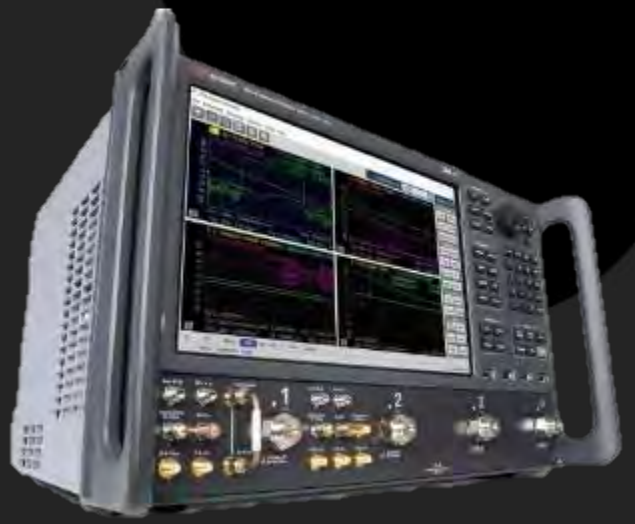
KEYSIGHT

The Configurable PXI VNA and ENA-X



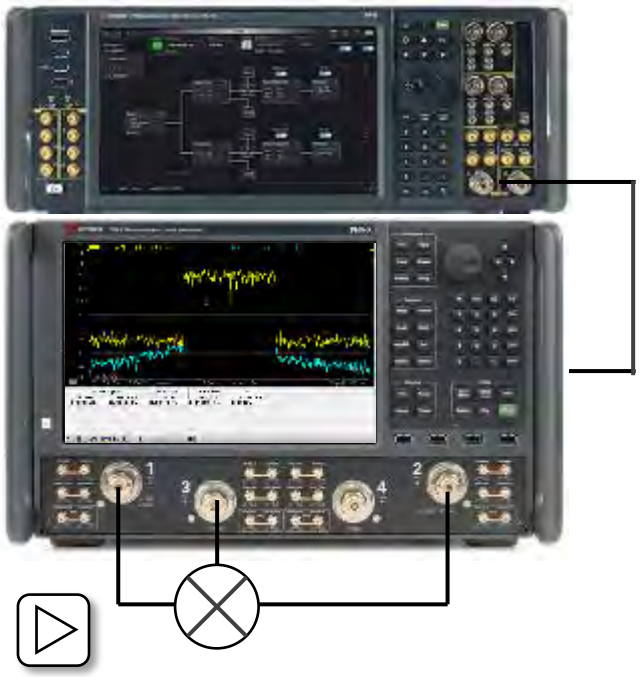
Nick Caira
May 2024

New Approach Using the Latest VNA

PNA-X with mmwave VSG

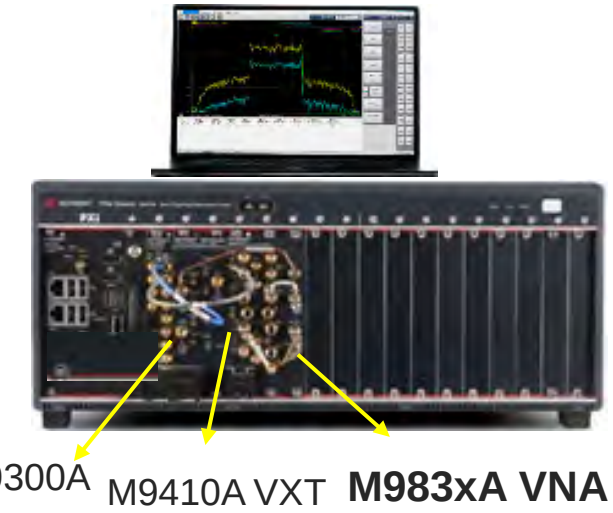
Modulated source
(ex. M9383/84 VXG, PSG+AWG, or MXG)

PNA-X



- ✓ Solution for **R&D and DVT**
- ✓ Requires external high-frequency source for signal generation
- ✓ Simple & easy setup, single connection
- ✓ DUT: Amplifiers, frequency converting components

