Preliminary

170/250 GHz Broadband VNA Solutions Using Frequency Extenders

Single-Sweep Millimeter-wave Broadband VNA to 170 / 250 GHz for 6G and Data Center Component Characterization

Introduction

Keysight's new NA5305A/7A Frequency extenders with 0.5 mm coaxial test port connector enable you to configure a millimeter-wave broadband VNA up to 170 GHz/250 GHz using the N522x/4xB PNA/PNA-X Microwave network analyzer and the N5292A Test set controller and measure S-parameters and power. Keysight's 85065A 0.5 mm coaxial precision calibration kit, which includes the impedance standards to 250 GHz and a combination of the U8489A 1.0 mm USB thermocouple power sensor and waveguide power sensors allow the user to fully calibrate the broadband measurement setup up to 250 GHz.



KEYSIGHT

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New 170 GHz / 250 GHz Broadband Vector Network Analysis

The N522xB PNA/N524xB PNA-X network analyzer with the N5292A test set controller and the NA5305A/NA5307A 170 GHz/250 GHz frequency extenders provide fully calibrated broadband, single-sweep S-parameter measurements from 100 kHz/10 MHz to 170/250 GHz.

The NA5305/7A frequency extenders equipped with a ruggedized 0.5 mm coaxial male test port connector are designed compact and lightweight and driven and controlled with a PNA/PNA-X network analyzer and a P9500A frequency extender hub via USB.

The 85065A 0.5 mm coaxial precision calibration kit includes 16 calibration standards to accurately calibrate the VNA measurement setup up to 250 GHz.

You can configure a 4-port VNA to make differential measurements of semiconductor device characterization/modeling up to 250 GHz for various applications: 6G research and data center network for 1.6 Tb, 3.2 Tb and beyond, like signal integrity and modeling of passive devices, PCBs, cables, packages, Optical RF drivers and TIAs (Transimpedance Amplifiers) can also be measured.

Key Features

- 170/250 GHz single-sweep broadband VNA
- Easily upgrade the broadband 110/120 GHz VNA setup using the N52xxB PNA / PNA-X network analyzer with the N5292A test set controller
- 4-port configuration for 2-port differential measurement
- 85065A 0.5 mm precision mechanical calibration kit up to 250 GHz
- ≥ -5 dBm output power up to 220 GHz
- System dynamic range >=105 dB @ 220 GHz
- 0.1 dB receiver compression @ +10 dBm (with 10 dB receiver attenuator)

