300 GHz Channel Measurement and Transmission System

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Abstract—**A 300 GHz channel measurement and transmission system designed for the characterization of THz communication channels has been set up. It consists of autarkic transmitter and detector units based on Schottky diode mixers. The system performance is shown including signal levels and noise. For demonstration of THz communications, analogue video signals have been transmitted over distances of up to 22 m.**

I. Introduction And Background

THE increased need of unoccupied and unregulated bandwidth for future wireless short-range communication systems will require the extension of carrier frequencies to values of 300 GHz and beyond in the lower THz range. Despite the high atmospheric attenuation due to absorption lines of polar molecules, transmission windows exist around 300 GHz and 350 GHz that could accommodate many GHz of transmission bandwidth. A study specifying the possible system architecture of such future communication systems has been undertaken previously including a detailed coverage analysis in indoor environments based on ray-tracing analysis [1]. Although previous channel modeling includes measured reflection properties of indoor building materials [2], transmission channel properties remain to be verified by measurements. As a first step, a versatile 300 GHz transmission system designed for THz communication channel modeling and propagation studies has been set up [3]. It consists of autarkic transmitter and detector units based on Schottky diode mixer technology [4]. The system performance is shown including the received signal levels, a linearity test and a noise budget. With the transmission system we demonstrated the feasibility of THz communications by transmitting an analogue video signal over a distance of 22 m and also over 4 m including a reflection from a painted wall.

II. Results

The system consisting of autarkic transmitter and receiver units is shown in Fig. 1. In the transmitter a dielectric phase-locked resonator oscillator (DPRO) at 16.66 GHz is amplified and tripled and then tripled again. It serves as a local oscillator for a Schottky mixer that is working on its second harmonic. At the Schottky mixer, a baseband signal with a maximum frequency content of 10 GHz is up-converted to 300 GHz and then transmitted via a horn antenna (26 dB gain) with a power of approximately 25 µW in each sideband. At the receiver, a similar horn antenna and Schottky mixer

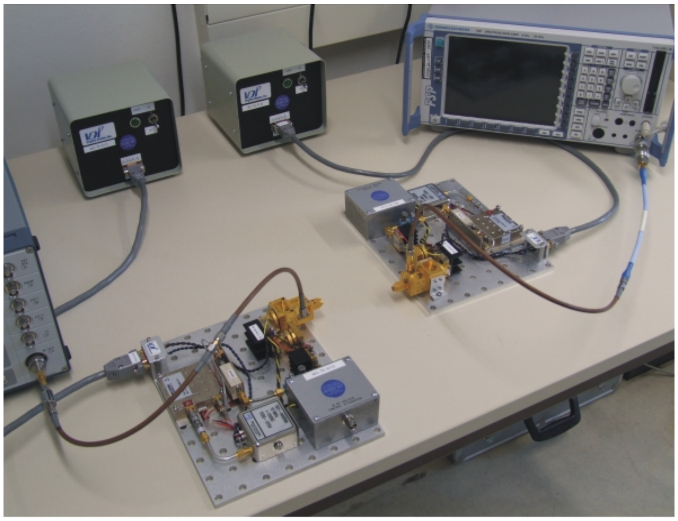

Fig. 1: Transmitter (left) and receiver (right) modules.

are used for down-conversion except that the DPRO operates at 16.38 GHz causing a down-conversion of the received signal to an intermediate frequency around 5 GHz. Ports at transmitter and receiver units allow to feed in a microwave signal that replaces the DPRO to synchronize transmitter and receiver for channel measurements with increased dynamics using a vector network analyzer.