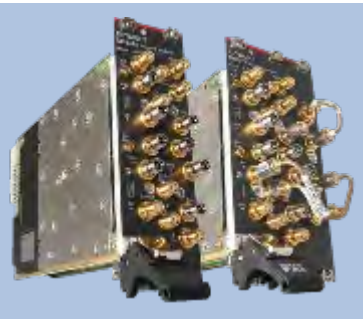
M983xA PXI VNA + RF VSG



- ✓ Lower-cost for **production tests**
- ✓ Requires external RF source (6 GHz) for high-frequency signal generation
- ✓ Scalable, compact PXI-based system
- ✓ **Multiport** configurations
- ✓ DUT: Amplifiers, frequency converting components

Keysight PXI VNA Portfolio

Performance



M983xA: Configurable PXI VNA NEW!

- 2-port, 20 and 44 GHz with configurable test set
- Flexible, scalable, and configurable system setup
- Noise figure measurements per port
- Network analysis and modulation distortion analysis with a single connection

M980xA (2, 4, 6-port)

M980xA: Standard PXI VNA

- 4-/6-port up to 20 GHz, or 2-port up to 53 GHz
- True multiport measurements: max 66-ports up to 20 GHz, or max 34-ports up to 53 GHz
- Wide application coverage
- Best-in-class PXI VNA performance

M937xA

M937xA: Economy PXI VNA

- 2-port up to 26.5 GHz
- Low-cost, true multiport measurements
- Simple passive component measurements

Price

ENA Series Vector Network Analyzers Portfolio

Performance

E5081A (2-port)

E5081A (4-port)

E5081A ENA-X: Configurable ENA

- 2- and 4-port, 20 and 44 GHz with configurable test set
- Noise figure measurements on both ports 1 and 2
- Network analysis and modulation distortion analysis with a single connection
- Best-in-class VNA performance

NEW!

E5080B (2-port)

E5080B (4-port)

E5080B ENA: Standard ENA

- 2- or 4-port options, up to 53 GHz
- Built-in hardware capabilities
- Wide application coverage
- Best-in-class VNA performance

E5061B (RF NA)

E5061B (LF-RF)

E5061B: LF-RF & Basic RF NA

- Low frequency down to 5 Hz (LF-RF Options)
- Impedance analysis (LF-RF Options only)
- 50- or 75-ohm up to 3 GHz (RF NA options)

E5063A

E5063A: Lowest-cost ENA

- 2-port, 50-ohm, up to 18 GHz
- Optimized cost and performance
- Simple passive component measurements

Price

E5081A ENA-X Vector Network Analyzer

- Keysight E5081A ENA-X Vector Network Analyzer (VNA) with **configurable test set**
- Integrated capabilities including **low-noise receivers on ports 1 and 2** for efficient noise figure measurements, spectrum analysis, and pulse modulator hardware
- Combines network analysis and **modulation distortion analysis** (ex. EVM, ACP) of active devices with a single connection.
- **Fast measurement speed**
- Same measurement science, GUI or SCPI commands as the trusted Keysight VNAs (PNA, ENA, Streamline Series VNA)

Keysight ENA & ENA-X

E5080B ENA

- **2-port**
- Up to 53 GHz
- Single source (**Opt.2x0**)
- Standard test set

- **4-port**
- Up to 53 GHz
- Single source (**Opt.4x0**) or dual source (**Opt.4x2**)
- Standard test set

✓ Ideal for small-signal S-parameter measurements up to 53 GHz

E5081A ENA-X

NEW!

- **2-port**
- 20 or 44 GHz
- Single source
- Configurable ports (port 1 & 2, **Opt.2K5/2N5**)
- Optional built-in upconverter for mmwave & wideband modulation distortion analysis (**Opt.2K6/2N6/2N7**)

- **4-port**
- 20 or 44 GHz
- Dual source
- 2x configurable ports (port 1 & 2) and 2x standard ports (port 3 & 4). (**Opt.4K5/4N5**)
- Optional built-in upconverter for mmwave & wideband modulation distortion analysis (**Opt.4K6/4N6/4N7**)

✓ Flexible configurations for a variety of measurements (ex. High-power, NF, EVM/ACP, NPR, etc.)

