PENALTY FREE SIMULTANEOUS 1 GBIT/S DIGITAL AND GSM-1800 RADIO SIGNAL TRANSMISSION OVER 600 M MULTIMODE FIBRE USING 850 NM VCSEL SOURCES

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Abstract - The paper presents first results on simultaneous 1 Gbit/s data and GSM-1800 radio signal transmission over 600 m of multimode fibre using low-cost Gigabit Ethernet components operating at 850 nm.

Keywords – Fibre radio, VCSEL, GSM, Gigabit Ethernet, Multimode Fibre, BER.

I. INTRODUCTION

Ethernet is the world's most successful network technology. In its latest version, the Gigabit Ethernet [1], fibre is essential for transmission lengths over 100 m. Ethernet technology is used for data networks in buildings or groups of buildings and more recently its possible usage has been extended to fibre to the home (FTTH) transmission [2].

The world's most widely used mobile radio system is GSM (Global System for Mobile Communications). Dedicated in-building coverage for GSM, e.g. in shopping malls and corporate office blocks, is gaining in importance and traffic for many wireless operators. Current indoor installations are mainly based on distributed antenna systems where the remote antennas, distributed within the building, are fed from a centralised base station location.

Combining the two transmission technologies by using the same transceivers and transmission media will enable new ways for combined services and coverage. The main purpose of our experiment is to demonstrate the possible usage of standard Gigabit Ethernet short wavelength (1000Base-SX) components [1] for radio transmission, e.g. GSM-1800. Standard low-cost components are used for the experiment.

We believe these are the first results showing the simultaneous transmission of digital 1 Gbit/s data and radio GSM-1800 signal over multimode fibre (MMF) with length up to 600 m using 850 nm VCSEL (Vertical Cavity Surface Emitting Laser) sources.

II. EXPERIMENT

In the experimental setup, Figure 1, a low-cost commercially available uncooled 850 nm VCSEL (MITEL 1A448 SC-2A) and PIN photodiode with preamplifier (MITEL 8C478 SC-2A) are used. These components are designed for Gigabit Ethernet applications. The MMF length is 600 m in order to comply with the minimum range requirements in the 1000Base-SX Gigabit Ethernet recommendation [1]. The MMF is Corning's InfiniCor 600 multimode 50/125 µm fibre designed for Gigabit Ethernet transmission (600 m at 850 nm using laser sources).

The 1 Gbit/s non-return-to-zero pseudorandom bit sequence signal, PRBS = $2^{23} - 1$, (Anritsu MP 1604B), and the GSM radio signal operating at 1800 MHz (Ericsson RBS 2202) are combined using a 6 dB power combiner operating from DC to 2 GHz. The bias current of 10 mA (transmitter output power –10 dBm) and the combined digital (Vpp = 0.3 V) and radio signal (Vpp = 0.4 V) are fed to the VCSEL using a bias tee.

After transmission through the fibre the signals are split into a digital and radio path. The bit error rate (BER) of the digital signal was measured after low pass filtering and amplification using a bit error test set (Anritsu MP 1605B). The data transmission speed of 1 Gbit/s was chosen as the available low pass filters had a cut-off frequency of about 1 GHz. At the transmitter site it was necessary to limit the output spectrum of the digital signal to enter the GSM band, and at the receiver site to limit the GSM signal to enter the broadband receiver of the digital bit error test set.

The BER of the radio signal was measured with an Ericsson test mobile station (TEMS) for GSM. The circulator separated the radio downlink and uplink path. The remote antenna would be normally connected to the circulator output as indicated in the figure.

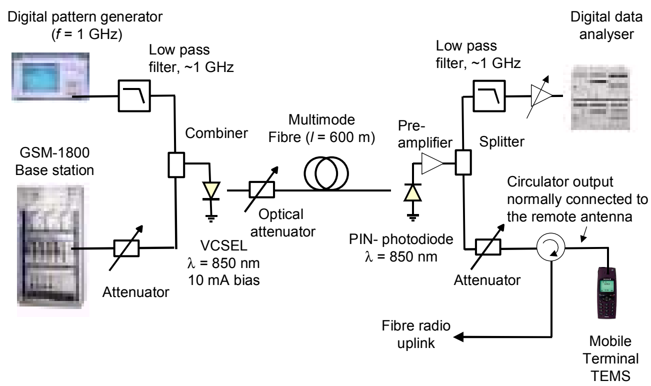

Fig. 1. Experimental setup.

