

Examination of Plastic Filter on 1×N Fused-Taper-Twisted Polymer Optical Fiber Demultiplexer

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Abstract: Problem statement: In this study we propose the examination of the plastic filter on 1×3 POF demultiplexer. **Approach:** Three wavelengths are injected to the device which then split into three branches. Each branch is filtered by using specific color according to the pass through wavelength. **Results:** The developed demultiplexer is tested by transmitting signals through the polymer fiber-optic (10 meters length) and the resulting signals are detected using an oscilloscope. The detected signal has an output power of 1.68V from peak to peak. **Conclusion:** From the results, it is shown that the WDM system has solved this problem by increasing the bandwidth in order to send larger data in a faster and effective way. System performance that uses the WDM concept has influenced this method especially in short-range communication systems.

Keywords: Demultiplexer, Polymer Optical Fiber (POF), fused-taper-twisted fiber, optical splitter, filter

INTRODUCTION

As telecommunication traffic increases due to the rapid growth in use of phones, faxes, computer networks and the internet, fiber capacity will have to keep pace. Instead of the huge capacity offered, fiber is also immune to the noises and ensures the signal quality assured towards the fiber end. The Wavelength Division Multiplexing (WDM) technique increases the value added and arises as a promising technology solution to realize very high capacity long distance transmission systems by exploiting the wide bandwidth available in optical fiber. Because of the dramatic increase in capacity of optical communication using WDM, there has been an increasing interest in the development of particular devices to manage a number of wavelengths. The WDM technology actually encompasses 3 sub-systems, transmitter technology, devices technology and receiver technology. Transmitter research fields demonstrate the Laser and LED, cooled and un-cooled laser, internal and external modulated. Meanwhile, various types of optical WDM devices have been proposed and demonstrated which are included fused-type fiber and waveguide-type devices, Bragg reflector and thin film technique for filtering and channel separation, EDFA and RAMAN for amplifier gain.

POF is an established medium in industrial and automobile networks due to its high reliability in even

the most rugged environments," says Hugh Hennessy, Firecomms vice president of worldwide sales and marketing. "With data rates of up to one Gigabit and assured quality of service to every device in the residence, POF is the most robust technology for 100 Mbps Optical Ethernet and 250 Mbps Optical FireWire in the home as depicted in Figure 1. These features of POF are especially advantageous for emerging IPTV implementations and other triple play services (FPR, 2008)."

Home networking application: Currently POF technology has been vastly used in small world communication including Home Networking Application. POF provides numerous advantages to home builders, installers, content providers and consumers alike. With "garden hose" connectivity, POF is quick and easy to terminate enabling it to be easily installed in the wall cavity, along baseboards, under carpet and - due to its immunity to interference - even next to electrical cabling, making its installation quicker and more flexible and cost-effective than CAT5/CAT6 (Shimada *et al.*, 2001). Because it's optical, polymer fiber is completely immune to electrical noise. That means existing copper wiring will not interfere with data passing through POF, so it can even be installed next to electrical cabling. Even other existing networks or wireless systems in the house cannot interfere with data passing through the POF cable.

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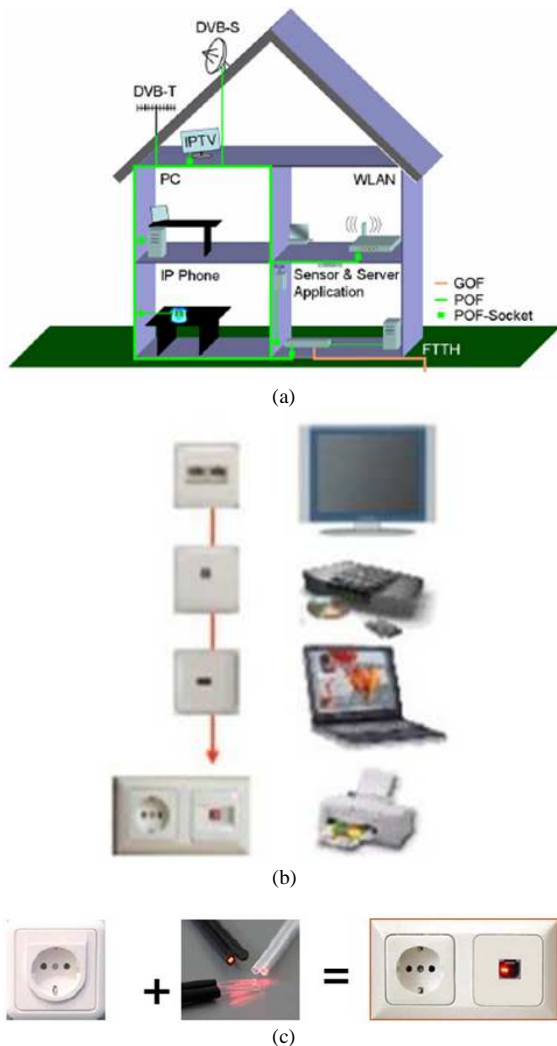