New Configurable PXI VNAs

Complementing Keysight's current high-performance PXI VNA Portfolio

- Keysight M983xA is a **configurable PXI VNA** that fits in just one hand
- Two new models, 20 GHz and 44 GHz
- Flexible and scalable **multiport** solution
- Built-in **low noise receivers per port** for accurate noise figure measurements
- Combines network analysis and **modulation distortion analysis** (ex. EVM, ACP) with a single connection.

Keysight PXI VNA Platform

M980xA: Standard PXI VNA

- **4.5, 6.5, 9, 13.5, 20 GHz**
  - 2, 4 or 6 ports
- **26.5, 32, 44, 53 GHz**
  - 2 ports

✓ Ideal for small-signal, multiport testing using standard configurations

M983xA: Configurable PXI VNA

NEW!

- **20 GHz**
  - 2 ports, with and without upconverter for MOD analysis
- **44 GHz**
  - 2 ports, with and without upconverter for MOD analysis

✓ Low-noise receiver per port
✓ Optional upconverter for mmwave modulation distortion analysis (ex. EVM, ACP)

M983xA Front Panel (2-slot Module. M9834A-205)

LO In/Out and control connectors
for sharing signals among multiple modules in a multiport configuration

M9834A Opt.205

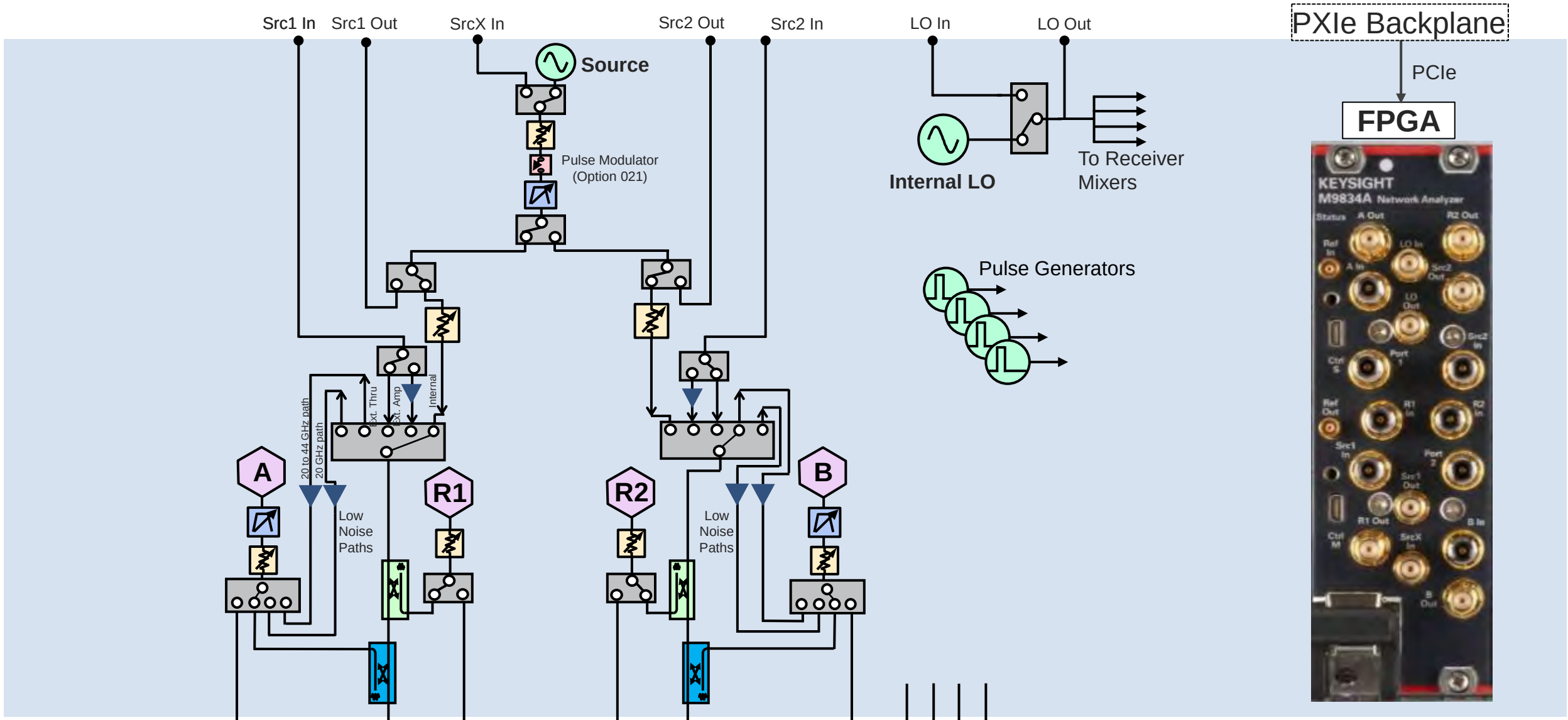
Port 1

- Port 1 : Test port 1
- A In : Test receiver RF input
- R1 In : Reference receiver RF input
- A Out : Test receiver IF output
- R1 Out : Reference receiver IF output

Port 2

- Port 2 : Test port 2
- B In : Test receiver RF input
- R2 In : Reference receiver RF input
- B Out : Test receiver IF output
- R2 Out : Reference receiver IF output

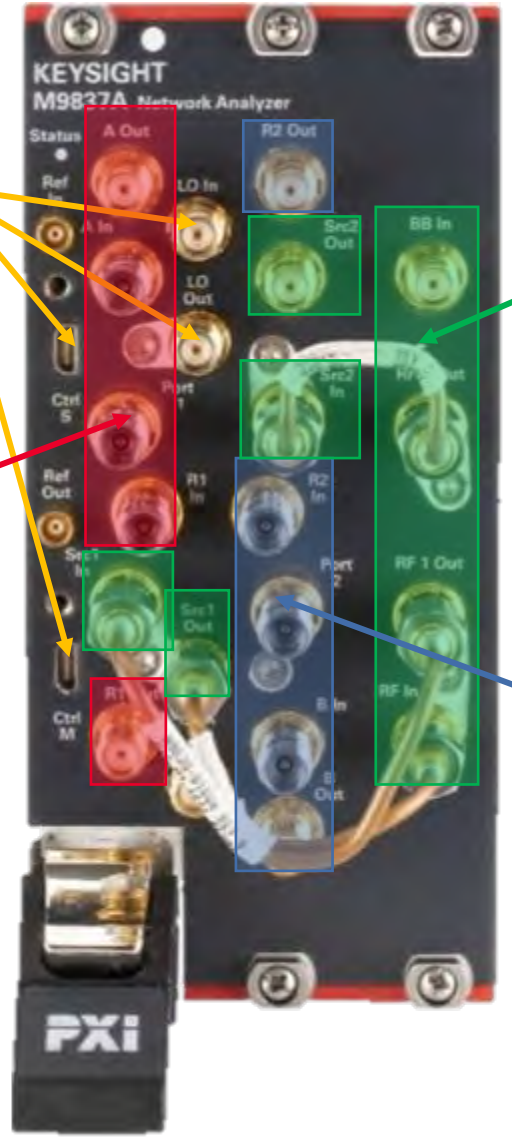
M983xA Block Diagram (2-slot Module, M9834A-205)



M983xA Front Panel (3-slot Module. M9834A-270, M9837A-205, -270)

LO In/Out and control connectors

for sharing signals among multiple modules in a multiport configuration



Port 1

- Port 1 : Test port 1
- A In : Test receiver RF input
- R1 In : Reference receiver RF input
- A Out : Test receiver IF output
- R1 Out : Reference receiver IF output

