COST-EFFICIENT WDM QAM TRANSMISSION OF 100 Mbit/s OVER 100m 1mm CORE DIAMETER POLYMER OPTICAL FIBER

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Abstract

By transporting the I- and Q-baseband QAM components using two inexpensive 460nm and 520nm wavelength LEDs, 100Mbit/s transmission over 100m large core SI PMMA POF has been realized.

Introduction

The 1mm core PMMA Step-Index Polymer Optical Fiber (SI-POF) is a very interesting medium for high capacity in-building and in-home networks. It is very attractive due to its large core and its ductility, which ease installation. It is much thinner than the copper UTP cable and could be installed in the same duct as power lines, thus reducing installation costs, benefiting from its immunity for EMI. Glass optical fibre has very small core diameters which make installation, connectorizing and splicing expensive. However, the transmission bandwidth of POF is very limited because of this large core diameter. The -3dB bandwidth for 1mm SI-POF over 100m is just 30.5 MHz [1]. Therefore, multi-level modulation schemes are considered to achieve high-speed transmission.

Since QAM technology has been already widely deployed in wireless LAN standards, such as the IEEE 802.11 x families, in digital video broadcast systems on coaxial cable networks (DVB-C), and for fast internet in cable modem systems such as DOCSIS, low cost chip-sets are already available. Thus, for our bandwidth-limited 1mm core SI-POF link, QAM is considered to be the best option, by combining two advantages: its high bandwidth efficiency, and its low chip set costs.

QAM system implementation

Wavelength-sliced emulated QAM (WS-QAM) [2] for the 1mm SI-POF system is proposed since it is very bandwidth efficient. With this principle, I and Q signals are transported both in baseband, on separate wavelengths. Two LEDs with different central wavelengths are used, and their data signals are combined using a wavelength slicing multiplexer and transported via the 1mm core POF. At the receiver side, the optical signal is demultiplexed into the two signals with different wavelengths and they are detected separately to recover the two branches of the QAM baseband signals. This implementation requires the least bandwidth of the POF link, namely about 0.7 R / N, where the data rate is R and a QAM-2^N scheme is used.

Experimental setup

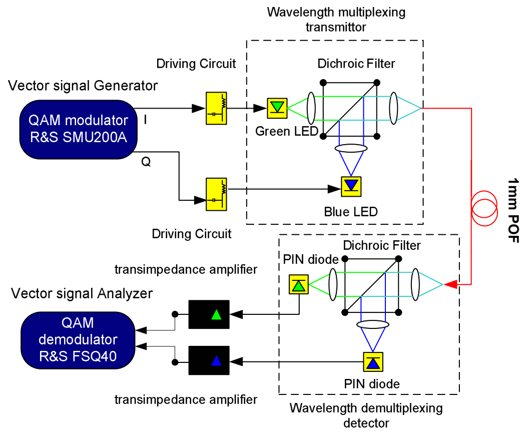

Figure 1: The setup of the WDM-QAM system

Figure 1 shows a laboratory setup to demonstrate the feasibility of this approach. The 16-QAM baseband I and Q signals from a Vector Signal Generator (VSG) directly modulate the two different optical sources; a green LED with 520nm central wavelength and a blue LED with 460nm wavelength. These wavelengths are chosen as PMMA POF has the lowest attenuation there [3]. The wavelength multiplexing is done with bulk optics. The two optical signals are launched from the pigtails of the LEDs using simple and cheap plano-convex lenses, which make parallel beams. Using a single-edge dichroic filter at a 45° angle, the optical signal of the green LED is passed through, while the blue beam is reflected at a 45° angle and superposed with the passed green beam. The edge wavelength of the filter is 495 nm, just between the wavelengths of the LEDs. Because of this pre-filtering, the overlap of the optical spectra for the 460 and 520nm LEDs is minimized in order to decrease crosstalk. Then the combined signal is focused onto the 100m SI-POF link also by a plano-convex lens. At the receiver side, the WDM optical signal is demultiplexed by a second single-edge dichroic filter at a 45° angle. The green beam (>495nm) passes the filter and is focused on a PIN photodiode. The blue beam (<495nm) is reflected and focused on another PIN photodiode. Transimpedance amplifiers are deployed after the photodiodes and their outputs are fed to a Vector Signal Analyzer (VSA) for assessment of the signal quality.

