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Characterisation of Millimetre Wave Multimode Radio-Over-Fibre Systems

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Abstract: Millimetre wave radio-over-fibre links using both singlemode and multimode fibres are demonstrated over a 0-50GHz bandwidth operating at 1550nm. Results show that good link gain can be achieved with both single mode and multimode detectors.
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OCIS codes: (060.2270) Fiber characterization; (350.4010) Microwaves

1. Introduction

Recently there has been much interest in high speed in-building/campus wide Radio-Over-Fibre (RoF) links at millimetre-wave (mm-wave) frequencies because at higher frequencies (> 30GHz) and especially at 60GHz they offer large baseband bandwidths, which can be utilized to transmit large amounts of data for multimedia/VoIP based applications and data storage [1]. Optical fibres are emerging as an ideal medium for the distribution of mm-wave signals due to their low loss, low cost, large bandwidth, and immunity to electromagnetic interference characteristics. Singlemode fibres (SMFs) are usually selected for long distance and high data rate RoF transmission systems but currently multimode fibres (MMFs) are also attracting much attention. According to the ISO/IEC 802.11 standard the majority of installed in-building legacy links of fibre (about 85-90%) consists of 62.5/125 µm multimode fibre [2] with typical link lengths of 300m–500m. If this MMF fibre base could be reused for the transmission of mm-wave RoF links, it could save huge fibre installation costs and allow a new generation of mm-wave communication systems to be developed. Recently, results have been shown for QPSK data transmission upto 18GHz for 500m and 5Km ranges of MMF [2] and a maximum of 25GHz for 575m and 1000m of MMF [3]. It is interesting to postulate what is the maximum frequency to which these links can be extended. This paper seeks to extend the measurement region further into the mm-wave band and results show good transmission properties upto 50GHz. An important factor in these MMF based links is the impact of using single mode or multimode detectors, since high speed multimode detectors operating at 60GHz are not readily available and are likely to be high cost components. This paper compares, for what is believed to be the first time, the performance of a 1550nm based link using both single mode and multimode detectors up to 50GHz.

2. Link Measurement Setup

In this setup, an Agilent 81682A CW-tuneable laser is used as a 1550nm light source. The 1550nm signal is fed into

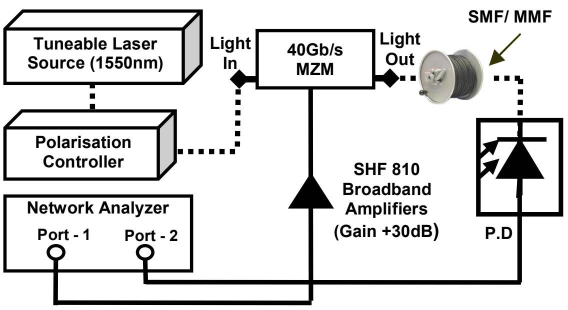

Figure 1. Setup diagram of the External Modulator based 50GHz link

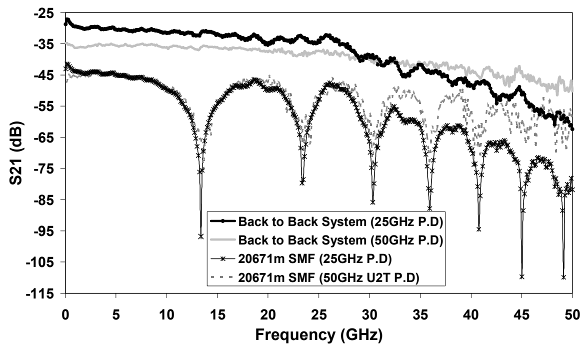

Figure 2. Shows the Back to Back System link gain with 25GHz multimode and 50GHz singlemode P.D and 20Km SMF results for both 25GHz and 50GHz P.D

a polarization controller and then into a Corning 40Gb/s Mach-Zehnder modulator (MZM). At the receiving end both single mode U^2T Photonics 50GHz Photodetector (XPDV-2020R) and New Focus 25GHz multimode

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Photodetector (Model -1434) were used to detect the optical signal. An Agilent E8364A Vector Network Analyser (VNA) is used to apply the RF modulation at the mm-wave frequency range. Port 1 of the VNA is connected to the SHF 810 broadband amplifier which is used to drive the MZM which has a bias voltage of 3.11V which is close to $V_\pi/2$ [4] (V_π=5.5V) and port 2 of the VNA is connected to the photodiode.