III. RESULTS AND DISCUSSIONS

The BER of the 1 Gbit/s digital signal versus optical received power is shown in Figure 2. The optical attenuator after the laser was used to reduce and balance the received power. The results are shown for the fibre back-to-back case (~7 m MMF) with the GSM signal switched off and switched on, and for the 600 m MMF with the GSM signal switched on. No penalty could be observed for the simultaneous digital and radio signal transmission. Indeed the measured BER for the 600 m MMF with simultaneous radio transmission showed slightly better receiver sensitivity than the back-to-back cases. This difference could also be observed by repeating the measurements. One reason for this observation may be the restricted laser launch condition used in the experiment, as equilibrium mode distribution may be not reached over such a short fibre length. The achieved receiver sensitivity is ~ –15.5 dBm for a BER of 10^{-11}.

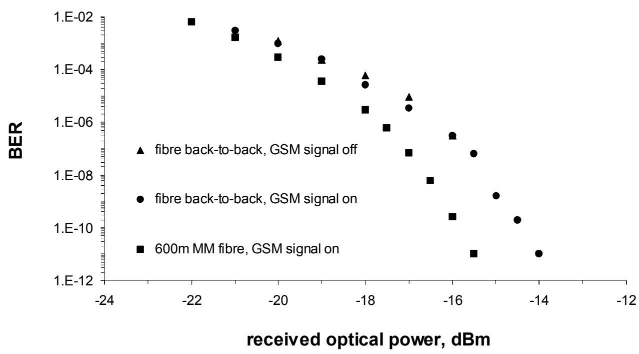

Fig. 2. BER for 1 Gbit/s digital baseband signal versus received optical power.

For the BER measurement on the GSM-1800 signal the optical attenuator was set to zero as the electrical attenuator in front of the TEMS receiver was used to reduce and balance the received signal level (RxLev). The raw BER in the radio downlink was measured on the radio broadcast channel. Figure 3 shows the BER as a function of received power for the back-to-back case using coaxial cable (~6 m), 600 m MMF with the digital signal switched off and with the radio and digital signal running simultaneously. No BER penalty is observed for the simultaneous radio and digital transmission over the 600 m MMF. The fibre back-to-back transmission showed similar BER values to the 600 m MMF transmission, and the measurement points have been omitted in the figure for clarity. For input powers greater than –102 dBm, no BER could be measured within the resolution given by the TEMS equipment. The reference sensitivity level for GSM-1800 terminals and base stations is –102 and –104 dBm respectively, with the maximum BER depending on the type of channel (e.g. data channel BER ≤ 0.1%) [3]. The back-to-back case using coax cable showed slightly larger BERs than the radio over fibre transmission. This difference is within the resolution of the used TEMS equipment. The loss for the GSM signal at 1.8 GHz between laser input and receiver output was ~23 dB for the 600 m MMF link.

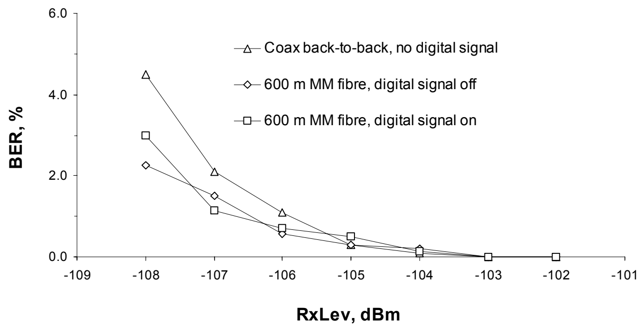

Fig. 3. BER for GSM-1800 radio signal versus the radio signal strength.

On the optical link as shown in Figure 1 we have also performed more GSM specific measurements, e.g. blocking and intermodulation attenuation, as specified in the GSM standard [3], in order to ensure proper radio operation. The laser linearity was found to be sufficiently high to keep within the GSM requirements for radio signal level up to the one used in the above experiment. Measurements of the required dynamic range have been performed in different in-building GSM installations. The fibre radio system like used in Figure 1 showed to have sufficient dynamic range for GSM in-building application even in the case if more than one carrier is sent over the link. The dynamic range of the optical link could be also easily increased by using VCSEL sources with higher optical output power and by matching the photoreceiver bandwidth to ~2 GHz.

IV. CONCLUSIONS

We have successfully demonstrated penalty free simultaneous 1 Gbit/s data and GSM-1800 signal transmission over 600 m multimode fibre using low-cost commercially available Gigabit Ethernet components operating at 850 nm. The results should enable new ways of realising low-cost radio in-building coverage, and the design of new architectures for LANs and equipments.

Although, we have shown simultaneous digital and radio transmission, which puts the most stringent requirements on the optical link, these low cost components can be used for separate radio and digital transmission. The idea is in general scalable to future Ethernet and mobile radio standards, e.g. the 10 Gigabit Ethernet and the Universal Mobile Telecommunication System (UMTS) operating at 2 GHz.

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[3] GSM specification, GSM 05.05.