Using a simple RF generator and a spectrum analyzer with the autarkic transmission scheme, a -10 dBm sine signal fed into the transmitter can be received with power levels between approximately -40 dBm and -65 dBm for antenna spacings between 5 cm and 80 cm at the receiver IF

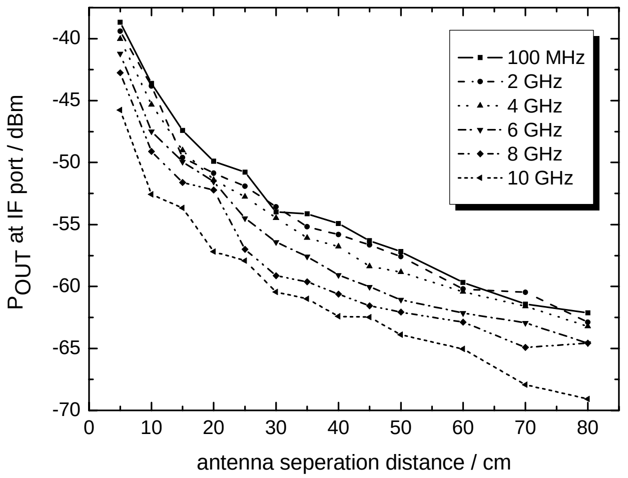

Fig. 2: Received output power P_{OUT} at IF port against antenna separation distance for different input frequencies and an input power of -10 dBm.

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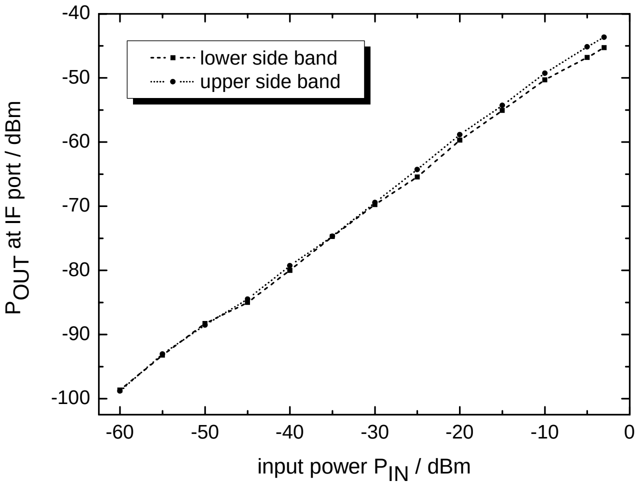

Fig. 3: Received output power P_{OUT} at IF port against input power level at 1 GHz indicating linearity of the system for a wide dynamic range.

frequency. Fig. 2 shows the received output power P_{OUT} at the IF port against antenna separation distance for six different input frequencies. Over a wide dynamic range, the transmission system exhibits linear behavior. Fig. 3 shows the received output power P_{OUT} at the IF port both in the upper and lower sideband against input power level indicating linearity of the system for input power levels between -60 dBm and -3 dBm within approximately 1 dB.

Using a typical measurement bandwidth of 1 MHz, a signal-to-noise ratio better than 60 dB can be maintained. Fig. 4 a) shows the noise budget for this configuration [3]. Both, signal and noise from the source are combined with the equivalent input noise of the transmitter and are then multiplied by the transmitter gain before being transmitted. At the receiver the incoming signal and noise is combined with the noise of the antenna and the equivalent input noise of the receiver.

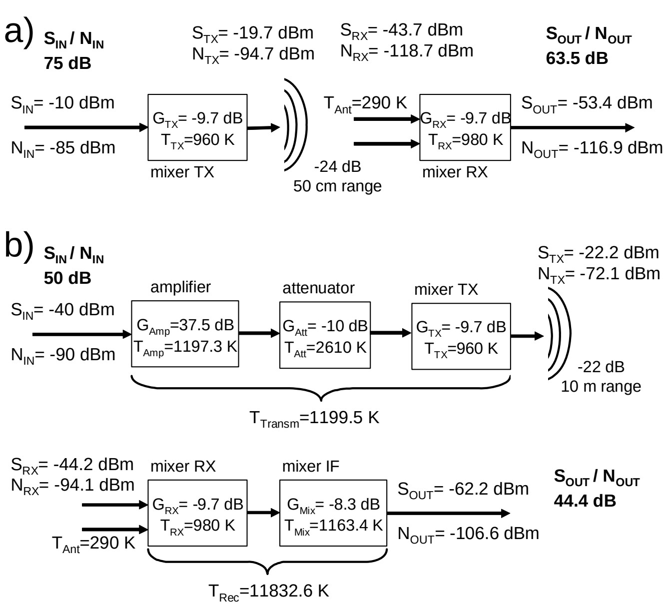

Fig. 4: Noise budget for transmission of a) signal generator output over 50 cm range assuming 1 MHz measurement bandwidth and b) video signal over 10 m using additional polyethylene lenses.

