Polymer Optical Fiber (POF) for In-House-Networks using Lower Girth Transmission System

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Abstract
The Plastic Optical Fiber strives to actively promote the proliferation of Polymer Optical Fiber (POF) systems serving both data communication and non-data markets. Single mode silica optical fiber has already established as undisputable position in core telecommunication networks and has reached Tbits/s throughputs. When optical fiber approaches the user's residence, even enters his home, the costs of installing and maintain become even more important. The Use of POF will be an attractive solution for future broadband CPN. Present systems work with 650 nm sources. In This Research I have proposed the use of 520 nm InGaN LED and will show advantages and open problems. The paper will present the present status of POF systems, based on 650 nm components. The ATM Forum specifies a link with a capacity of 155 Mbps and 50 m reach. For a number of applications it would be helpful to improve this system in the direction of a longer reach and/or more system margin in the power budget.

Introduction

Optical fiber is gradually penetrating towards the end user, driven by his needs for more capacity that is fueled by appliances online fast internet application, communication and interactive services including both audio and video[1]. Single mode silica optical fiber has already established as undisputable position in core telecommunication networks and has reached Tbits/s throughputs [2]. When optical fiber approaches the user's residence, even enters his home, the costs of installing and maintain become even more important. In comparison with single mode optical fiber, Polymer Optical Fiber (POF) is much easier to handle and to install due to its large core and its ductility. Multimode polymer optical fiber (POF) has emerged as very attractive medium for easy to install in-house telecommunication networks [3]. The distinct advantages of POF over fixed wiring media such as copper cable and wireless technologies are more bandwidth and lower losses with complete signal format and protocols with QoS. However more attenuation and lower bandwidth has been observed due to higher dispersion as compared to single mode silica fiber [4].

In-house, there presently is a wide variety of networks, each optimized for transporting a particular set of services (such as CATV, voice telephony, high-speed data, etc.). The lack of a common network infrastructure hampers the introduction of new services, and the creation of mutual relations between the services [5]. Optical fibre may open the way towards such a common network. In particular, multimode fibre is attractive because it is easy to install due to its large core diameter, and it is already widely accepted for short-range data communications in broadband LANs, benefiting from low-cost transceiver modules. Moreover, multimode Polymer Optical Fibre (POF) offers large flexibility and ductility, which further reduces installation costs in often less accessible customer locations. Its attenuation per unit length is being reduced steadily, as production technology improves; presently, losses below 10 dB/km have been obtained [6].

However, the limited bandwidth of multimode fibre due to its large multimodal dispersion still complicates the integration of multiple broadband services. In this paper, mode group diversity multiplexing is proposed as an alternative approach for service multiplexing without putting high requirements on the fiber's bandwidth. Multiple groups of modes in a highly multimode fibre network are being used in parallel, in order to host independently multiple sets of services [7]. Thus in a single in-home network e.g. broadband user terminals with fixed-wire connections (such as Gigabit Ethernet) may be supported, as well as broadband wireless terminals (such as in a wireless LAN)

A high number of residential and small business users will be connected to new broadband telecommunication networks as HFC, xDSL or broadband radio/satellite in the next years. A very important requirement for the success of these new networks will be the availability of low cost, simple to use and to install, broadband In-House-Network solutions [8]. Besides the well known copper based solutions, the use of Polymer Optical Fibres (POF) can be very attractive. The advantages of POF in comparison to twisted pair copper cables are the small cable diameter, the easy installation and the immunity against electromagnetic fields [9]. The paper will present the present status of POF systems, based on 650 nm components. The ATM Forum specifies a link with a capacity of 155 Mbps and 50 m reach. For a number of applications it would be helpful to improve this system in the direction of a longer reach and/or more system margin in the power budget.

Status of POF systems using 650 nm sources

Sources for POF transmitters include LEDs, laser diodes, resonant cavity LEDs (RC-LEDs), and VCSELs. LEDs have been the main sources for POF links due to their low cost, however, recent developments in Resonant Cavity LEDs and soon to be introduced VCSELs at 650nm provide a broader mix of sources for higher speeds for systems designers. Polymer Optical Fibres based on PMMA with step index profile offers the possibility of transmitting data rates in the order or some 100 Mbps over distances up to 100 m [10]. The attenuation minima of these fibres arc at 520 nm, 580 nm and 650 nm. Due to the large core diameter and high Numerical Aperture (NA), low cost LED can be used for POF systems. Red LED based on AlInGaP or AlGaAs are well established for a number of applications. In spite of the higher POF attenuation at 650 nm in comparison to the other two minima, the availability of high efficient and high bandwidth low cost LED leads to the nearly exclusive use of these red sources for commercial POF systems.

