A WIRELESS LAN AT 60 GHZ - NOVEL SYSTEM DESIGN AND TRANSMISSION EXPERIMENTS

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ABSTRACT

A novel system design for a wireless LAN simplifying the base station and transponder complexity is proposed. It advantageously uses the WDM technology for simultaneous modulation of optical carriers with a master oscillator signal. Transmission experiments under realistic conditions prove the concept by achieving BER<10^{-9} at 50 MBit/s.

I. INTRODUCTION

The ever increasing demand for mobile broadband communication leads to the development of wireless LANs at millimeter wave transmission frequencies, e.g. 60 GHz [1]. Due to the high propagation loss at 60 GHz, pico cells with a few meters radius result. Hence, numerous transponders are to be applied and simple transponder design is essential. In [2] we proposed and demonstrated a system concept for a mobile broadband communications system at 60 GHz, where a local oscillator signal for carrier generation was fed into the laser diodes at the base station and transmitted via optical fiber to the transponders. This configuration minimizes transponder complexity, since generation of a stable 60 GHz carrier with an oscillator at the transponder site is rather complicated.

In this paper, we extend this concept by advantageously utilizing optical wavelength division multiplex (WDM). This leads to a significant reduction of circuitry effort at the base station. Data transmission experiments at 60 GHz with a complete downlink path have been made under realistic conditions (omnidirectional dielectric lens antenna at transponder, 4.5 meter radio link). For

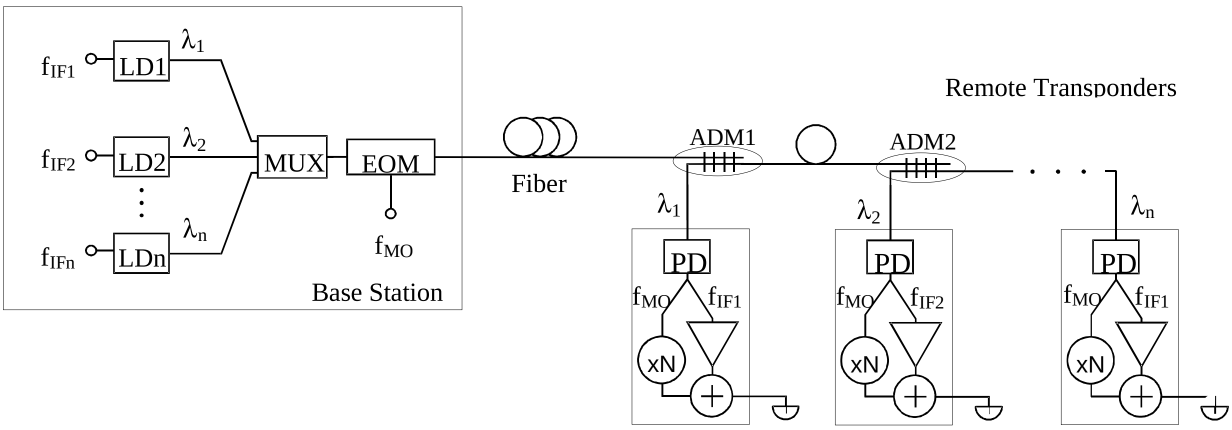

Fig. 1: Schematic diagram of the proposed system

50 MBit/s uncoded binary FSK transmission, bit error rates of better than 10^{-9} were obtained.

II. SYSTEM CONCEPT

The basic system concept is shown schematically in Fig. 1. The utilization of a dense WDM system for connecting the base station with the numerous transponders offers several advantages such as easy system extendability, common use of optical amplification and easy fiber handling. Since WDM technology is increasingly used for optical fiber transmission, standard components are now available. An optical channel is assigned to each transponder (pico cell). Distributed demultiplexing at the transponders can be done using all-fiber add-drop-multiplexers (ADM) with Bragg gratings [3]. A master oscillator (MO) signal is identically applied to all transponders, at which it is received and multiplied to a frequency at V-band. Thus, a main objective of having no signal processing or frequency determining elements at the transponder is achieved. Different cell frequency bands are obtained by assigning different IF to the laser diodes at the base station. Once all optical channels are multiplexed at a single fiber, the MO signal is modulated onto all optical carriers simultaneously by using just one electro-optical