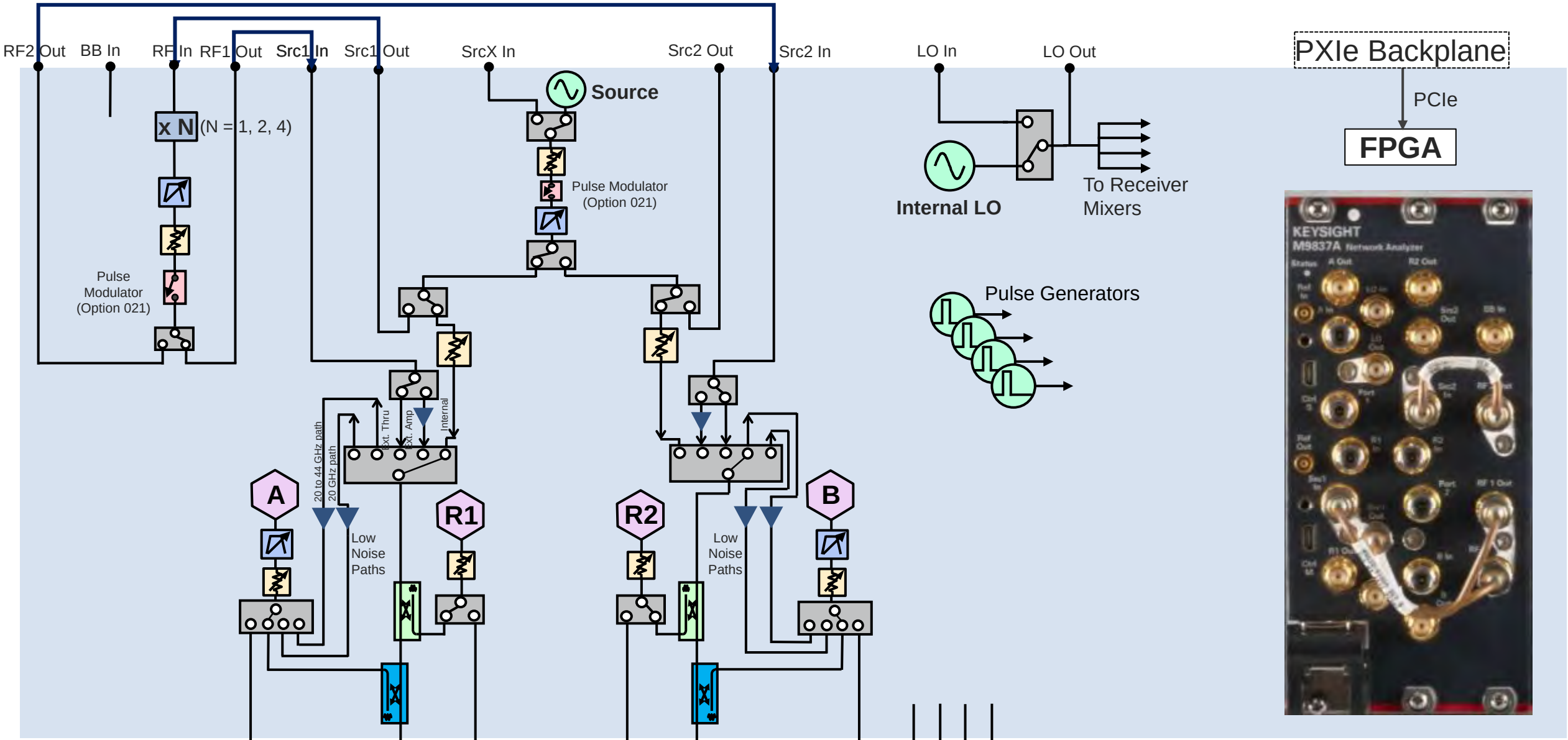
Upconverter

- BB In : Mod signal input (Opt. 270 only)
- RF1 Out : CW & Mod signal output
- RF2 Out : CW & Mod signal output
- RF In : CW input

