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Millimeter Wave (30 – 300 GHz) Virtual Connected Vector Network Analyzer

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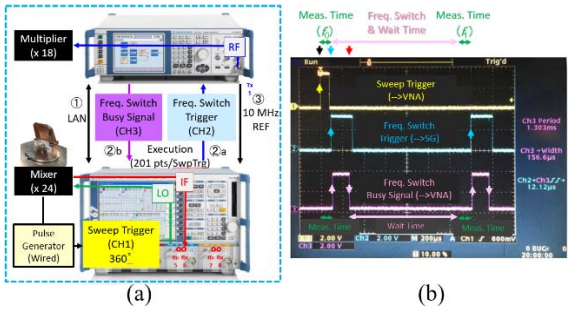
A Vector Network Analyzer (VNA) with virtual (wireless) connection of external transmission systems is proposed for efficient characterization of millimeter-wave band (30 to 300 GHz) antennas in a multi-path environment, and its configuration and effectiveness are described.

VNAs are often used in various antenna measurements because of their advantages such as phase measurement, multi-channel measurement, ultra-wideband measurement, high-resolution delay measurement, frequency conversion measurement, calibration function, and high dynamic range for narrowband signals, but they are also practical instruments for millimeter-wave band field measurements. In a typical configuration, the three elements of the VNA (transmitter system, receiver system, and S-parameter set) are mounted in the same housing. However, for antenna measurements in large anechoic chambers or at open sites, the transmitter system of the VNA is connected externally and the receiver system is connected directly (bypassing the S-parameter set) because of the long transmitting and receiving antenna distances. This external transmit/direct receive VNA configuration [1] is considered to be extremely effective in the evaluation of antenna characteristics and direction-of-arrival characteristics in a multiple-path environment. However, the above configuration requires a wired connection between the external transmitter and the receiving VNA, which is not suitable for outdoor field measurements. In this paper, we propose a VNA system in which the transmitter and receiver systems are virtually connected (wirelessly) in order to further expand the range of application of millimeter-wave band outdoor multiple-path environmental antenna measurements.

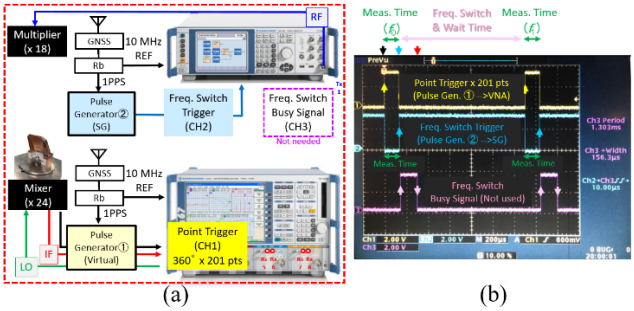
As shown in Figure 1(a), four cables are connected in the conventional wired connection VNA system (blue frame) [2]: (1) LAN cable for control commands, (2-a) trigger sending and (2-b) receiving cables, and (3) 10 MHz reference signal cable, and the angle pulse from the pulse generator is input as an external trigger. Figure 1(b) shows an example of trigger observation in the wired connection and sweep trigger mode.

Figure 2(a) shows the proposed virtual connected VNA configuration. Separate GNSS receivers, rubidium oscillators (Rb), and pulse generators are connected to the main VNA (receiver system) and the transmission system, respectively. The transmitter system is not controlled by the VNA main unit, so the frequency sweep transmission is synchronized with the GNSS 1 PPS signal as a reference. The VNA main unit (receiving system) is also synchronized by sweeping the frequency and receiving with respect to the 1 PPS signal of the separately installed GNSS. As described above, the virtual connection VNA has (1) no LAN cable for control commands because there is no control of the transmission system, (2) no trigger cable because both sides have synchronized trigger signals, and (3) no reference signal cable because a rubidium oscillator with GNSS is available, resulting in a configuration with no cables at all. As shown in Figure 2(b), unlike the conventional type, the proposed type adopts the point-trigger mode, in which a measurement trigger (yellow, upper row) is given as an external trigger at each sweep frequency point.



(a) (b)

Figure 1. Conventional wired connection VNA



(a) (b)

Figure 2. Proposed virtual connected VNA

References

[1] Keysight Technologies, Antenna Test, Selection Guide, 5968-6759JAJP, Feb. 2006.
[2] Toshiki Hozen, et all. Proceedings of ISAP2022 Oct. 2022. doi: 10.1109/ISAP53582.2022.9998851.