Broadband 60GHz Wireless Radio-over-Fibre System for up to 12.5Gb/s Wireless Transmission

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Abstract – We investigate a 60GHz radio-over-fibre system for wireless transmission up to 12.5Gb/s and 20m wireless path length. This data rate is sufficient for bridging 10Gb/s Ethernet with 8/10- and 64/66-coding.

Introduction – The ever rising bandwidth requirement has lead to the introduction of higher standards like the IEEE 802.3ae standard for 10Gb/s Ethernet (10GbE). This standard needs gross data rates of up to 10.3125Gb/s (64/66-coding) and 12.5Gb/s (8/10-coding), which can be achieved wireline, but up to now no wireless transmission system has yet achieved such a high data rate over relevant distances. Typically, multilevel modulation schemes are applied in wireless communications for achieving high data rates. Another practical approach is to rise the carrier frequency into the millimetre-wave (mm-wave) band (e.g. 60GHz) with more available bandwidth and to use a simplified modulation scheme [1]-[3]. Currently, research within the field of 60GHz wireless communication is centered on short-range in-door WPAN applications (IEEE 802.15.3c) because of the high gaseous losses at 60GHz [4]. Therefore, other mm-wave bands offering lower atmospheric gaseous losses such as the E- and F-band are strongly discussed. However, the potential of 60GHz medium-range broadband wireless transmission has not been fully exploited yet. Due to the rising interest in 60GHz technology (mostly for WPAN), more components are available. Furthermore, 60GHz CMOS technology predicts drastically cost reductions. Considering this, scenarios using 60GHz also for medium-range wireless transmission of broadband signals such as 10GbE can be justified. Applications scenarios for such wireless transmission systems are wireless local area network (WLAN) extensions, enterprise campus connectivity or wireless storage area networks (WSAN). In this paper, a 60GHz radio-over-fibre (RoF) wireless photonic system is investigated. At first, we discuss the realised setup incorporating advanced mm-wave photonic devices and RoF techniques for generation, amplification and transmission of broadband modulated data signals at 60GHz. Further on, we present our experimental results achieved by a field trial with wireless transmission of 20m.

60GHz Photonic Wireless Link System for Multi-Gigabit Transmission – The system configuration of the constructed radio-over-fibre is shown in Fig. 1. The basic parts of the system are the 60GHz optical carrier generation which is followed by a broadband data modulation, a wireless RoF transmitter and a wireless heterodyne receiver.

Fig. 1. Schematic of the constructed 60GHz wireless RoF system comprising optical 60GHz carrier generation, broadband data modulation, wireless RoF transmitter and wireless heterodyne receiver.
For optical 60GHz generation, an external cavity laser with a wavelength of $\lambda_0=1.55\mu m$ is amplified by an erbium-doped fibre amplifier (EDFA) and further modulated by a Mach-Zehnder modulator (MZM-A) in single-drive mode at a frequency of $f_{LO}/2=30GHz$. The modulator bias is set to $V_\pi$ generating an optical double-sideband signal with carrier suppression. The optical mm-wave signal is coupled to a subsequent Mach-Zehnder modulator (MZM-B) which is biased to the quadrature point and modulated by non-return to zero on-off-keying data (NRZOOK). For our experiments, we used a pseudo-random binary sequence with a word length of $2^{31}-1$ and a data rate of up to $12.5Gb/s$. The data-modulated signal is amplified by an EDFA, optical band-pass filtered to remove amplified spontaneous emission (ASE) noise and coupled to an optical attenuator for controlling the optical power and thus the later generated electrical signal power. After fibre-optic transmission via 50m standard single mode fibre (SMF), the signal is o/e-converted by a 70GHz photodetector. Before wireless transmission with a 20dBi gain horn antenna, an amplifier is implemented to enhance the RF power level up to $+11dBm$ and thus to extend the covered wireless path length. The signal is received by an identical 20dBi horn antenna and amplified by a low noise amplifier (LNA). Further on, the received signal is down-converted to base band using a low-loss custom design balanced mixer. Finally, the base band data is amplified to perform bit error rate (BER) measurements.

**Experimental Results** – We performed medium-range out-door experiments with data rates of $10.3125Gb/s$ (gross rate for 64/66-coded 10GbE) and $12.5Gb/s$ (gross rate for 8/10-coded 10GbE). Fig. 2 shows BER characteristics after 20m wireless transmission. From this results, a sensitivity of $-46dBm$ for error-free 10.3125Gb/s transmission (BER<$10^{-9}$) is observed. The system even achieved 12.5Gb/s wireless transmission over 20m.

![Fig. 2. Measured BER levels after 20m wireless transmission for 10.3125Gb/s and 12.5Gb/s wireless transmission.](image)

**Conclusion & Further Work** – In this paper, a 60GHz RoF system achieving 20m wireless transmission up to 12.5Gb/s was presented, which is suitable for bridging 10GbE links. We furthermore plan to also report on ongoing broadband wireless transmission experiments over larger wireless distances at the workshop.

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**References**