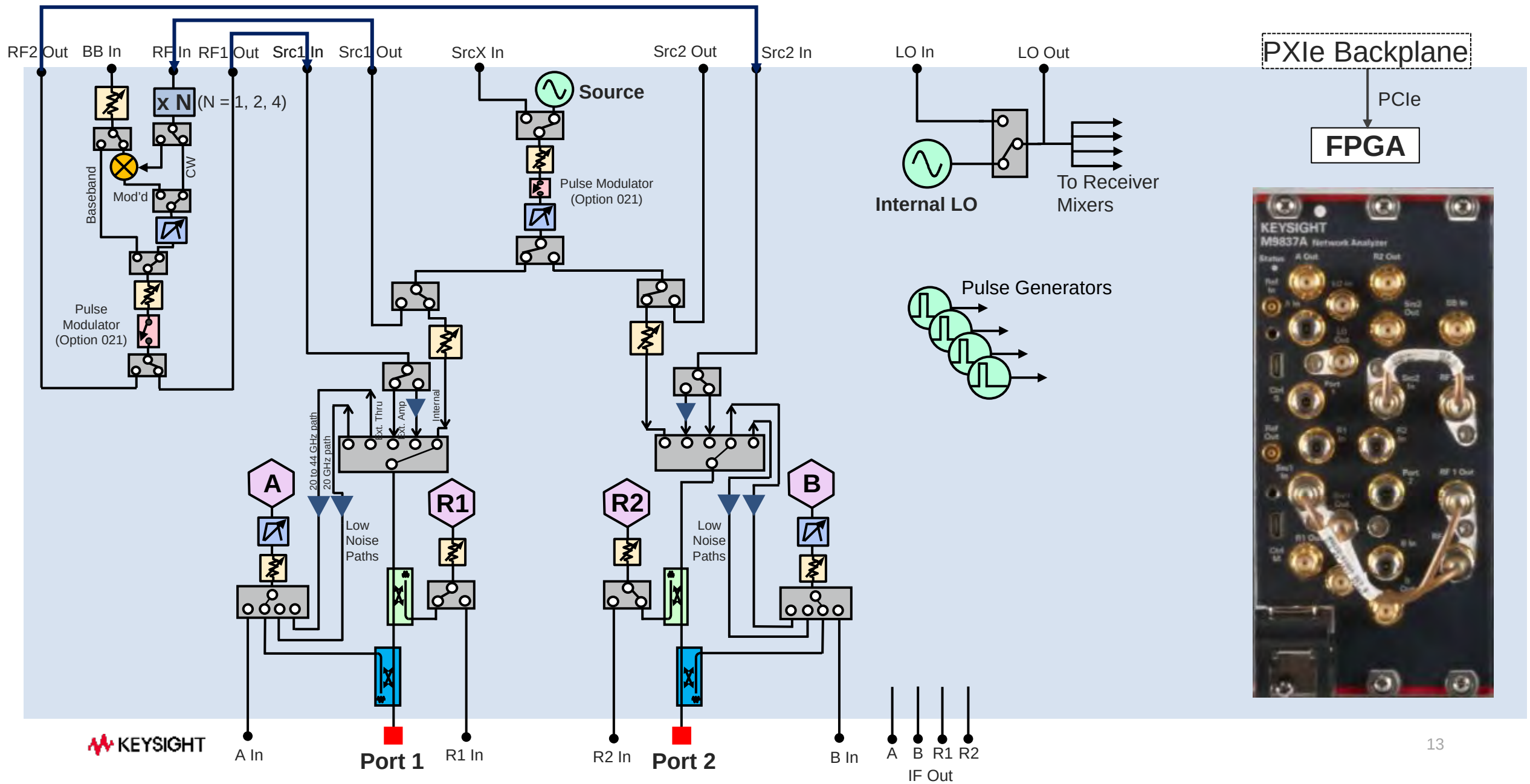
Port 2

- Port 2 : Test port 2
- B In : Test receiver RF input
- R2 In : Reference receiver RF input
- B Out : Test receiver IF output
- R2 Out : Reference receiver IF output

M983xA Block Diagram (M9837A-205)



