## Millimeter-Wave S-Parameter Measurements

Keysight Technologies and OML

## Perform millimeter-wave S-parameter measurements with VNA frequency extension modules

Millimeter-wave (mm-wave) measurements require the same fundamental tools that engineers use for the RF & microwave spectrum. For S-parameter measurements this means a vector network analyzer (VNA). Frequency extension of a microwave vector network analyzer is possible up to 0.5 Terahertz (THz). By adding frequency extension modules you can overcome the inherent microwave limitations of your vector network analyzer allowing you to achieve accurate and repeatable millimeter-wave S-parameter measurements

Millimeter-wave measurements are essential for research into next generation technology in areas such as radio astronomy, imaging, communication, semiconductors, space research, biomedical and homeland security. With a spectrum from 50 GHz to 500 GHz and greater, the complexity of measurements requires specialized solutions, especially as the wavelengths approach sub-millimeter in length.

The key enablers for millimeter-wave S-parameter measurements are harmonic mixer

and multiplier technologies. OML provides vector network analyzer frequency extension technology that connects as external modules to the Keysight PNA or PNA-X for mm-wave S-parameter measurements. The external VNA modules extend the frequency range of the vector network analyzer into the mm-wave bands. By using external modules the connections to the device-under-test (DUT) are closer giving improved dynamic range. They can be interfaced to the DUT via over-the-air, on-wafer, or waveguide connections. The waveguide interface is compatible

with MIL-DTL-3922/67D (UG 387/U-M).

- Perform millimeter-wave S-parameter measurements
- Millimeter-wave extension modules for vector network analyzers
- Extend the frequency range of the Keysight PNA and PNA-X
- External VNA modules simplify setup and optimize performance
- Over-the-air, on-wafer, or waveguide connections to your DUT
- Waveguide interface compatible with MIL-DTL-3922/67D (UG 387/U-M)
- Accurate and repeatable S-parameter measurements on mm-wave devices



## Millimeter-Wave S-Parameter Measurements

Once connected, the OML VNA modules utilize the predetermined RF, LO and IF to effectively multiply the PNA or PNA-X microwave capabilities to the mm-wave spectrum. The familiar front panel operation for setup, calibration, measurement, and output are the same, except the readouts are in the mm-wave instead of microwave spectrum. The Keysight PNA and PNA-X are plug-and-play compatible with the frequency extension modules available from OML.

A typical mm-wave S-parameter configuration consists of a PNA or PNA-X vector network analyzer, an optional mm-wave test set controller and the external module(s). For one-port S-parameter measurements (S11), the VNA module configuration is transmit/receive. For one-path, two port measurements (S11, S21), two modules are necessary — transmit/receive & transmit configurations. For all four S-parameters (S11, S21, S12, S22), two transmit/receive modules are necessary. For active device testing, an optional 25 dB manual adjustable attenuator is available and for antenna applications, optional 15 dB amplification can be used to overcome long cable runs in RF & LO paths. Waveguide calibration kits are also available as separate accessories.

OML's external frequency extension modules when combined with an Keysight vector network analyzer allow you to extend the frequency range of your instruments to perform accurate and repeatable S-parameter measurements on your millimeter-wave band circuits and devices.

## **System Components**

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PNA/PNA-X	Vector network analyzer	
OML		
V15VNA2	WR-15, 50-75 GHz	
V12VNA2	WR-12, 60-90 GHz	
V10VNA2	WR-10, 75-110 GHz	
V08VNA2	WR-08, 90-140 GHz	
V06VNA2	WR-06, 110-170 GHz	
V05VNA2	WR-05, 140-220 GHz	
V03VNA2	WR-03, 220-325 GHz	
V02.2VNA2	WR-02.2, 325-500 GHz	
Option - A	Add 25 dB manual attenuator (Except WR-02.2)	
Option - RLA	Add RF&LO amps (15 dB)	

To learn how this solution can address your specific needs please contact Keysight's solutions partner, OML

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OML, Inc. is a premier supplier of innovative millimeter and sub-millimeter wave frequency extension products for vector network analyzers, scalar network analyzers, spectrum analyzers, converters, and signal generators. Our solutions empower engineers in R&D and manufacturing to pursue opportunities in emerging applications spanning radio astronomy, communication, imaging, space research, and homeland security

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