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Editorial

Millimeter-Wave Wireless Communication Systems: Theory and Applications

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Recently, millimeter-wave radio has attracted a great deal of interest from academia, industry, and global standardization bodies due to a number of attractive features of millimeter-wave to provide multi-gigabit transmission rate. This enables many new applications such as high definition multimedia interface (HDMI) cable replacement for uncompressed video or audio streaming and multi-gigabit file transferring, all of which intended to provide better quality and user experience. Despite of unique capability of millimeter-wave technology to offer such a high data rate demand, a number of technical challenges need to be overcome or well understood before its full deployment. This special issue is aimed to provide a more thorough understanding of millimeter-wave technology and can be divided into three parts. The first part presents the recent status and development of millimeter-wave technology and the second part discusses various types of propagation channel models. Finally, the last part of this special issue presents some technical challenges with respect to suitable millimeter-wave air interface and highlights some related implementation issues.

In the first paper by S.-K. Yong and C.-C. Chong, the authors provide a generic overview of the current status of the millimeter wave radio technology. In particular, the potential and limitations of this new technology in order to support the multi-gigabit wireless application are discussed. The authors envisioned that the 60 GHz radio will be one of the important candidates for the next generation wireless systems. This paper also included a link budget study that highlights the crucial role of antennas in establishing a reliable communication link.

The second paper by N. Guo et al. extends the overview discussion of the first paper by summarizing some recent works in the area of 60 GHz radio system design. Some new simulation results are being reported which shown the impact of the phase noise on the bit-error rate (BER). The authors concluded that phase noise is a very important factor when considering multi-gigabit wireless transmission and has to be taken into account seriously.

In the third paper by C.-P. Lim et al. the authors propose a 60 GHz indoor propagation channel model based on the ray-tracing method. The model is validated with measurements conducted in indoor environment. Important parameters such as root mean square (RMS) delay spread and the fading statistics in order to characterize the behavior of the millimeter-wave multipath propagation channel are extracted from the measurement database. This ray-tracing model is particularly important in characterizing the multipath channel behavior of various types of indoor environments, which are the typical application scenarios for 60 GHz technology.

The fourth paper by H. Yang et al. uses a different modeling approaches in characterizing the 60 GHz propagation channel. In this paper, a statistical-based channel model is proposed based on the extensive measurements campaign conducted in indoor office environment. Based on this, a single-cluster power delay profile (PDP) is found to best characterize the channel statistics in which the PDP can be parameterized by K-factor, RMS delay spread, and shape parameter under both line-of-sight (LOS) and non-LOS (NLOS) conditions. Various types of antenna beam patterns such as omnidirectional, fan-beam and pencil-beam, and their directivities are being investigated at both the transmitter and receiver sides. Finally, in order to analyze the effect of multipath channel on system design, an OFDM-based system is used to compare the BER performance of both measured and modeled channels. The authors conclude that the directive configurations can provide additional link margins and improved BER performance for multi-gigabit transmissions using the 60 GHz radio technology.

The fifth paper by V. Kvicera and M. Grabner investigated the effect of rain attenuation at 58 GHz based on the large measurement results collected over a 5-year period. The measurement results obtained were analyzed and compared to the ITU-R recommendations which are valid for estimating long-term statistics of rain attenuation for frequency up to 40 GHz. The results reported are important as an extension to the ITU-R recommendations for realistic link-level analysis especially for point-to-point fixed system up to 60 GHz.

In the context of the wide deployment of 60 GHz links, the sixth paper by H. T. van der Zanden et al. addresses the modeling and prediction of rain-induced bistatic scattering at 60 GHz. This factor is important as it could cause link interference between nearby 60 GHz links when rain falls. The paper shows that despite of the high oxygen attenuation, coupling between adjacent links caused by bistatic scattering could be significant even in light rain.

The seventh paper by J. Nsenga et al. is related to the baseband system design in which two new modulation schemes, firstly, offset quadrature phase shift keying (OQPSK) with frequency domain equalization (FDE), and secondly, constant phase modulation (CPM) with time domain equalization. Both techniques are targeted for low-cost and low-power 60 GHz communications systems and are evaluated and compared by considering the effects of front end nonideality. The authors found that OQPSK with FDE and nonfractional sampling minimum mean square error (MMSE) receiver yields best tradeoffs between BER performance and system complexity study in terms of analog-digital-converter (ADC) clipping and quantization effect, phase noise effect, as well as power amplifier nonlinearity effect.

In the eighth paper, by A. Mohammadi et al. a direct conversion modulator-demodulator for fixed wireless applications is proposed. The circuits consist of even harmonic mixers (EHMs) realized with antiparallel diode pairs (APDPs), where self-biased APDP is used in order to flatten the conversion loss of the system versus local oscillator (LO) power. The impacts of I/Q imbalances and DC offsets on BER performance of the system is also being considered. A communication link is built with the proposed modulator-demodulator and the experimental results shown that such a system can be a low-cost and high-performance 16-QAM transceiver especially for the local multipoint distribution system (LMDS) applications.

The last paper by S. O. Tatu and E. Moldovan proposed a practical circuit for the 60 GHz radio. In this paper, a V-band receiver using an MHMIC multiport circuit is proposed. It was demonstrated that the combination of multiport circuit with power detectors and two differential amplifiers can replace the conventional mixer in a low-cost heterodyne or homodyne architecture. The operating principle of the proposed heterodyne receiver and demodulation results of high-speed MPSK/QAM signals are also discussed. Simulation results in the paper shown that an improved overall gain can be obtained. The authors concluded that such a multiport heterodyne architecture can enable the compact and low-cost millimeter-wave receivers for the future wireless communications systems such as the IEEE 802.15.3c wireless personal area networks (WPAN) applications.

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