On the teaching of S-parameters for the study of Antenna Problems

Tapan K Sarkar[(1)], Mohammad Najib Abdallah[(1)], and Magdalena Salazar Palma
(1) Department of Electrical Engineering and Computer Science, Syracuse University, Syracuse, New York 13244-1240, USA, E-mail: tksarkar@syr.edu, http://lcs3.syr.edu/faculty/sarkar/
(2) Dept. of Signal Theory & Communications, Universidad Carlos III de Madrid, Avenida de la Universidad, 30, 28911 Leganés, Madrid, Spain, E-mail: salazar@tsc.uc3m.es

The purpose of this paper is to demonstrate that the S-parameters are not suitable to characterize antenna problems where the impedance changes a sa function of frequency. Thus, the first objective of this paper is to introduce the two different types of S-parameters generally used to characterize microwave circuits with lossy characteristic impedance. The first one is called the *pseudo wave*, an extension of the conventional travelling wave concepts, and is useful when it is necessary to discuss the properties of a microwave network junction irrespective of the impedances connected to the terminals. However, one has to be extremely careful in providing a physical interpretation of the mathematical expressions as in this case the reflection coefficient can be greater than one, even for a passive load impedance with a conjugately matched transmission line. Also, the power balance cannot be obtained simply from the powers associated with the incident and reflected waves. The second type of S-parameters is called the *power wave scattering parameters*. They are useful when one is interested in the power relation between microwave circuits connected through a junction. In this case, the magnitude of the reflection coefficient cannot exceed unity and the power delivered to the load is directly given by the difference between the powers associated with the incident and the reflected waves. Since this methodology deals with the reciprocal relations between powers from various devices this may be quite suitable for dealing with a pair of transmitting and receiving antennas where power reciprocity holds. This methodology is also applicable in network theory where the scattering matrix of a two port (or a multiport) can be defined using complex reference impedances at each of the ports without any transmission line being present, so that the characteristic impedances become irrelevant. Such a situation is typical in small signal microwave transistor amplifiers, where the analysis necessitates the use of complex reference impedances in order to study simultaneous matching and stability. However, for both the definition for the S-parameters, when the characteristic impedance or the reference impedance is complex, the scattering matrix need not be symmetric even if the network in question is reciprocal.