

# **Microwave Theory & Techniques, Photonics and Aerospace and Electronics Systems Societies**

**6:00 PM, 23 April, 2013**

**Simultaneous transmit and receive: a new capability to increase the utilization of the RF spectrum and improve the efficiency of systems that use the spectrum**

**Dr. Charles H. Cox, III, President of Photonic Systems, Inc.**

The increasing (exploding?) trend to make almost everything wireless – from wireless mice to the wireless web – has put extreme pressure on what is basically a fixed resource: the RF spectrum. There are of course myriad approaches to meeting this challenge, including data compression schemes to reduce the amount of data that needs to be sent and spectral efficiency enhancements to increase the data that can be conveyed in a given bandwidth. But one avenue that has not been explored – at least until recently – is to use the same spectrum band to simultaneously transmit and receive (STAR). It was taken as axiomatic that this was not possible, and with good reason. To realize STAR, the isolation required between transmit and receive signals can exceed 100 dB!

Within the last few years, several design configurations have been proposed to implement STAR, or full duplex communication as the communications community prefers to refer to it. This talk will begin with an overview of the role STAR can play in addressing the spectrum challenge, as well as the technical performance, regulatory revisions and standard formats that must be realized for STAR to become viable. We will also briefly present an overview of the various approaches that have been proposed to implement STAR.

The talk will then focus on the design and performance of a STAR prototype developed by PSI. As one might expect, a STAR system design involves a large design trade space, because implementing STAR requires merging what have traditionally been two separate – and largely independent – design trade spaces: the transmit and receive paths. Hence in this talk we discuss in detail how investigators at Photonic Systems, Inc. (PSI) have addressed two of STAR's most important challenges: dealing with the antenna return loss and achieving high T/R isolation. To achieve the required combination of bandwidth and antenna return loss improvement typically required for STAR turns out to be physically unrealizable, since such a combination of bandwidth and impedance match exceeds the Bode-Fano limit. Hence we describe an alternate approach that PSI has developed, which achieves the required performance. Key to achieving high T/R isolation is a new type of fiber-optic link we call TIPRx, for Transmit Isolating Photonic Receive link. As will also be described in the talk, TIPRx link combines the RF functions of a ferrite circulator and a low noise amplifier. Compared to a ferrite circulator, which typically achieves up to 20 dB T/R isolation over an RF bandwidth of one

octave, we will show that a TIPRx has achieved > 40 dB over > 3 decades of RF bandwidth. The talk will conclude with a hardware demonstration of a STAR system applied to the commercial FM radio band.

Dr. Cox founded Photonic Systems Inc. in 1998 to provide expert engineering services in fiber-optic system design and to develop low-cost, high-performance fiber-optic links for government and commercial applications. Prior to organizing Photonic Systems Inc., Dr. Cox was on the research staff at MIT and at Lincoln Laboratory; he received his ScD from MIT in 1979.

Dr. Cox holds 10 US patents, has given 3 plenary and 71 invited talks on photonics and has published more than 70 papers on his research in the field of photonics. He has written a textbook titled Analog Optical Links, which was published in 2004, co-edited a book on milestone papers in photonics and written five book chapters. He is a fellow of IEEE and OSA. Dr. Cox served as a member of the Advisory Group on Electron Devices (AGED) from 2003 – 2009.

### **Meeting Location and Directions**

Meeting is being held at MIT Lincoln Laboratory is located at 244 Wood St., Lexington, MA 02420. The cafeteria is open to the public and visitor parking is available adjacent to the main entrance (in front of the parking structure). The Laboratory is also accessible via MBTA Bus route 76. When entering the Wood St. gate and the Main Cafeteria entrance, please tell the guard on duty that you are a visitor attending the IEEE meeting. Refreshments are served at 5:30PM.

(Thanks to the Boston Photonics Society for the following directions.)

From interstate I-95/Route 128: Take Exit 31B onto Routes 4/225 towards Bedford - Stay in right lane; Use Right Turning Lane (0.3 mile from exit) to access Hartwell Ave. at 1st Traffic Light.; Follow Hartwell Ave. to Wood St. (~1.3 miles).; Turn Left on to Wood Street and Drive for 0.3 of a mile.; Turn Right into MIT Lincoln Lab, at the Wood Street Gate.

From Exit 30B: Take Exit 30B on to Route 2A - Stay in right lane; Turn Right on to Mass. Ave (~ 0.4 miles - opposite Minuteman Tech.); Follow Mass. Ave for ~ 0.4 miles.; Turn Left on to Wood Street and Drive for 1.0 mile.

Turn Left into MIT Lincoln Lab, at the Wood Street Gate.

To get to the Cafeteria, proceed toward the Main Entrance of Lincoln Laboratory. Before entering the building, proceed down the stairs located to the left of the Main Entrance. Turn right at the bottom of the stairs and enter the building through the Cafeteria entrance. The Cafeteria is located directly ahead.

For additional information, please contact Chris Galbraith at [chris.galbraith@ll.mit.edu](mailto:chris.galbraith@ll.mit.edu)