Fig. 1: POF increases the application for use in household, get rid of the bottleneck occurs between the Optical Network Unit and electronic appliances.

This is very important for multimedia data transmission, in which the quality of the signal could be negatively impacted by external noise. Troubleshooting is quick and easy as POF uses an eye-safe visible red light. In fact, it's the only interconnect technology where the signal can be seen at both ends (Im *et al.* 2002; Koonen *et al.*, 2003; Wittmann *et al.*, 1999).

The introduction of WDM technology to POF network has increased the efficiency, scalability and also survivability of POF network. The reliable and feasible mesh topology and the specifically assignment of wavelengths as the data carrier has enable the restoration scheme can be embedded to the system, such as dedicated protection and shared protection

scheme as implemented in FTTH customer access network (Ab-Rahman *et al.*, 2006a; 2006b; Ab-Rahman and Shaari, 2007). The increment of capacity with the increase of LED numbers will also expand the network and enlarge the number of users. Besides that, the data signals (e.g., MEMs sensor signal, voice, video, information) are modulated using the multi-wavelength respectively and then send to the destination through the POF devices such as splitter, wavelength selective coupler, directional coupler and ADM (Ab-Rahman *et al.*, 2011). The WDM-POF has also approved the silica-fiber based device also could be fabricated using the POF specification. The proposed WDM-POF also increased the capacity of data communication. For example, the bandwidth of one LED is about 20 MHz at rate 200 MHz, therefore if we used five LED to develop the WDM system, the transmission is expected to have five times bigger than the existing TDM based technology (Ab-Rahman *et al.*, 2012a). Nowadays POF optical device has going to concur the optical communication devices in industries. The fusion technique for device fabrication is the easiest method and environmental friendly to produce massive fabrication with various size of devices and types (Ab-Rahman *et al.*, 2009; 2010; 2012b).

Performance on transmitted signal with the presence of noise signal in fiber: This experiment uses only red and green filter film that has been injected with red and green LED in order to get the OSNR values that available in demultiplexer. Based on the graph in Fig. 2, a longer fiber length indicates the less signal value compared to shorter fibers. The presences of interference (noise) that exist in longer fibers are larger. Also, the wavelength frequency that passes through the longer fibers will also be faded (attenuation). Thus, this experiment shows the fiber length has influences the carried signal strength. A demultiplexer that has been used in this experiment will be more effectively if using a shorter fiber length.

Referring to Fig. 3 for OSNR measurement on green filter film with presence of emitted red LED signal interference, the fiber length of 1, 2 and 3 meter have higher signal strength compared to fiber length of 4 and 5 meter. These same factors also affect on the signal rate that used in OSNR which is measured on red filter film. This experiment also shows the influence of fiber length with the rate of transmitted signal strength. However, the fiber length of 5 meter can still be used to transmit signal effectively because the difference between OSNR of 1 meter fiber length does not have much different with OSNR of 5 meter fiber length

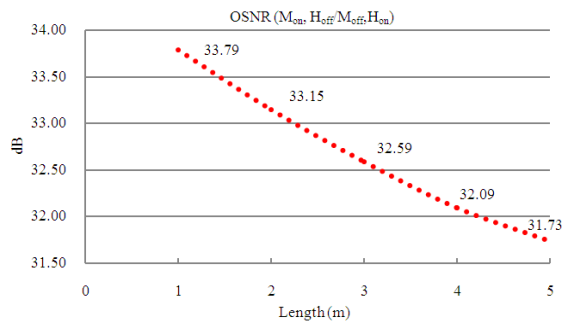


Fig. 2: OSNR that measured on red filter film with the presence of green LED signal interference

