respectively. Three photovoltaic cells, all made from GaAs serve as power converters. The power signal (820 nm wavelength) is supplied to a photo detector and a preamplifier, after the main signal is split into three signals with a power ratio of 2:2:1.

SPACE DIVISION MULTIPLEX

For the SDM technology, the concept of separate fibers is used. Dahlmann developed a system which supplied power and is electrically isolated. The supply voltage capacity of the system is 5V. It contained two optical fibers, one for supplying energy and the other for signals transfer. The optical power of magnitude 15 mW is fed into a 200/230 µm gradient index fiber. The measuring head contains a power converter (optical to electrical energy conversion), GaAs diodes connected in series to deliver 6 mW and a capacitor. When the voltage across the capacitor reaches 5 V value, a short impulse is send by the sensor head to initiate operation.

III. FACTORS AFFECTING THE WORKING OF SYSTEM

As discussed earlier, the net efficient working of the optical system depends primarily on its components i.e. source, medium and receiver.

Efficiency of Photovoltaic converters

The system efficiency in case of any system depends on input power and power conversion rate. In order to ensure proper functioning, an optimum input power (optical) and efficiency need to be determined. For this purpose, these converters are semiconductor devices (made up of Si, GaAs, InGaAs and GaSb). For the overall efficiency determination, the values of V_{OC} and E_G of the converter devices are taken into account.

Converter material	V_{OC} (in V)	E_G(in eV) at 27 C
Si	0.7	1.12
GaAs	1.0	1.42
InGaAs	0.5	0.74
GaSb	0.5	0.73

From various experiments conducted, the efficiencies of devices of InGaAs, GaSb and GaAs have been found to be 34%, 40% and 52% respectively.

Losses due to Temperature

Different photo diodes and devices operate in a wide range of temperatures. GaAs is less sensitive to the temperature rise. To keep a track of these losses, four temperature coefficients (I_{MP}, V_{MP}, I_{SC} and V_{OC}) are estimated to find the fill factor.

$$\text{Fill factor (FF)} = (V_{MP}*I_{MP})/ (I_{SC}*V_{OC}),$$

where fill factor is the ratio of the actual maximum power to the theoretical maximum power.
When PV cells are illuminated by higher intensities, FF shows a negative temperature dependency.

Transmission medium losses

The medium gets attenuated when the transmitters as well as the receivers are coupled with the fibers. In case of Polymer Optical Fiber, the glass transition temperature is very low which further limits the maximum power being launched in a fiber. The unideal fiber end surfaces and difference in air-fiber refractive index also contribute to the interfacial coupling losses. The attenuation can be largely summarized as Rayleigh’s diffusion, absorption and optical cladding attenuation.

ISSN (Print) : 2320 – 3765
ISSN (Online) : 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 1, January 2015

IV. DISPENSED OPTICAL FIBERS

To minimize the losses incurred in WDM and SDM, the concept of micro-dispensing is useful. As a result of which the POF can be applied to 3-dimensional devices. The main advantage of the above technology is that it is highly flexible and selective and involves a direct laser-diode coupling. A new method that has been adopted is Mode Group Diversity Multiplex (MGDM). It involves separation of various propagation angles of light in a fiber. These angles can be determined independently i.e. if they are grouped into separate modes. But MGDM is a method that is restricted only to very short distances. Once the distances become large, it is not possible to identify the groupings of the modes, thereby making the above method a failure. But nevertheless MGDM is very advantageous since Dispensed optical fibers and devices can be directly coupled.

V. CONCLUSION

In the above paper, the various conventional optical powering architectures have been discussed. The various factors affecting the system efficiency and finally the new technology of Dispensed Optical Fibers have been summarized. The transmission of power through these fibers is smoother and more reliable in comparison to transmission through metal conductors. Further research and study in this regard is being carried out.

REFERENCES

[1] Deloach, B.C., Miller, R.C., Kaufman, S., "Sound alerter powered over an optical fiber", Bell Syst. Tech. Journal, Vol. 57, pp. 3303-3316, 1978.
[2] Mizusawa, J., "Advantages of POF WDM System Design", 8th International Conference on Plastic Optical Fiber Proceedings, pp. 31-35, 1999.
[3] Takezawa, Y., Akasaka, S.-i., Ohara, S., Ishibashi, T., Asano, H., Taketani, N., "Low excess losses in a Y-branching plastic optical waveguide formed through injection molding", Appl. Optics Vol. 33, No. 12, pp. 2307-2312, 1994.
[4] Dahlmann, H., Hoferer, G., "Optische Energie- und Signalübertragung für Meßsonden. Zeitschriften-aufsatz Elektronik, München", Vol. 23, pp. 86-88, 1995.
[5] Liu, Y., Brown, J.J., Lo, D.C.W., Forrest, S.R., "Optically Powered Optical Interconnection System", IEEE Photonics Technology Letters, Vol. 1, No. 1, pp. 21-23, 1989.
[6] Krut, D., Sudharsanan, R., Isshiki, T., King, R.., Karam, N.H., "A 53% High Efficiency GaAs Vertically Integrated Multi-junction Laser Power Converter", 65th Annual Device Research Conference, pp. 123-124, 2007.
[7] Green, M.A., Emery, K., Blakers, A.W., "Silicon Solar Cells with Reduced Temperature Sensitivity", Electronic Letters, Vol. 18, No. 2, pp. 97-98, 1984.
[8] King, D.L., Kratochvil, J.A., Boyson, W.E., "Temperature Coefficients for PV Modules and Arrays: Measurement Methods, Difficulties and Results", 26th Photovoltaic Specialists Conference, pp. 1183-1186, 1997.
[9] Ziemann,O., Poisel, H., Vinogradov, J., Junger, S., Weber,N., Offenbeck,B., Tschekalinskij,W.,Weickert,B., Bauernschmitt, H., "Multi Channel Broadband Data Transmission over Thick Optical Fibers", 15th International Conference on Plastic Optical Fiber, pp. 359-366, 2006.