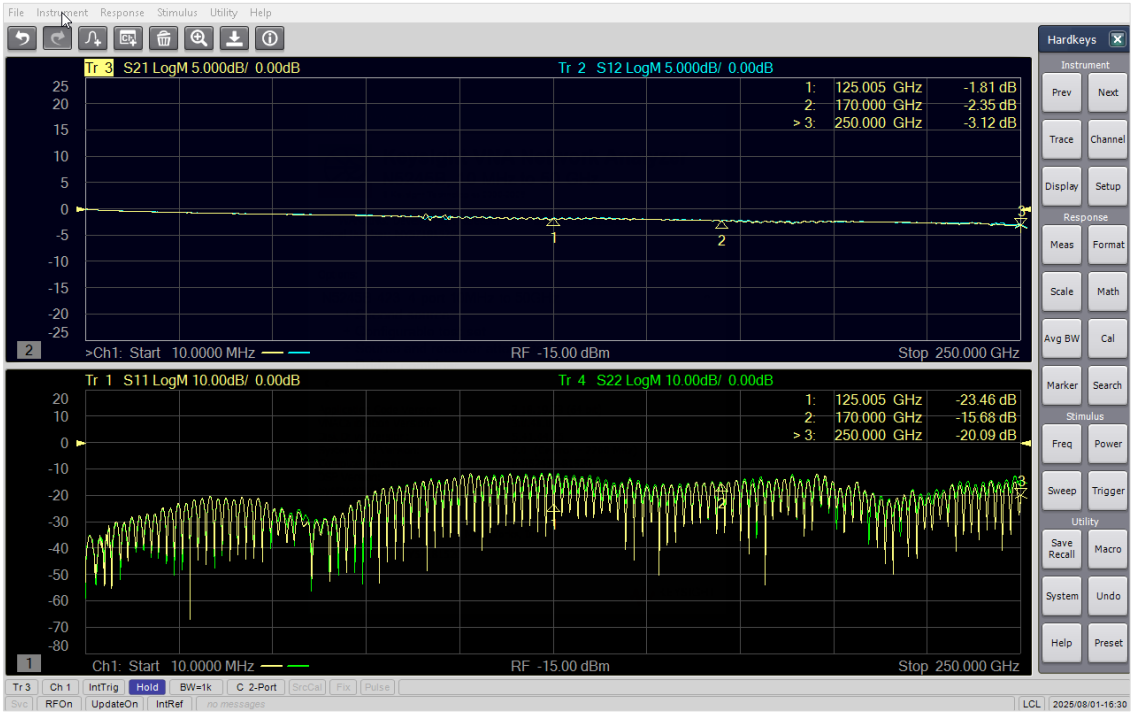


Figure 1. S-parameter measurement from 10 MHz to 250 GHz. (DUT: Junkosha 0.5 mm cable assembly)

Measurement Performance

Description		Typical[1]
Minimum frequency		10 MHz (100 kHz with PNA/PNA-X with Low Frequency Extension (LFE) option)
Maximum frequency[2]		170 GHz (NA5305A) / 250 GHz (NA5307A)
Output power	100 kHz to 100 MHz (with LFE)	> 0 dBm
	10 MHz to 120 GHz	> 0 dBm
	120 GHz to 220 GHz	> -5 dBm
	220 GHz to 250 GHz	> -20 dBm
System dynamic range	100 kHz – 100 MHz (with LFE)	≥ 95 dB
	10 MHz to 50 MHz	≥ 75 dB
	50 MHz to 100 MHz	≥ 90 dB
	100 MHz to 500 MHz	≥ 95 dB
	500 MHz to 20 GHz	≥ 100 dB
	20 GHz to 170 GHz	≥ 110 dB
	170 GHz to 220 GHz	≥ 105 dB
	220 GHz to 250 GHz	≥ 75 dB
Noise floor (10 Hz BW)	100 kHz to 100 MHz (with LFE)	≤ -95 dBm
	10 MHz to 50 MHz	≤ -75 dBm
	50 MHz to 100 MHz	≤ -90 dBm
	100 MHz to 500 MHz	≤ -95 dBm
	500 MHz to 20 GHz	≤ -100 dBm
	20 GHz to 170 GHz	≤ -110 dBm
	170 GHz to 220 GHz	≤ -110 dBm
	220 GHz to 250 GHz	≤ -95 dBm
Minimum power setting	100 kHz to 250 GHz	-50 dBm (Ports 1 and 3)[3] / -25 dBm (Ports 2 and 4)
Receiver compression	0.1 dB relative to linear value	0 dBm (with no attenuator)[4]
Environmental temperature	Operating and calibration range	23° ±3 °C, with < 1 °C deviation from calibration temperature
Input damage level at test port		+12 dBm[5]

1.Preliminary typical data. The data may be subject to change.
2.Measurements in the 245-250 GHz region may exhibit increased ripple associated with higher-order mode
3.Open loop and receiver leveling are required to reach the minimum settable power or below.
4.Receiver attenuators can be used for increasing the compression level. 0.1 dB compression is expected @ +10 dBm with 10 dB receiver attenuator.
5.Input damage level with >=10 dB receiver attenuator is +15 dBm. Note: Preset will set the receiver attenuator to 0 dB.

170 GHz / 250 GHz Broadband VNA Configurations

To configure a customized broadband solution using separate system components, follow these three steps:

- Select one of the supported PNA or PNA-X network analyzers.
- Select the N5292A test set controller with the appropriate port number and interconnect kit options and the P9500A Frequency extender hub
- Select the NA5305A 170 GHz or NA5307A 250 GHz frequency extenders and appropriate option
- Select PNA application software.
- Select necessary accessories including a calibration kit, power sensors and adapters.

