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Multiple input multiple output (MIMO) and fifth generation (5G): an indispensable technology for sub-6 GHz and millimeter wave future generation mobile terminal applications

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Abstract

The in-depth exploration in the future 5G technology symbolizes a revolution in technology for antenna designers to encounter the all time increasing need as well as demand for higher data rate wireless communications. The paper gives out an exhaustive review of the evolution and characteristics of the 5G spectrum allocations, the MIMO antenna design with regard to mutual coupling reduction techniques and safer user applications. It precisely covers almost all the aspects of 5G which mainly include the types of antenna designs and their performance parameters related to MIMO design. The paper also presents a brief description of massive MIMO technology for base station applications. The main aim of the paper is: (1) to emphasize the frequencies allocated for the 5G including sub-6 Ghz and mm-wave bands; (2) to underline the suitable antenna designs for MIMO applications for mobile devices and base stations; (3) to highlight the mutual coupling effects in MIMO designs and its reduction techniques; (4) to consider the gaps in the literature and the challenges for reducing SAR effects for the safety of the users. This review paper has been an attempt to explore the evolution of 5G bands and antenna designs for 5G applications, comparison based on the literature, and the techniques implemented for enhancing the MIMO antenna performances.

Introduction

With the escalation in demand for high data rate communication systems along with commercialization of the fourth generation (4G) networks, there is an emergence of research related to ongoing fifth generation (5G) technologies. The initiatives have been taken and programs launched by a number of organizations worldwide that aim at the key technologies for 5G. There is an ongoing study that suggests the major requirements for 5G include high spectral efficiency (SE) and energy efficiency (EE), low latency, and greater number of node connections. The SE in the available spectrum is considered to be the prioritized design constraint for wireless networks considering the increasing capacity demand. There has been an improvement of data rates from Kilo-bits per second (Kbps) in 2G to Giga-bits per second (Gbps) toward 5G. There is an overall 70% of the total power consumed by the radio access networks. The improvement in the EE is lagging with the overall growth of data traffic in the networks. There is a need of reliable wireless networks for future generations that will be both spectrally efficient as well as in terms of energy. Thus the optimization of SE and EE together is very critical related to 5G technology research [1].

There is a target of deploying 5G in 2020 and beyond with regard to International Telecommunications Union (ITU) radio communication standards sector. One of the most important issues related to 5G deployment is the availability of spectrum required for 5G which could be managed and used efficiently. In view of this, the institutions for 5G research are paying greater attention on the available spectrum to be utilized for 5G deployment. Some of the global institutions include IMT-2020 promotion group of China (IMT-2020 PG), Europe's EU-FP7-METIS project, etc. [2]. Some of the requirements for specifying the 5G technology include frequency allocation bands, data rates, density of connectivity and reliability, spectral density, latency, and mobility as depicted from Fig. 1 [3–5].

The emerging potential frequency bands include the bands above and below 6 GHz. 5G is able to operate in millimeter-wave frequency bands in addition to lower frequency bands of below 6 GHz. In comparison to 4G with the delivering data rates of around 20 Gbps (maximum) and the average of more than 100 Mbps (minimum), the 5G is considered to be very fast. The lower latencies in 5G are achieved by using low density parity check coding as the error correcting code in the forward direction. The maximum speed at the mobile station which refers to the mobility is around 500 kilometers per hour in case of 5G. In 5G, the capacity of the systems is increased by utilizing beam division multiple access and filters bank multicarrier thus handling more number of users at a particular instant of time. In addition to the higher data rates of 2–20