3. Link Gain Results

Figure 2 above shows the measured system link gain for the back-to-back system which is a function of modulator slope efficiency, input optical power and photodiode responsivity. It can be seen that the back-to-back system performance rolls off up to 50GHz, but the level is sufficiently above the VNA noise floor to take accurate measurements of the effect of fibres inserted into the link. The other two lines show 20-Km SMF response with both 50GHz singlemode and 25GHz multimode P.D. The first point to note is the drop in the low frequency link gain, this is largely due to the 4-5dB of optical loss being introduced by the fibre and RF loss will be twice the optical loss. The second important feature is the large dip in the link gain observed around 13GHz. This is the sideband cancellation effect which is dependent on the modulation frequency, the fibre dispersion parameter, and the fibre transmission length. Thus, if one of these dips coincides with the mm-wave carrier frequency the system would no longer function. Figure 3 below shows the results of back-to-back system and different lengths of MMFs using 50GHz singlemode U^2T PD. These results show the strikingly different performance obtained for MMF as opposed to SMF. Since the length is much shorter, the optical loss will be less and thus there is only a few dB drop at low modulation frequencies. The major difference is the lack of a large cancellation dip due to the strongly multimode nature of the propagation.

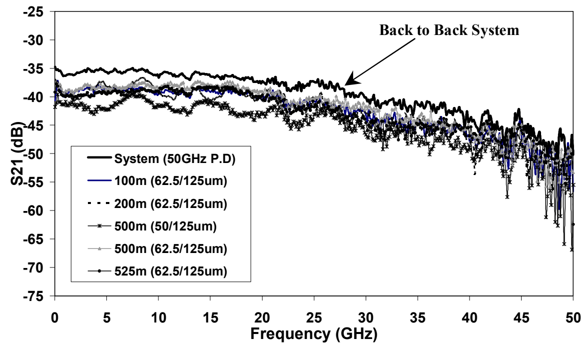

Figure 3. Shows the Back to Back System with different lengths of MMFs using 50GHz U^2T singlemode P.D

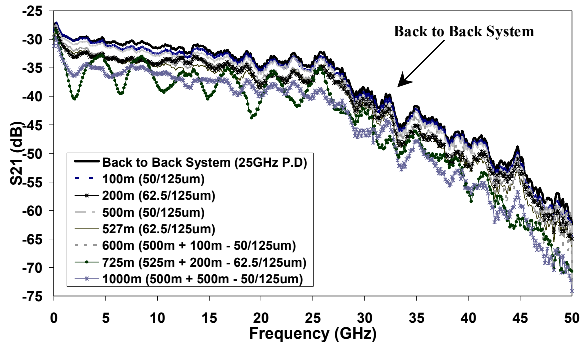

Figure 4. Shows the Back to Back System with different lengths of MMFs using 25GHz multimode P.D

To observe the complete multimode nature of the MMFs, a 25GHz multimode PD was then used. Figure 4 shows the results for 100m to 1000m lengths of MMF. It can be seen that very similar performance to the case of a single mode detector is obtained. These results suggest that high speed multimode detectors may not be required in mm-wave systems operating over MMF.

4. Conclusion

This paper has shown what are believed to be the first characterization results for standard MMF operating in a radio-over-fibre link up to 50GHz using both single mode and multimode photodiodes. The multimode nature of the fibre means that there are large passband regions which could potentially be used as part of a mm-wave communications system. Sub-carrier modulation techniques will now be used to up-convert standard baseband data streams for transmission over these links to assess whether they are feasible for mm-wave applications.

5. References

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