The performance of the individual products is guaranteed to have all of the functionality of those in the pre-configured N5290A/91A system, but system level specifications are not supplied for all configurations.

If you have the PNA/PNA-X network analyzer and the N5292A test set controller, you can start the upgrade in the N5292A interconnect kit upgrade.

Step 1: Supported PNA Configurations

Select one of the PNA and PNA-X models in the tables below.

The supported PNAs and PNA-Xs for 2-port configuration

- N5222/4/5/7B 26.5/43.5/50/70 GHz PNA with Option 2xx [1] and 020.
- N5242/4/5/7B 26.5/43.5/50/70 GHz PNA-X with Option 2xx and 020.

The supported PNAs and PNA-Xs for 4-port configuration

- N5222/4/5/7B 26.5/43.5/50/70 GHz PNA with Option 4xx[1] and 020.
- N5242/4/5/7B 26.5/43.5/50/70 GHz PNA-X with Option 4xx and 020.

For details or to add other PNA or PNA-X options to the above listed minimum configuration please refer to the PNA Family Microwave Network Analyzers (N522x/3x/4xB) - Configuration Guide.

1 Option 210/410 can't be used. An option with configurable test set is recommended.

Step 2: N5292A Millimeter-Wave Test Controllers and P9500A Frequency Extender Hub

Select either 2-port (Option 200) or 4-port (Option 400), and then an interconnect kit option (Option 5xx) depending on the PNA or PNA-X and the number of port of the selected N5292A.



N5292A Millimeter-wave test set controller (Option 200)



N5292A Millimeter-wave test set controller (Option 400)

Port Configuration	N5292A Required Option
2-port millimeter-wave measurements	Option 200
4-port millimeter-wave measurements	Option 400

N5292A Interconnect Kit Options

N52xxB PNA/PNA-X		2-Port Test Set Controller (N5292A with Option 200)	4-port Test Set Controller (N5292A with Option 400)
2-port	N52x2B with Option 2xx	Option 501 Interconnect kit for 2 or 4-port test set and 2-port VNA with 3.5 mm ports for use with NA530xA frequency extenders	
	N52x4/5/7B with Option 2xx	Option 502 Interconnect kit for 2 or 4-port test set and 2-port VNA with 2.4 mm or 1.85 mm ports for use with NA530xA frequency extenders	
4-port	N52x2B with Option 4xx	Option 503 Interconnect kit for 2-port test set and 4-port VNA with 3.5 mm ports for use with NA530xA frequency extenders	Option 505 Interconnect kit for 4-port test set and 4-port VNA with 3.5 mm ports for use with NA530xA frequency extenders
	N52x4/5/7B with Option 4xx	Option 504 Interconnect kit for 2-port test set and 4-port VNA with 2.4 mm or 1.85 mm ports for use with NA530xA frequency extenders	Option 506 Interconnect kit for 4-port test set and 4-port VNA with 2.4 mm or 1.85 mm ports for use with NA530xA frequency extenders

Upgrades for PNA/PNA-X and N5292A Users

If you already have the N5292A test set controller to use with the N5293AX/AY or N5295AX/AY frequency extenders for the 110/120 GHz broadband VNA, most of the interconnect kit cables can be used even in the setup with the NA530xA frequency extenders. You can order the upgrade kit that will provide new additional interconnect cables for the setup with the NA530xA frequency extenders.

N5292A Interconnect Kit Upgrade Options (Y9400A)[1]