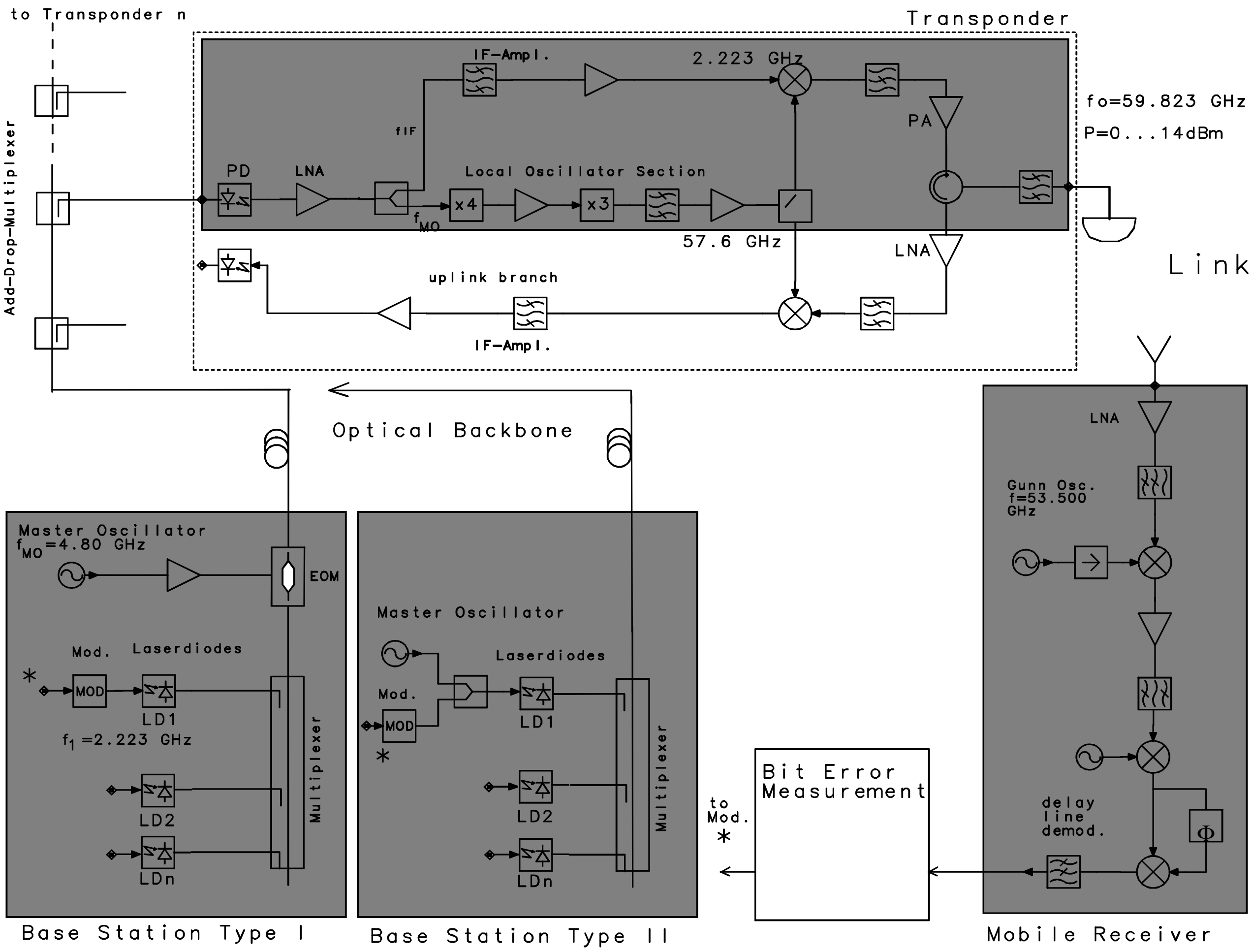

Fig. 2: Block diagram of the experimental setup

modulator (EOM). This principle significantly reduces the circuit complexity at the base station. It can be shown that no signal degradation due to the nonlinear EOM behaviour results.
Furthermore, laser diodes with a lower modulation bandwidth, sufficient for an IF in S- or C-band, can be used and a higher MO frequency can be applied to the EOM.

III. EXPERIMENTS AND RESULTS

Comprehensive data transmission experiments have been carried out for verification of the system concept proposed using a complete downlink path. The block diagram of the experimental setup used is shown in Fig. 2. Two base station configurations have been constructed. In base station type I, a high stability source has been used as master oscillator signal f_{MO}=4.8 GHz which - after being amplified to P=+30 dBm - drives the Mach-Zehnder EOM (V_π=7.9 V). The base station downlink IF centered around f_1=2.223 GHz directly modulates a laser diode

