Radio frequency/microwave attenuation and phase-shift standards

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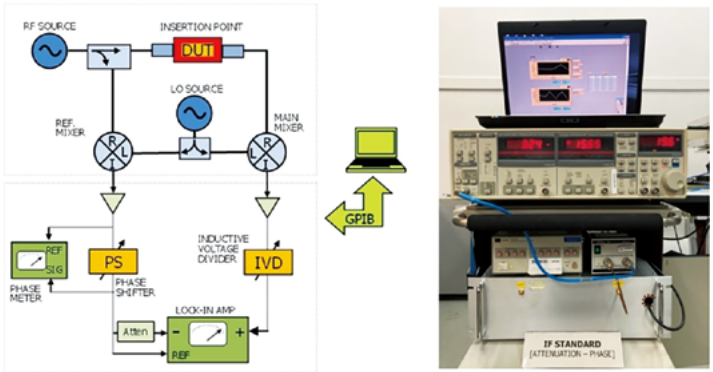
In radio-frequency (RF) and microwave (MW) S-parameter (transmission and reflection coefficients) measurements, the phase information can often be ignored because of its small impact on specification measurements. However, with the increasing complexity of antenna devices, such as various smart antennas used in 5G/6G wireless technology, and with applications related to safety and security, such as current radars used in advanced emergency braking systems, phase information can no longer be ignored. Therefore, accurate information on both amplitude and phase is essential for the S-parameter measurements used in such applications.

Recently, NMIJ developed a precision attenuation and phase-shift measurement system in the frequency range of 10 MHz to 18 GHz, which is used as a primary national standard. The system works based on the intermediate frequency (IF=1 kHz) substitution technique built into a dual-channel null system configuration using a lock-in amplifier as a precision-null detector. An inductive voltage divider and a particular IF phase-shifter are used for the amplitude or attenuation and phase adjustments, respectively, in the null-balancing process. The IF attenuation and phase-shift values represent the RF attenuation and the phase shift of the calibrated device. The dual-channel null balancing system is employed because it is advantageous for signal stability of the source, gain stability of the detector and the highest sensitivity. This system has measurement capabilities of up to 60 dB of attenuation with uncertainties ranging from 0.002 dB for attenuation and 0.029° for phase shift. Standards in the frequency range of 10 MHz to 1 GHz are distributed according to the Japan Calibration Service System (JCSS). A simple working standard system for routine calibration services has also been developed using a general-purpose receiver traceable to the primary standard mentioned above.



Block diagram of the primary standard system for RF/MW attenuation and phase-shift (left) and a photograph of its working standard system (right).

References:
1. A. Widarta, *IEEE Trans. Instrum. Meas.*, 68, 6, 1840–1843, 2019, DOI: 10.1109/TIM.2018.2888920
2. A. Widarta, *Proc. CPEM Dig.*, Wellington, New Zealand, 2022