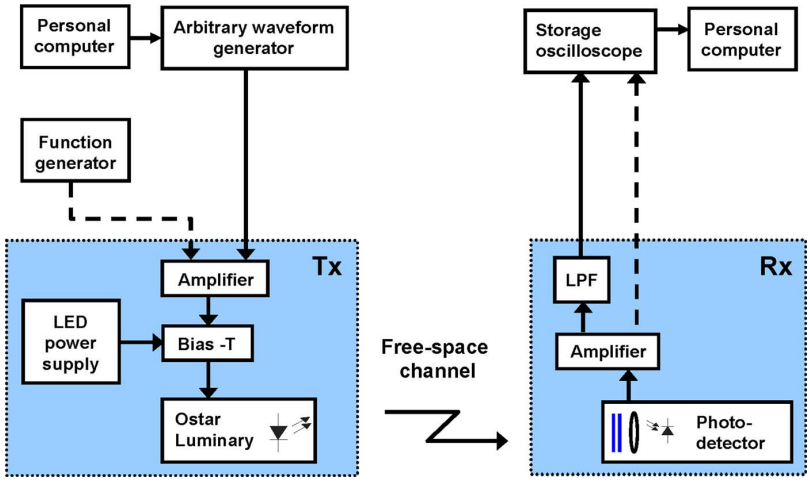

Fig. 1. Experimental setup. Dashed lines denote the setup used for measurement of the EOE channel frequency response. LPF: Low-pass filter.

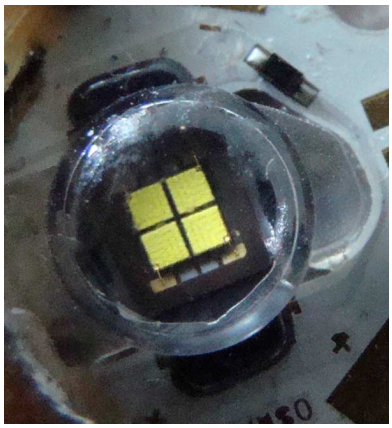

Fig. 2. Photograph of the commercial LED luminary (with spherical lens), as used in the measurements.

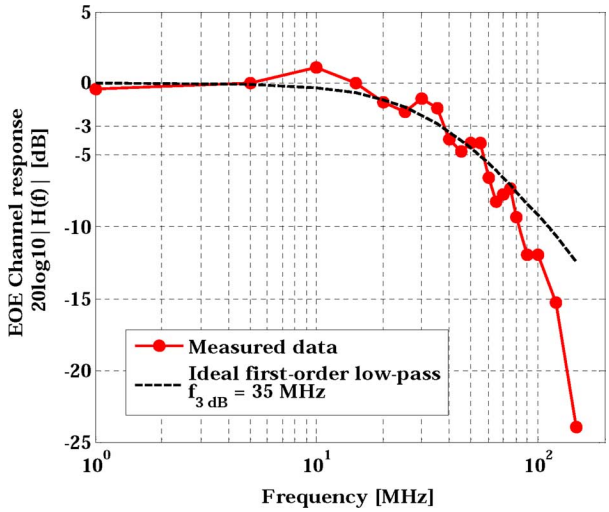

Fig. 3. EOE channel response of the data-transmission link in Fig. 1.

white LED module (OSTAR® LE CW E2B, see Fig. 2), devised for lighting applications. This module consists of four chips, providing a luminous flux of ∼250 lm (at 700 mA dc). This module comes with a factory-designed spherical lens, converting the emission from the rectangular LED module into a divergent light beam with a 130° full opening angle at 50% maximum intensity.

All experiments were performed at a certain brightness level (illuminance) in front of the receiver. Illuminance values of around 1000 lx were chosen in agreement with the lighting standard for well-lit working environments [6] and realized by separating the Tx and Rx module by an appropriate distance. Brightness levels were checked by a light meter placed at the position of the receiver in the otherwise dark laboratory. Deployment of a single module resulted in a relatively short link length (∼0.3 m for 1000 lx). Nevertheless, given that the used source is primarily devised for lighting purposes, we considered the illuminance at the receiver as the most relevant design parameter, [7]. In practical indoor scenarios with wireless distances of several meters the specified brightness levels needed for illumination can be achieved by using several LED modules and/or stronger collimation of the emitted light beam.

The ac-coupled analogue receiver (Rx in Fig. 1) consisted of the following components. An optical short-pass filter (customized design from Berliner Glas) with a cut-off wavelength of 500 nm was mounted in front of the photodiode to suppress the phosphorescent component of the LED radiation. A commercial large-area silicon APD (Electro Optics, C30872, 3 mm diameter) combined with an aspherical glass lens (New Focus 5728-A, 0.5 NA and 8 mm focal length) was used for detection. An amplifier (Pico-Amps pA4-00125-76) boosted the signal level up to the operation range of the storage oscilloscope (Agilent MSO71041, 4 GS/s sampling rate). Finally, the output amplitude was either directly monitored with the oscilloscope or stored for off-line demodulation.

The magnitude of the channel's frequency response was measured by varying the frequency of a small-signal sine wave provided by the function generator, and directly monitoring the receive amplitude at the oscilloscope. Fig. 3 presents the measured magnitude of the EOE channel frequency response. Since the receiver itself has a relatively large bandwidth (APD ∼80 MHz, amplifier ∼2.3 GHz), it can be concluded from the figure that the system bandwidth (∼35 MHz) is limited by the LED module.