The ATM Forum (ATMF) /1/ has specified a link using Low-NA-POF with a data rate of 155 Mbps and 50 m reach. The maximum fibre attenuation at room temperature is 156 dB/km, yielding a link loss of 7,s dB. Limited by eye safety requirements, the source optical output power should not exceed -2 dBm. Taking into account ageing, manufacturing tolerances and, first of all, the temperature dependence of the sources, the guaranteed source power is -8 dBm. Besides the pure fibre loss, the ATMF specification taking into account additional loss by climatic conditions (0,8 dB for +70°C and 95% Relative Humidity), source spectral properties (3,4 dB for 40 nm spectral width and 10 nm centre wavelength deviation) coupling loss by source NA (0,s dB for NA=0,3) and static fibre bends (0,s dB for 15 bends with 90" and 25 mm radius). Furthermore, two connections with each 2,0 dB loss are permitted. All these values cause a maximum possible link loss of 17 dB. With a specified receiver sensitivity of -25 dBm, there is no additional power margin for worst case conditions. In spite of the fact, that most of the applications will not reach all worst case parameters at the same time, one should have some margin e.g. in order to avoid problems due to not perfect installations. Furthermore, a number of specifications for LAN and In-House-Wiring include the requirement of minimum 100 m reach[11]. If it would be possible to fulfill this requirement with POF, more application can be covered with this technology. The next chapters will describe which of the loss portions can be significantly reduced using new InGaN based green LED.

Advantages of 520 nm sources

The attenuation of PMMA based POF in the first two attenuation windows with values below 100 dB/km is significant smaller that at the third window. Unfortunately the typically used LED in this wavelength regions, based on materials like Gap, GaAsP or AlInGaP are less efficient and have small modulation bandwidths in comparison to red LED.

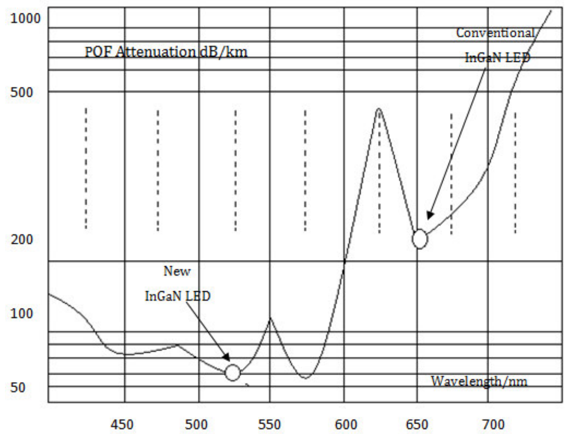


Fig 1

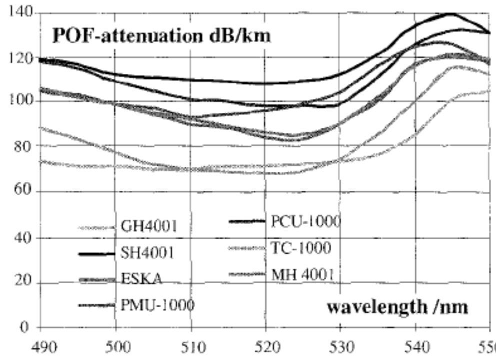
In the last few years a new class of LED in the blue anti green wavelength region based on GaN or InGaN was developed . These LED connect very high Efficiency with high modulation bandwidth, long life time and small temperature dependence. The use of GaN-LED for POF transmission systems with bidirectional WDM was described.

We propose to use new LED based on InGaN in the 520 nm window as an alternative to the existing ATMF specification. As can be seen in fig. I, the attenuation of POF at 520 nm wavelength is smaller than in the 650 nm window. Some of the present available POF have attenuation values between 70 dB/km and 90 dBlkm. Allowing the same link loss, nearly twice the reach of 650 nm systems is possible.

Loss by source spectrum

The POF attenuation increases fast with deviations from the minimum value at 650 nm. Due
to the relative broad source spectrum (typical 25 nm to 30 nm FWHM) and deviations from the centre wavelength with temperature changes and manufacturing tolerances. The effective loss of the link can be much higher than the theoretical value.