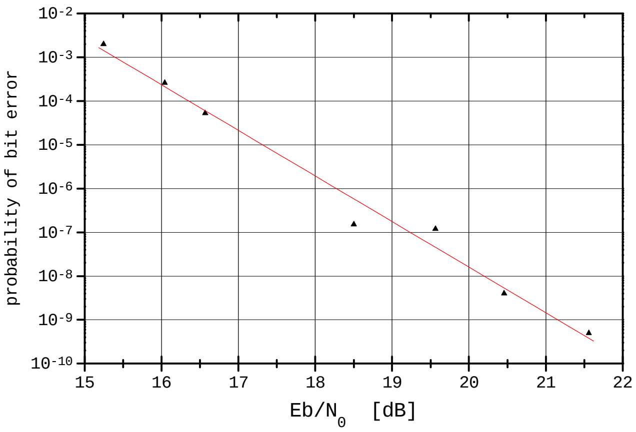

Fig. 3: Measured BER @50 MBit/s of uncoded FSK

having an efficiency of η_{LD}=0.05 W/A and an optical output power of P_{opt}=3 mW. Fig. 5 shows the optical WDM spectrum of three optical channels ($\Delta\lambda$=0.8nm) depicting the master oscillator and corresponding IF frequency sidebands on each optical carrier.

The total electrical loss of the fiber-optic link of 63 dB results in P_{MO}=-54 dBm and P_{IF}=-55 dBm received by the transponder site

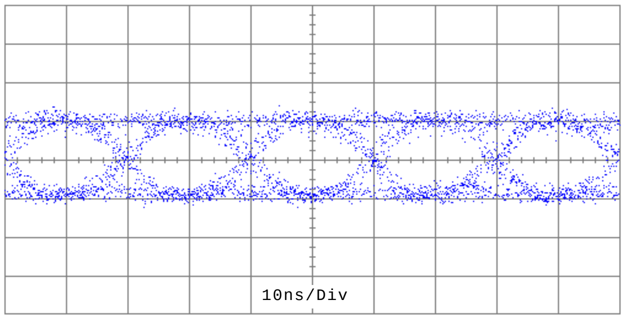

Fig. 4: Eye diagram @50 MBit/s

photo diode (η_{PD}=0.38 A/W). After frequency separation by a microstrip diplexer and multiplication (×12) of the master oscillator, the latter upconverts the IF to a millimetric center frequency of f_0=59.823 GHz. The transmit power could be varied by the laser diode drive power, the maximum possible V-band output power obtained was P_{max}=+14 dBm at 1 dB compression. The choice of an omnidirectional dielectric lens antenna [4] at the transponder achieving relatively low gain (G_1=4 dBi) and a link range of l=4.5 m approaching the indoor pico cell coverage area of our system, has been based on the consideration of having a realistic testing

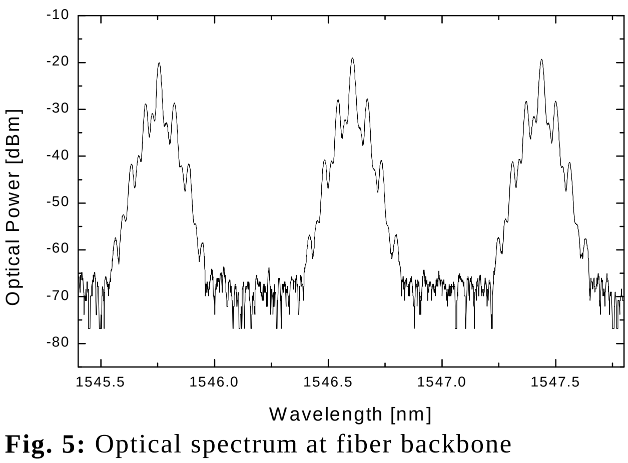

Fig. 5: Optical spectrum at fiber backbone

environment [5]. On the receiver site a directive antenna (G_2=20 dBi) and LNA (NF=6 dB) have been used in the front stage.

Fig. 3 shows the measured bit error performance (utilizing base station type I) and Fig. 4 the eye diagram (@ BER=10^{-9}) of one experiment at 50 Mbit/s (PRBS 2^{31}-1). The penalty of optical link, upconversion, radio link and downconversion relative to modem back-to-back was measured 5 dB at BER 10^{-9}.

IV. CONCLUSIONS

A novel system concept for a wireless LAN at 60 GHz has been proposed, resulting in a greatly simplified transponder and efficient base station design. We have carried out data transmission experiments at 50 MBit/s using a complete downlink path with realistic link parameters, range and antenna configurations, thus verifying the feasibility of the system designed. For uncoded binary FSK modulation bit error rates of better than 10^{-9} have been obtained at E_b/N_0 of 21.5 dB.

Fig. 6: Experimental transponder setup

V. ACKNOWLEDGEMENT

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