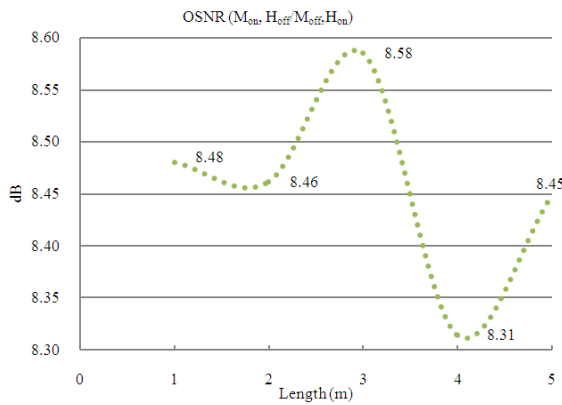
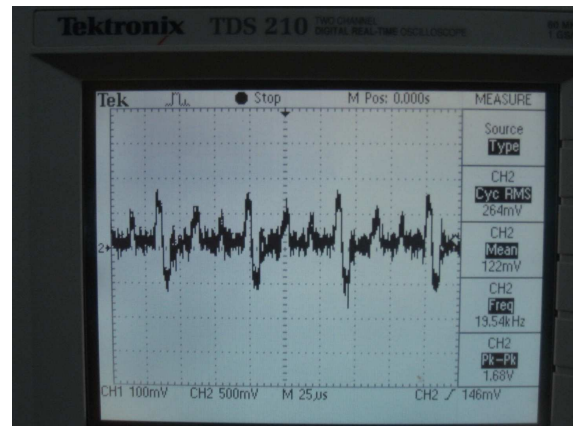


Fig. 3: OSNR that measured on green filter film with the presence of red LED signal interference

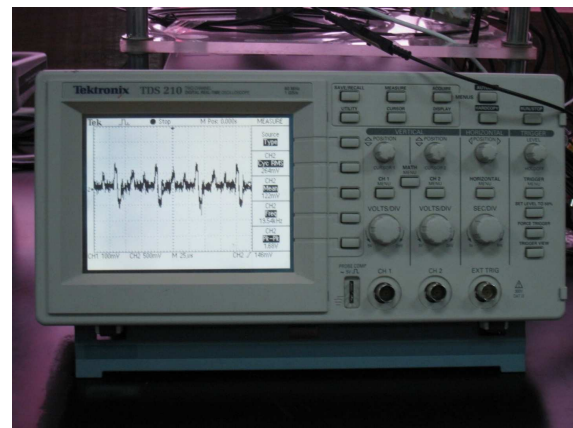
Video signal: The developed demultiplexer is tested by transmitting signals through the polymer fiber-optic (10 meters length) and the resulting signals is detected using an oscilloscope as shown in Fig. 4. The detected signal has an output power of 1.68V from peak to peak.

Conclusion and recommendation: Before the concept of WDM being applied in optical technology of communication system, a single channel (theoretically, a signal wavelength) is used for sending data over polymer optical fiber, but this technique has a limited bandwidth. Therefore, the WDM system has solved this problem by increasing the bandwidth in order to send larger data in faster and effectively way. System performance that use WDM concept has influenced this method especially in short-range communication system.

The manufacturing method of optical splitter and demultiplexer in this study is using multimode polymer optical fiber with a core diameter of 1mm. The fabrication of demultiplexer manufacturing and characterization analysis is done in order to develop a high performance of demultiplexer component for short-range data transmission.



(a)



(b)

Fig. 4: (a) Video signals that carried through green LED light source (b) Video signal is detected using an oscilloscope

From the experiment, it shows that some of transmitted signal that using different wavelength is carrying through a single fiber. The basic concept for this experiment is based on multiplex and demultiplexer concept. System that being applied in this study used three wavelength which are red ($\lambda = 650\text{nm}$), blue ($\lambda = 475\text{nm}$) and green ($\lambda = 510\text{nm}$). At the end of the system, LED light source has been multiplexed through single optical fiber and has separated by demultiplexer.

The red wavelength of 650 nm is injected through an optical fiber that has been connected to red, blue and green film demultiplexer for the characterization purpose of demultiplexer efficiency analysis, which is based on the output power that measured by power meter. Analysis showed on the efficiency of signal that has same wavelength with film filter allows the signal to pass through. This concept is fully applied in the demultiplexer construction for short-range transmission

system. The analysis shows that the effectiveness of filter film has reaches up to 70%.

