## **Small Antenna Remote Impedance Measurement**

Ali Hosseini-Fahraji\*, and Majid Manteghi (1) Bradley Department of Electrical& Computer Engineering, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA

For measuring the input impedance of an antenna, it is common to connect the antenna under test (AUT) through feeding cable to a network analyzer. However, the induced current on the outer surface of the feeding cable in the electrically small antenna (ESA) case interfere with this process. Therefore, the conventional methods such as using a network analyzer to measure the input impedance of an ESA may not be suitable. An idea is to measure the input impedance of an ESA based on the impulse response of the ESA terminated to three standards loads, short/open/matched load (SOL).

In the first approach to this idea as a remote antenna measurement system (M. Manteghi, "Small Antennas Remote Impedance Measurement Using Electrostatic Discharge", IEEE AP.2017), AUT was sequentially terminated to three standard loads (SOL) and it was excited using an electrostatic discharge (ESD) as an impulsive source. The probe in some distance from the AUT captures three time-domain radiated signals corresponding to each of three standard loads (SOL). By extracting the complex natural resonances (CNRs) of the antenna from these signals, the components of a circuit model of the ESA were estimated. Finally, the input impedance of the circuit model was computed as a representative of the input impedance of the ESA.

In this paper, a new method is proposed for measuring the input impedance of an antenna based on the original idea. In this new method, we omit the circuit model, which allows us to extend the application of the technique to the antennas that do not have any circuit model. Instead of estimating the circuit model, the input impedance of the ESA is extracted by using the microwave network analysis and CNRs of the antenna while terminated to three standard loads (SOL). By defining the extra port somewhere random on the AUT structure as the impulse port, the remote antenna measurement setup including a probe, AUT, and the impulse port is supposed as a three port network. Thereafter, the input impedance of the ESA is calculated fast and straightforward in only one equation which related to the CNRs of the antenna. The merit of this method is more straightforward than former and is expected to be applied to larger antennas with a wider bandwidth. Two different types of antennas- a planar inverted-F antenna (PIFA) and Electrically Coupled Loop Antenna (ECLA) - are designed, simulated and prototyped to verify the proposed method. Finally, the input impedance of the antennas are measured using this technique and the measured results are compared with the simulated results.