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# Preface

Terahertz regime of the electromagnetic spectrum which coarsely extends from 100 GHz to 10 THz has been treated as the bandgap for a long time mainly due to the scarcity of powerful sources and detectors. However, in the last two decades, the breakthrough in the semiconductor technology, nanotechnology, and quantum dot mechanism have yield a number of powerful electronic and photonic sources and detectors to explore this untouched regime of the spectrum for the benevolent applications to the society.

In the last decade, numerous applications of this band have been proposed by the scientists and researchers which are focused to the area like spectroscopy, imaging, detection, and health science.

With the development in the low-cost compact electronics devices, the need of the rapid information transform has also been experienced worldwide. To enable the rapid transmission of the information, always there is the need of the well-developed and mature communication system and this maturity is also related to the bandwidth need. In the last two decades, the need of the bandwidth has increased which can be described with the Edholm's law. Owing to the increase in the demand of the bandwidth, this century dawn with the novel ideals of pioneer thinkers in the field of the communication to enhance the operating frequency of the communication system to terahertz range to meet the future bandwidth requirement. However, this novel concept has remained under the dark due to the atmospheric condition on the earth surface and the limitation of the sources and detectors power and sensitivity, respectively. Apart from the sources and detectors, the other concerns are the system compatible antennas and interconnect, which may also play a pivotal role in the development of reliable the terahertz communication system.

To meet the need of the high gain/directivity, several antennas with different objectives have been developed but compatibility to the communication system of these antennas is difficult. Various scientific and research fraternity are in the opinion of two basic types of the antennas such as waveguide and planar, which will be the most suitable for the communication system. This fact is due to the ability of these antennas to be integrated with the monolithic transreceiver system. The waveguide type antenna has extensively been studied and even used in the terahertz communication system. At the same time, the planar antenna is attractive due to its integration, low cost, and lightweight but suffers from the low gain and directivity. Due to this reason, this antenna system has not found the ample applications in terahertz communication system; hence, there is the need to explore the potential of this type of the antenna at terahertz frequency.

In view of the existing demand of high gain planar antenna at terahertz frequency, this book is written to address the design issues and directivity and gain enhancement mechanism of the planar antennas. The authors believe that the book would prove to be instrumental in accelerating the research in the field of the planar antennas to optimize its utility at terahertz frequency and would be helpful to the researchers and professional in the field of antenna to give a look at the planar antenna design in terahertz regime of the electromagnetic spectrum.

The book is organized in 10 chapters. The Chap. 1 is devoted to the literature review in the field of the terahertz sources, antennas, and interconnects. The special attention has been given to the sources operating below 1 THz because it is expected that the future communication system will be available below 1 THz frequency only due to the massive attenuation of the signal. However, below 1 THz, there are a number of semiconductor sources which are used in the communication system.

Chapter 2 deals with a method to characterize the different parameters like effective dielectric permittivity, characteristic impedance, and attenuations of the multilayer microstrip transmission line. The transmission line analyses provide insight for understanding of the frequency-depended behavior of the planar devices.

To enhance the gain of the antenna, it is needed to reduce the various losses and one of the losses is the surface wave loss, which needs the due consideration at terahertz frequency because the substrate may have to be deliberately thick to introduce the substrate mode loss of the energy. To overcome this problem, electromagnetic bandgap material (EBG) is used. In Chap. 3, the electromagnetic bandgap material using air-drill and its effect on the antenna performance is discussed. Further, to increase the directivity of the antenna, the array concept may be used. In Chap. 4, the antenna array using the EBG substrate is discussed.

The lens-type antenna is commonly used to enhance the directivity in the terahertz communication system. Theoretically, it is possible to integrate any kind of the primary source to the lens antenna however, only certain type of the antennas have been used as the primary source. In view of the integration of the devices in co-plane, a novel structure is discussed in Chap. 5 and this kind of the structure would certainly find its place in the future applications when all the components would be packaged on the same chip.

In Chap. 6, a cavity type of the antenna is discussed. The directivity enhancement mechanism of the cavity type of the antenna at terahertz frequency is presented. Although, at the moment, it seems to be unrealistic but later with the use of the non-Foster Fabry Perot cavity, certainly this kind of the structure will find the place in Pico-cell communication system.

In Chap. 7, a thick substrate antenna is discussed and the effect of the loss tangent on the antenna performance is described. It is found that the loss tangent of the material is also important in addition to the relative dielectric permittivity and needs the due care at terahertz frequency.

The Chaps. 8 and 9 deals with the frequency selective surface for the antenna design and effect of the cavity structure on the electrical characteristics of the antenna.

Finally, in Chap. 10, the state of the art of terahertz communication system along with various kinds of sources, channel property, modulation schemes, channel propagation model, and the error correction techniques have been discussed, and it is expected that the book would be able to help the graduate student, researchers, and professionals practitioners to build a robust terahertz communication system.

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