Experimental Results

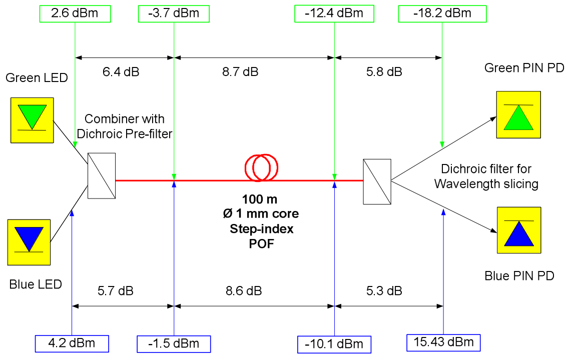

Figure 2: The link budget of the system

In Figure 2 the optical powers at various places in the system are shown. The power provided by the green LED is 2.6 dBm, which is smaller than the power of the blue LED, which is 4.2 dBm. The losses of the optical multiplexer in the transmitter and demultiplexer in the receiver are both more than 5 dB for each wavelength. These losses are mainly caused by the use of simple plano-convex lenses with relative large spherical aberrations. Other lens types with lower aberrations, such as aspherical ones, are now tried to lower these losses.

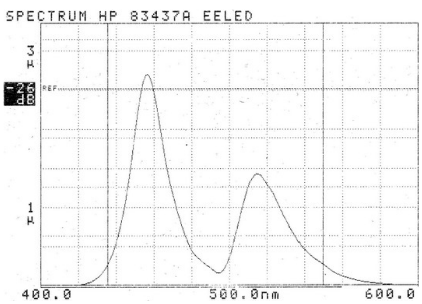

Figure 3: The spectrum before slicing

In this WDM-QAM system, it is important that the two WDM channels have the same transmission characteristics. The optical spectrum of the combined two optical signals has been measured and is shown in Figure 3. As can be seen, the green (520nm) channel has a much lower optical power so the electrical signal at the output of the blue receiver was attenuated to achieve balanced detection. Due to the well performing optical filters, the optical crosstalk from the green channel in the blue channel was -12.7 dB and only -13 dB from the green in blue channel. To indicate the performance of the whole WDM-QAM system, the Error Vector Magnitude (EVM) in percentage is measured versus the Baud rate in the case of back-to-back, over 50 m and over 100 m 1mm core diameter SI-POF for 16-QAM. The EVM is increasing only very little, when the symbol rate increases as can be seen in Figure 4.

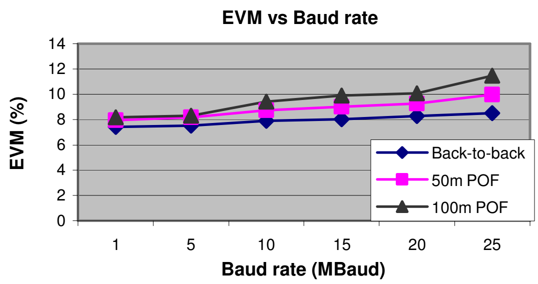

Figure 4: EVM vs Baud rate over different fiber lengths

In Figure 5, the measured constellation map is shown in case of a Baud rate of 25 MBaud and 16-QAM modulation format achieving 100Mbit/s over 100m POF with an Error Vector Magnitude, EVM=11.4%. So the transmission can be error-free if some forward error correction is added to the system [4].

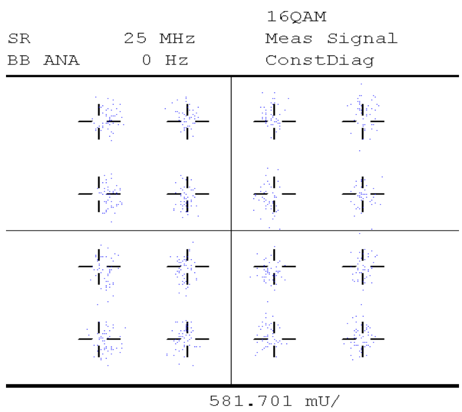

Figure 5: The constellation map for 16-QAM, 25 MBaud over 100m SI-POF

Acknowledgement

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Conclusions

The feasibility of transmitting the I and the Q channel of a 16-QAM signal with two different wavelengths achieving 100Mbit/s over 100m, 1mm core diameter SI-POF has been demonstrated. 460nm (blue) and 520nm (green) wavelength channels have been used because of the low attenuation of the PMMA POF. The crosstalk between the green and blue channels did not noticeably degrade the system performance.

References

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