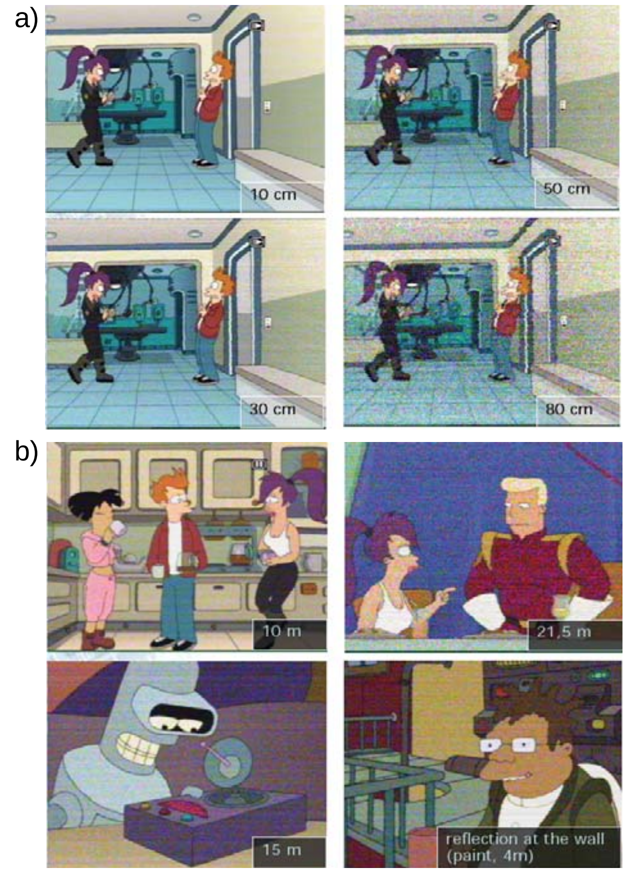

Fig. 5: Video transmission results indicating the picture quality at different transmission distances a) without lenses and b) with lenses.

For the video transmission demonstration a UHF signal at 855.25 MHz was transmitted over the 300 GHz link. Fig. 5 indicates the quality of the video signal transmission. The transmission could be maintained up to a distance of 0.8 m. To further enhance the transmission distance, two polyethylene lenses were used that increased the antenna gain by 14 dB each, allowing for a transmission distance of 22 m. In this configuration, the signal could also be transmitted over a distance of 4 m including a reflection from the wall. The results are consistent with the noise analysis for the video link shown in Fig. 4 b) containing the additional components of the setup [3]. For 10 m distance, the signal with a noise bandwidth of 6 MHz reaches the TV card with a S/N of 44 dB (40 dB required). Hence a reliable link can be maintained.

References

[1] R. Piesiewicz, T. Kleine-Ostmann, N. Krumbholz, D. Mittleman, M. Koch, J. Schoebel, and T. Kürner, "Short-range ultra broadband terahertz communications: concept and perspectives", IEEE Ant. & Propag. Mag. **49**, 24-39 (2007).

[2] R. Piesiewicz, C. Jansen, D. Mittleman, T. Kleine-Ostmann, M. Koch and T. Kürner, "Scattering analysis for the modeling of THz communication systems", IEEE Trans. Ant. & Prop. **55**, 3002-3009 (2007).

[3] C. Jastrow, K. Münter, R. Piesiewicz, T. Kürner, M. Koch, T. Kleine-Ost-mann, "300 GHz Transmission System", Electr. Lett. **44**, 213-214 (2008).

[4] T. W. Crowe, D. W. Porterfield, J. L. Hesler, and W. L. Bishop, "Sub-millimeter-wave and Terahertz Diodes, Components and Subsystems", IRMMW/THz 2006.