REVIEW OF SIX-PORT REFLECTOMETERS INTENDED FOR SENSOR APPLICATION

Kamil Staszek

Department of Electronics, AGH University of Science and Technology, Al. Mickiewicza 30, 30-059 Krakow, Poland
e-mail: kamil.staszek@agh.edu.pl

Six-port reflectometers constitute a well-known class of microwave circuits, which serve for vector measurements in high frequency domain [1]. They combine simple circuitry, as they are composed of a simple passive power division network and power detectors, with high measurement accuracy. A great majority of these reflectometers are considered as general-purpose measurement circuitry, meaning that their measurement uncertainty is optimized for a wide range of the measured reflection coefficient [2]. As such they can be widely applied not only in direct measurements of scattering parameters, but also in indirect measurement of non-electrical values e.g., material permittivity [3]. However, in the second application the signal measured by the six-port reflectometer i.e., reflection coefficient of the sensor exposed to material under test usually exhibits insignificant dynamics. This in turn becomes highly demanding for measurement circuitry of general purpose.

Recently, the above problem has been addressed by proposing a new measurement uncertainty distribution. In [4] a reflectometer has been proposed, which is characterized by the measurement uncertainty significantly narrowed down to only a small area close to the reflection coefficient of the sensor. It has been achieved by a novel topology of the power distribution network, which increases dynamics of the measured power for the considered small range of the reflection coefficient. As a consequence, measurement of values outside this area would become inaccurate, however, they are never measured with the reflectometer dedicated to a given application. It must be underlined that by such a modification of the passive network can lead to an enhancement of the measurement uncertainty by the factor greater than two [5]. On the other hand, the reflectometer reported in [5] suffers from two reasons. Firstly, it is a narrowband circuit, hence measurement of the sensor's response is limited to a single frequency. Secondly, the passive network must be precisely designed to operate in conjunction with a given sensor.

The above drawbacks have been eliminated in a reflectometer described in [6]. It is a wideband circuit, operating over bandwidth greater than two octaves. This allows for gathering more data related to the sensor's response and using it to suppress noise, leading to much higher final sensitivity. Additionally, this reflectometer is equipped with an additional port, to which so-called reference reflection coefficient can be connected. Its value corresponds to the center of the area with the optimized measurement uncertainty. Hence, by connecting as a reference (not used in actual measurements) a similar sensor to the one exposed to tested material, the measurement uncertainty automatically adjusts to the desired region over the entire frequency of operation. Finally, both aspects mentioned above leads to a significant enhancement of the measurement uncertainty. As given in [6], this solution has been used to detect low concentration of acetone in the air, and the obtained results shows a high-quality sensor's response even below 1 ppm of acetone concentration measured in a room temperature.

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