<table>
<tr><th colspan="2">N52xxB PNA/PNA-X</th><th>2-port Test Set Controller
(N5292A with Option 200)</th><th>4-port Test Set Controller
(N5292A with Option 400)</th></tr>
<tr><td rowspan="2">2-port</td><td>N52x2B
with Option 2xx</td><td colspan="2">Option 511
Upgrade kit from N5292A Option 222/422 to Option 501 for use with NA530xA frequency extenders</td></tr>
<tr><td>N52x4/5/7B
with Option 2xx</td><td colspan="2">Option 512
Upgrade kit from N5292A Option 224/424 to Option 502 for use with NA530xA frequency extenders</td></tr>
<tr><td rowspan="2">4-port</td><td>N52x2B
with Option 4xx</td><td>Option 513
Upgrade kit from N5292A Option 242 to Option 503 for use with NA530xA frequency extenders</td><td>Option 515
Upgrade kit from N5292A Option 442 to Option 505 for use with NA530xA frequency extenders</td></tr>
<tr><td>N52x4/5/7B
with Option 4xx</td><td>Option 514
Upgrade kit from N5292A Option 244 to Option 504 for use with NA530xA frequency extenders</td><td>Option 516
Upgrade kit from N5292A Option 444 to Option 506 for use with NA530xA frequency extenders</td></tr>
</table>

PNA Windows OS

The PNA/PNA-X Windows OS must be Windows 11. If your PNA/PNA-X run on an older version of Windows OS, you need to upgrade the Windows OS. The upgrade kit depends on the hardware and the OS version. Refer to this page to find an appropriate Windows upgrade kit.
https://www.keysight.com/us/en/lib/resources/miscellaneous/pna-windows-upgrades.html

PNA Signal Source

The PNA/PNA-X signal source must be DDS source (Synthesizer 7).

1 The main model number of this upgrade kit is Y9400A.

Step 3: Millimeter-Wave Frequency Extenders

Select the model and option number of the frequency extenders depending on the maximum frequency, cable length and bias operation. The frequency extender is controlled via USB.

Maximum Frequency	170 GHz		250 GHz	
Model number	NA5305A[2]		NA5307A[2]	
	Option number			
Cable length	1.2 m	1.8 m	1.2 m	1.8 m
No bias tee	Option 012	Option 018	Option 012	Option 018
with bias tee	Option T12	Option T18	Option T12	Option T18

Description		
Option T12 or T18	Maximum DC bias voltage / Damage level	±20 V / ± 22 V (typical)[1]
	Maximum DC bias current / Damage level	100 mA / 120 mA (typical)[1]
	DC bias input connector	SMA (f)
	DC bias sense connector	Lemo K connector, 2 contacts
Dimensions		80 mm (H) x 50 mm (W) x 215 mm (D)
Weight		1 kg
Furnished accessory		2 m USB cable 1ea
Operation temperature range		23 ± 5 ℃



NA5307A Frequency extender

1. Preliminary typical data. The data may be subject to change.
2. Export controlled

P9500A Frequency Extender Hub

Select P9500A Frequency extender hub, which drives up to four NA5305/7A frequency extenders via USB.

Description	
DC input	24 V / 10 A
DC output	15 V / 3 A (45 W) maximum per port
Dimensions	48 mm (H) x 176 mm (W) x 333 mm (D)
Weight	1.5 kg
Line Power	250 W maximum



P9500A Frequency extender hub

Frequency Extender Bias Tee Adapter Kit (NA5311A301)

The frequency extender bias tee adapter kit is used to adapt the bias tee connectors on the NA5305A/07A to a standard triax connector for use with a SMU or a DC power supply.

The NA5311A301 includes the following:

- An adapter module with Force and Sense input and Force, Sense, and Ground output (P/N: N5290-60007)
- 1.2 m BNC (m) – SMA (m) cable (P/N: 8120-3347) 1.2 m length
- Lemo to Lemo cable (P/N: NA5300-60006) 1.2 m length

The different components may be purchased as replaceable parts see part numbers in parenthesis.

A single NA5311A301 adapter is required per NA5305A/07A frequency extender with the bias tee option used in the system.



NA5311A301 Frequency extender bias tee adapter for NA530xA

Frequency Extender Positioner (NA5311A302)[1]

Designed to position the NA5305A/7A frequency extenders when the measurement setup is used on a desktop and provides the following capability:

- Easily aligns the frequency extenders for connection to 0.5 mm connectorized devices.
- Simplifies the interconnection of the 0.5 mm ruggedized test ports.
- Improves repeatability of connections.
- Restricts module movement to protect 0.5 mm connectors.

1. One NA5311A302 is required per NA5305A/07A frequency extender.

Step 4: PNA Application Software

Select supported PNA software applications as appropriate.

