Terahertz Radio Systems – The Next Frontier

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ABSTRACT

Terahertz (THz) frequencies (also called T-rays) have almost unlimited potential in a wide variety of applications including imaging, spectroscopy, sensing and actuation, and wideband communications. The main reasons are that the THz spectrum, which covers frequencies from about 300 GHz to 10 THz, is currently largely unallocated, which opens up the prospect of huge bandwidths, and also electromagnetic waves at these frequencies give millimetre resolution of objects. This resolution is essential in imaging of metallic and non-metallic objects for medical, non-destructive testing and security applications. In addition, most molecules have vibrational and rotational spectra at THz frequencies. However, the techniques used at THz frequencies are in early stages of development, although some components and systems are now available. Also, two distinct approaches to THz systems have evolved from the radio frequency and the optical domains. Terahertz is a region where the two domains mix, and practical systems of the future will undoubtedly combine the best of both domains.

This talk will outline the progress being made in technology and applications for potential radio systems operating in the THz frequency range. Most technologies used to date derive from scaling components from the microwave or optical domains. However, in some cases, these scaled components are either too small from the microwave domain or too large from the optical domain to be of practical use. An example of this is THz sources. Most electronic sources cannot be extended directly upwards in frequency due to materials, time delay or fabrication constraints. Therefore, the most common technique to create power electronically is to use a high-power millimetre wave source and multiply in frequency. This approach has proved very successful although its maximum power efficiency is typically only a few percent. At the other extreme, an optical laser approach can produce high powers although the equipment tends to be very large and not very portable. The development of new sources for the THz region, such as those based on GaSe and other crystals, will be important to its future development. Another issue at THz frequencies is that the material properties are often quite different from microwave or millimetre-wave frequencies and some of the most useful components in waveguide and printed circuits technologies are very lossy. A way to reduce the amount of loss and simultaneously create new and compact components is to use artificial materials such as electromagnetic bandgap (EBG) or metamaterials.

Examples of recent technologies applicable to THz sources and components will be given in the talk. This will be accompanied by a description of particular THz radio systems. The applications considered will be a THz camera, which could provide images in dark or foggy conditions, electromagnetic sensors to measure the molecular constituents of the earth's atmosphere and other planets, and extremely wideband communication systems. The paper will discuss some of the current methods and applications as well the technical challenges being faced to deliver radio systems operating at the fringes of current capability.