Fig. 2: Attenuation of different POF around 520 nm



In comparison to the red window, the attenuation window at 520 nm is less steep. Assuming comparable source spectrum parameters (40 nm FWHM and t10 nm centre wavelength deviation) the additional loss for a 100 m POF link is only 0,8 dB in comparison to the 3,4 dB excess loss for a 50 m POF link using 650 nm LED.

Temperature dependence of different LED

The fig. 3 shows a comparison of the temperature dependence of red, yellow and green LED (according to the POF windows) 121. As can be seen, the optical output power of InGaN LED varies with temperature considerable less, than those of the other LED types. If the source power is limited by eye safety aspects, the guaranteed power for the whole range of environmental conditions is much higher for the green as for the red source.

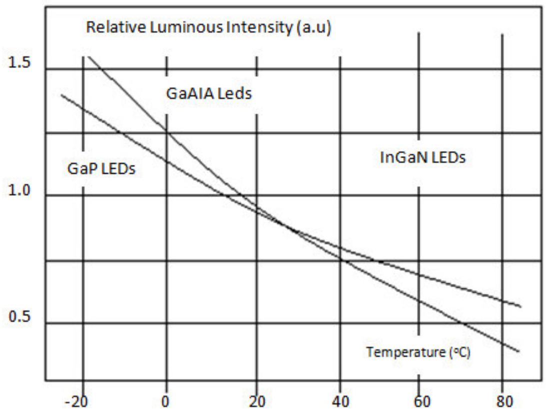


Fig 3

Comparison of power budgets at 650 nm and 520 nm

In fig. 4, the proposed power budget for a 520 nm based system, compared to the calculation according to the present ATMF specification, is shown. The paper will describe the different values of this proposal. The most important advantages of the use of 520nm sources are the smaller POF attenuation in comparison to the 650 nm window, the smaller attenuation increment besides these window and the considerable smaller temperature dependence of the optical output power of GaN LED .

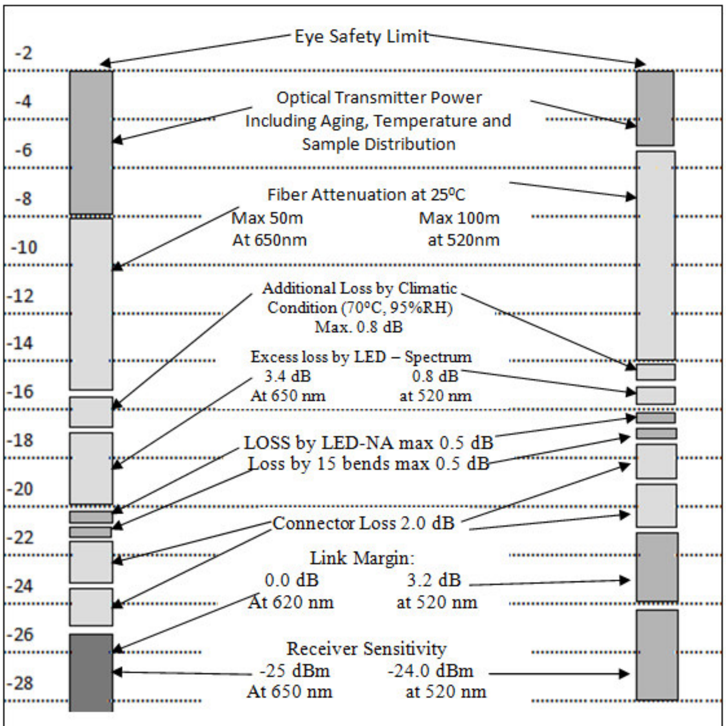


Fig. 4

We have shown in first experiments that the possible modulation speed of InGaN LED can reach or exceed the speed of the conventional red LED.

Conclusion

This research article have shown that conventional POF transmission systems, as has been specified in the ATM Forum can be improved significant by using new 520 nm wavelength InGaN-LED instead of 650nm LED. After comparing most of the key features and after thorough analysis I came up with a result that using 520nm wavelength is better than 650nm wavelength in current transmission system when using Polymer Optical Fiber (POF) for In-House Networks. The reach can be increased to 100 m, and an additional power budget margin of about 3 dB is possible.

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