- S93007B Automatic fixture removal
- S93010B Time domain application
- S93080B Frequency-offset measurement
- S93089B Differential and I/Q application
- S93460B True mode stimulus

For more details, please refer to the “PNA Family Microwave Network Analyzers (N522x/3x/4xB) - Configuration Guide”, literature number 5992-1465EN.

Step 5: Accessories

Select the accessories depending on the application.

Calibration Kit

85065A Precision calibration kit, 0.5 mm

85065F Precision calibration kit, 0.5 mm female-only

The 85065A precision calibration kit includes 8 male standards and 8 female standards each include 6 offset shorts, an open and load. Also included are three adapters (male-male, male-female and female-female) and torque wrenches for the 0.5 mm connector. The 85065F precision calibration kit contains female standards only.



85065A Precision calibration kit, 0.5 mm

The torque wrench for the 0.5 mm connector, KPN 8750-0575 (Wrench–torque, double-ended, 3-in-lb and 10-in-lb, 12 mm open end) is included in the 85065 A/F calibration kit but not a furnished accessory of the frequency extender. If you don’t have the wrench for the 0.5 mm connector and if you don’t order the calibration kit, you need to purchase the wrench.

Power Meters and Power Sensors for Power Calibration

Select one power meter and power sensors to cover the entire frequency range.

	Description
Power meter	N1913B EPM series single-channel power meter (or N1914B EPM series dual-channel power meter)
Power sensor	U8489A USB thermocouple, 1.0 mm coaxial power sensor, DC to 120 GHz
	N8486DD Waveguide power sensor, 110 to 170 GHz
	N8486DG Waveguide power sensor, 170 to 220 GHz
Power meter	N1913PM5B-701 VDI Erickson PM5B millimeter-wave power meter standard configuration
power sensor	N1913PM5B-004 WR4.3 Waveguide Taper, 170-260 GHz
	N1913PM5B-005 WR5.1 Waveguide Taper, 140-220 GHz
	N1913PM5B-006 WR6.5 Waveguide Taper, 110-170 GHz



N1913B single-channel power meter



U8489A USB Thermocouple power sensor, DC to 120 GHz





N8486DD 110 to 170 GHz and N8486DG 140 to 220 GHz Waveguide power sensors



N1913PM5B-701 VDI Erickson PM5B millimeter-wave power meter with a taper

An adapter is required for connecting the power sensor for each band for the power calibration. If you don't know the power loss of the adapter in each frequency band, you need to measure the power loss with the mechanical calibration kit in the corresponding frequency band.

Frequency Range	Power Sensor	Adapter	Mechanical Calibration Kit
<=120 GHz	U8489A	Y1922F	85059B
110 to 170 GHz	N8486DD [1] (or N1913PM5B with Option 006)	Y1932D	N5262AC06
140 to 220 GHz	N8486DG [1] (or N1913PM5B with Option 005)	Y1931D	N5262AC05
170 to 250 GHz	N1913PM5B with Option 004	Y1930D	N5262AC04

1 Requires a compatible power meter like N1913B.

Adapters

Select necessary adapters to connect the frequency extenders with ruggedized 0.5 mm male connector to the DUT for the measurement and to the calibration kit, and the power sensors for the calibration.