The demultiplexer that has been developed by using selected filter film sample based on test and characterization analysis has shown that it is able to provide a better performance in data transmission system. Demultiplexer restoration can be made by continuous practice and experiments. Although the developed system shows that there is a loss in data transmission, an experiment to transmit data and video signal has performed in order to observe a good performance by using the spectrum analyzer.

REFERENCES

- Ab-Rahman, M.S. and S. Shaari, 2007. Survivable mesh upgraded ring in metropolitan network. J. Optical Commun., 28: 206-221. DOI: 10.1515/JOC.2007.28.3.206
- Ab-Rahman, M.S., A.A. Ehsan and S. Shaari, 2006a. Survivability in FTTH PON access network using optical cross add and drop multiplexer switch. J. Optical Commun., 27: 263-269. DOI: 10.1515/JOC.2006.27.5.263
- Ab-Rahman, M.S., A.A. Ehsan and S. Shaari, 2006b. Self-protection passive optical network using Access Control System (ACS). Proceedings of the 5th International Conference on Optical Communications and Networks and the 2nd International Symposium on Advance and Trends in Fiber Optics and Applications, (ATFPA' 06), ICOCN/ATFO 2006 China, pp: 335-341.
- Ab-Rahman, M.S., H. Guna, M.H. Harun and K. Jumari, 2009. Cost-Effective fabrication of self-made 1×12 polymer optical fiber-based optical splitters for automotive application. Am. J. Eng. Applied Sci., 2: 252-259. DOI: 10.3844/ajeassp.2009.252.259
- Ab-Rahman, M.S., H. Guna, M.H. Harun and K. Jumari, 2010. Fabrication and characterization of hand-made 1×12 splitter based on polymer optical fiber made of polymethyl methacrylate. Sains Malaysiana, 39: 459-466.
- Ab-Rahman, M.S., H. Guna, M.H. Harun and K. Jumari, 2011. Novel fused 1 × N polymer coupler for video surveillance applications. Proceedings of the Symposium on Business, Engineering and Industrial Applications, Sept. 25-28, IEEE Xplore Press, Malaysia, pp: 486-490. DOI: 10.1109/ISBEIA.2011.6088863
- Ab-Rahman, M.S., L.S. Supian, H. Guna, M.H. Harun and K. Jumari, 2012a. Performance of Thin-film as wavelength filter in WDM-POF network. Am. J. Applied Sci., 9: 180-185. DOI: 10.3844/ajassp.2012.180.185
- Ab-Rahman, M.S., Mohammad, N.N.S., Hadiguna, Harun, M.H., Sufian, L.S., 2012b. Customer-made 3×3 polymer optical fiber splitter based on green technology using fusion technique. J. Comput. Sci., 8: 591-598. DOI: 10.3844/jcssp.2012.591.598
- FPR, 2008. Firecomms and isms collaborate to deploy plastic optical fiber networking solutions in local municipalities. Firecomm Press, Room.
- Im, S.H., D.J. Suh, O.O. Park, H. Cho and J.S. Choi *et al.*, 2002. Fabrication of a graded-index polymer optical fiber preform by using a centrifugal force. Korean J. Chem. Eng., 19: 505-509. DOI: 10.1007/BF02697164
- Koonen, T., A. Ng'oma, P. Smulders, H.V.D. Boom and I.T. Monroy *et al.*, 2003 In-house networks using multimode polymer optical fiber for broadband wireless services. Phot. Netw. Comm., 5: 177-187. DOI: 10.1023/A:1022172511450
- Shimada, K., H. Sasaki and Y. Noguchi, 2001. The Home networking system based on IEEE1394 and ethernet technologies. Proceedings of the International Conference on Consumer Electronics, (ICCE' 01). IEEE Xplore Press, pp: 234-235. DOI: 10.1109/ICCE.2001.935289
- Wittman, B., M. Johnck, A. Neyer, F. Mederer and R. King *et al.*, 1999. POF-based interconnects for intracomputer applications. IEEE J. Select. Topics Quantum Elec., 5: 1243-1248. DOI: 10.1109/2944.806747