Chapter 5
Phased Millimeter-Wave Antenna Array for 5G Handled Devices

Emna Jebabli
https://orcid.org/0000-0001-5499-028X
Higher School of Communications of Tunis, Tunisia

Mohamed Hayouni
Higher School of Communications of Tunis, Tunisia

Fethi Choubani
Higher School of Communications of Tunis, Tunisia

ABSTRACT

In this chapter, the authors present the fundamental theory behind microstrip antenna array design and beamforming. Thus, design and simulation of low profile microstrip phased arrays for 5G applications will be discussed. It will be organized as follows: In Section 2, the 5G mobile network frequency spectrums will be discussed. In Section 3, the authors will explore the recent trends and developments on the main used techniques in systemic designs of low-profile antenna arrays followed by their investigations on some mm-wave antenna arrays. Next, in Section 4, fundamental theory behind phased antenna array, followed by some simulation results, will be presented and discussed. Finally, in Section 5, a conclusion highlighting the advantages of some techniques will be presented.

1. INTRODUCTION

By the deployment of the new generation of mobile network (5G), we will witness an enhancement mobile broadband to support the enormous demand for higher traffic capacity and higher data rates, massive machine-type communications to provide a massive Internet of Things, and ultra-reliable and low-latency communications to offer extreme real-time communications (Navarro-Ortiz et al., 2020). Hence, by dint of the spectrum in the sub 6 GHz and the need for higher peak data rates and network capacity,

DOI: 10.4018/978-1-6684-5955-3.ch005

the 5G will exploit the frequency in the upper 6 GHz frequency band, in millimeter wave (mm-wave) bands (Jebabli et al., 2021). However, the mm-wave frequency band is very sensible to atmospheric and rain absorption, shadowing by materials and human body also it suffers from the high pathloss (Jebabli et al., 2021; Zhou et al., 2020). So, the antenna array provides a high gain that can be considered as a solution to overcome this problem (Molisch et al., 2017). Indeed, the microstrip antennas are very used in the design of antenna due to their low profile, easy of fabrication and installation (Balanis, 2005, pp. 811). However, the antenna array provides a fixed narrow beam which causes a limited coverage results in badly mobile communication networks (Yang et al., 2018; Selvaraju et al., 2018). Thus, to enhance the coverage of the antenna array, beamforming technique is considered as a promising solution for 5G mm-wave wireless communication (Selvaraju et al., 2018). Moreover, the beamforming antenna can compensate for the omnidirectional path loss and may offer further gains (Jebabli et al., 2022). Hence, to realize a beamforming antenna, one of the commonly used techniques is the passive beamforming network Butler matrix due to its simple configuration (Kim et al., 2019).

This chapter presents the theory and design of phased antenna array in millimeter waves. Thus, practical applications of mm-wave antenna arrays for 5G applications in ka-band have been designed and simulated. Hence, in the second Section, the 5G mobile network frequency spectrums will be discussed. In Section 3, radiation characteristics of 1x2 and 1x4 microstrip antenna arrays designed at 28 GHz are presented and discussed. In Section 4, a 4x4 beam switching microstrip antenna arrays are designed in ka-band by using Butler matrix. Finally, Section 5 reserved for conclusions.

2. 5G MOBILE NETWORK FREQUENCY SPECTRUMS

The bands available in mm-wave are Ka-band (26.5–40 GHz), V-band (57–71 GHz), and E-band (71–76 GHz and 81–86 GHz). Thus, the 5G spectrum is generally subdivided into two frequency bands (FR1) and (FR2), the first frequency band (FR1) extends from 450 MHz to 6000 MHz, while the second frequency band (FR2) is from 24.25 GHz to 52.6 GHz. Note that the FR2 contains frequencies above 30 GHz for this reason the word mm-wave and FR2 are often used mutually (Lopez et al., 2019). The different bands defined for FR2 are summarized in the following Table 1.

Table 1. Frequency band for FR2

Band	Frequency Band (GHz)
n257	26,5–29,5
n258	24,25–27,5
n260	37–40
n261	27,5–28,35

(Lopez et al., 2019)

The mm-wave covers the frequencies between 30 and 300 GHz, these waves have a wavelength varying between 1 to 10 mm. Figure 1 gives an illustration of the mm-wave region of the electromagnetic spectrum (Lawrence et al., 2017).

Related Content