Adapter	Description
Y1904B	Ruggedized 1.0 mm (f) to Standard 0.8 mm (f) Adapter, DC to 120 GHz
Y1904C	Ruggedized 1.0 mm (f) to Standard 0.8 mm (m) Adapter, DC to 120 GHz
Y1920A	Standard 0.5 mm (m) to Standard 0.5 mm (m) Adapter, DC to 250 GHz
Y1920B	Standard 0.5 mm (f) to Standard 0.5 mm (f) Adapter, DC to 250 GHz
Y1920C	Standard 0.5 mm (m) to Standard 0.5 mm (f) Adapter, DC to 250 GHz
Y1920F	Ruggedized 0.5 mm (f) to Standard 0.5 mm (f) Adapter, DC to 250 GHz
Y1920H	Ruggedized 0.5 mm (f) to Standard 0.5 mm (m) Adapter, DC to 250 GHz
Y1920K	Ruggedized 0.5 mm (f) to Ruggedized 0.5 mm (f) Adapter, DC to 250 GHz
Y1920L	Ruggedized 0.5 mm (f) to Ruggedized 0.5 mm (m) Adapter, DC to 250 GHz
Y1921F	Ruggedized 0.5 mm (f) to Standard 0.8 mm (f) Adapter, DC to 167 GHz
Y1921H	Ruggedized 0.5 mm (f) to Standard 0.8 mm (m) Adapter, DC to 167 GHz
Y1922F	Ruggedized 0.5 mm (f) to Standard 1.0 mm (f) Adapter, DC to 120 GHz
Y1922H[1]	Ruggedized 0.5 mm (f) to Standard 1.0 mm (m) Adapter, DC to 120 GHz
Y1922K	Ruggedized 0.5 mm (f) to Ruggedized 1.0 mm (f) Adapter, DC to 120 GHz
Y1922M	Ruggedized 0.5 mm (f) to Ruggedized 1.0 mm (m) Adapter, DC to 120 GHz
Y1923F	Ruggedized 0.5 mm (f) to Standard 1.85 mm (f) Adapter, DC to 72 GHz
Y1930D	Ruggedized 0.5 mm (f) to WM-1092 Waveguide Adapter, 170-250 GHz
Y1931D	Ruggedized 0.5 mm (f) to WM-1295 Waveguide Adapter, 140-220 GHz
Y1932D	Ruggedized 0.5 mm (f) to WM-1651 Waveguide Adapter, 110-170 GHz

1. This adapter can't be used for connecting the NA5305A/7A frequency extender and MPI's 1.0 mm probe. Spinner supplies the appropriate adapter.



Specification

The warranted performance of a calibrated instrument that has been stored for a minimum of 2 hours within the operating temperature range of 25 °C ± 5 °C and after a 60-minute warm up period.

Typical

The performance, which 80% or more of manufactured instruments will meet. This data is not warranted, does not include measurement uncertainty, and is valid only at room temperature (approximately 23 °C).

Nominal

The mean or average performance, or the value of an attribute that is determined by design such as a connector type, physical dimension, or operating speed.

Conclusion

The NA5305A/NA5307A Frequency extenders with the PNA/PNA-X network analyzer with the N5292A test set controller achieves single-sweep broadband S-parameter measurements up to 170/250 GHz to help you to characterize millimeter-wave components/devices.

Related Literature

Literature	Publication Number
PNA Family Microwave Network Analyzers (N522x/3x/4xB) – Configuration Guide	5992-1465EN
PNA/PNA-X Series Microwave Network Analyzers – Brochure	5990-4592EN
Millimeter Wave Network Analyzers (N5290A/N5291A) – Configuration Guide	5992-2179EN
Banded Millimeter Wave Network Analysis to 1.5 THz – Technical Overview	5992-2177EN
Keysight 2-Port and 4-Port PNA Network Analyzer: N5221B – 900 Hz to 13.5 GHz, N5222B – 900 Hz to 26.5 GHz – Data Sheet	N5221-90003
Keysight 2-Port and 4-Port PNA Network Analyzer: N5224B – 900 Hz to 43.5 GHz, N5225B – 900 Hz to 50 GHz – Data Sheet	N5224-90003
Keysight 2-Port and 4-Port PNA Network Analyzer: N5227B – 900 Hz to 67 GHz – Data Sheet	N5227-90005
Keysight 2-Port and 4-Port PNA-X Network Analyzer: N5249B – 900 Hz to 8.5 GHz, N5241B – 900 Hz to 13.5 GHz, N5242B – 900 Hz to 26.5 GHz – Data Sheet	N5242-90027
Keysight 2-Port and 4-Port PNA-X Network Analyzer: N5244B – 900 Hz to 43.5 GHz, N5245B – 900 Hz to 50.0 GHz – Data Sheet	N5245-90028
Keysight 2-Port and 4-Port PNA-X Network Analyzer: N5247B – 900 Hz to 67 GHz – Data Sheet	N5247-90029

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