Electro-Optic Mapping Techniques for Characterization of Microwave Circuits, Devices and Antenna Systems

Kazem Sabet
President, EMAG Technologies Inc., USA
ksabet@emagtech.com

ABSTRACT

The last four decades have witnessed the development and productization of electro-optic (EO) sampling methods for non-invasive measurement of electric fields. These methods are based on the linear Pockels electro-optic effect, whereby the polarization state of an optical beam is modified as it propagates through an electro-optic crystal medium due to the presence of an impinging electric field. An EO field probe consists of an electro-optic crystal whose bottom side is covered with a distributed Bragg reflector, and its top side is mounted at the tip of an optical fiber. A typical EO field sensor head has the shape of a cube with 1 mm side dimensions. Thanks to their optical nature, EO field probes are ultra-wideband, have a very small footprint, can be made totally free of metallic parts, and feature a very high spatial resolution. Most common EO sampling systems use an ultrafast pulsed laser source. More recently, continuous wave (CW) semiconductor laser diodes have been utilized as an alternative source together with high-frequency photodetectors in an optical-fiber-coupled system configuration. The incorporation of polarization maintaining (PM) fiber has made it possible to develop and realize very reliable and repeatable continuous wave EO field measurement systems. Due to their very small footprint and absence of metallic parts, EO field probes provide a highly non-invasive method of electric field measurement, in which the probe can approach the surface of the device under test (DUT) at very close distances less than 1 mm without perturbing the field to be measured. The same EO probe can be used in conjunction with a software-controlled frequency synthesizer to measure electric fields over a very wide frequency bandwidth from less than 1 MHz to tens of GHz. Two or three collocated probes can measure the tangential field components or all the three field components simultaneously. Moreover, the same probe can be used to measure very weak electric field with a strength less than 1 V/m and high-intensity fields above 1 MV/m.

Electro-optic field measurement systems can be operated in the frequency domain for the purpose of near-field scanning or in the time domain for waveform detection and tracking. This talk will present an overview of the physics and theoretical foundation of electro-optic field mapping technology along with some of its exciting applications in various areas such as antenna and phased array characterization, microwave device diagnostics, and field measurement inside biological environments, to name a few.