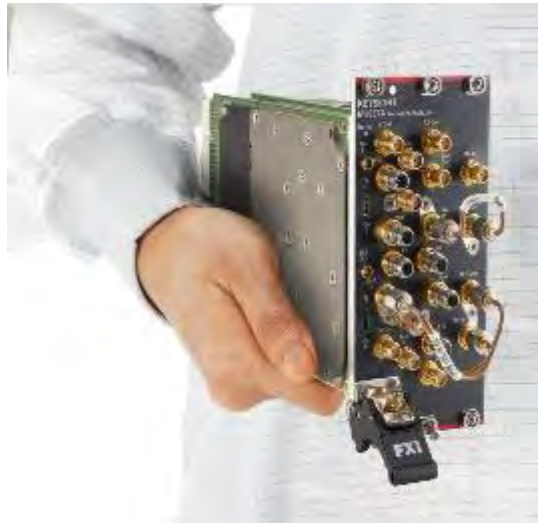
M983xA Block Diagram (M9834A-270, M9837A-270): Microwave Modulation



M983xA PXIe VNA

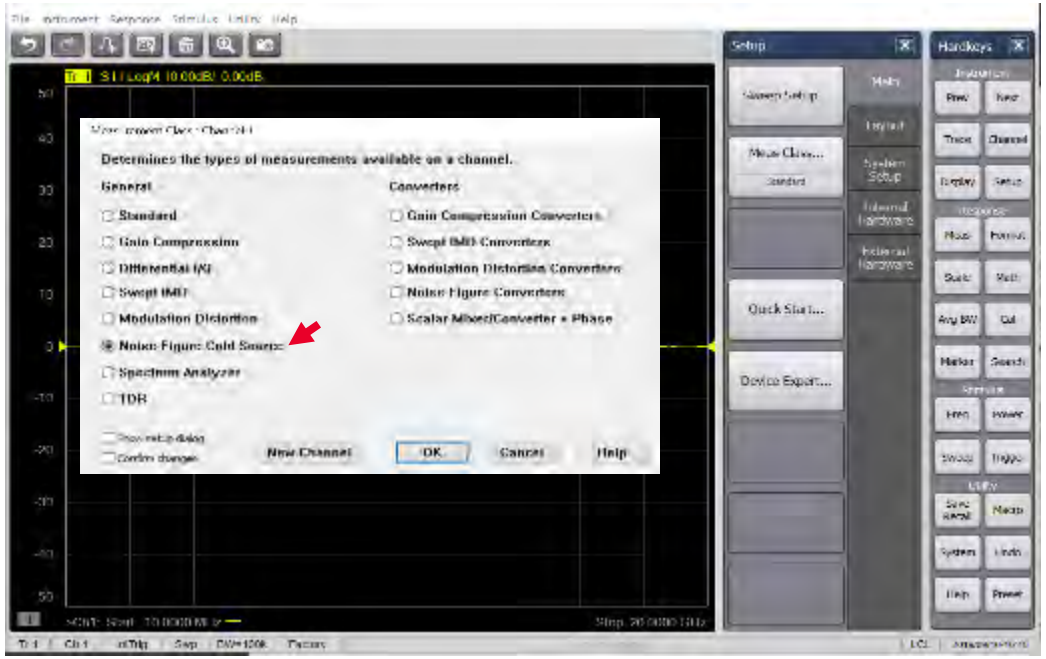
Your solution to measurement challenges

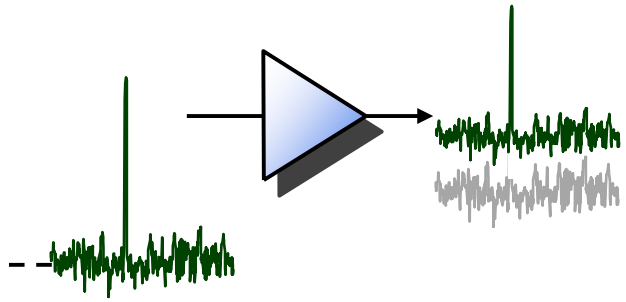
- Flexible & configurable test setup
- Best-in-class VNA performance in a small form factor
- Wide application coverage



Noise Figure Measurements using M983xA

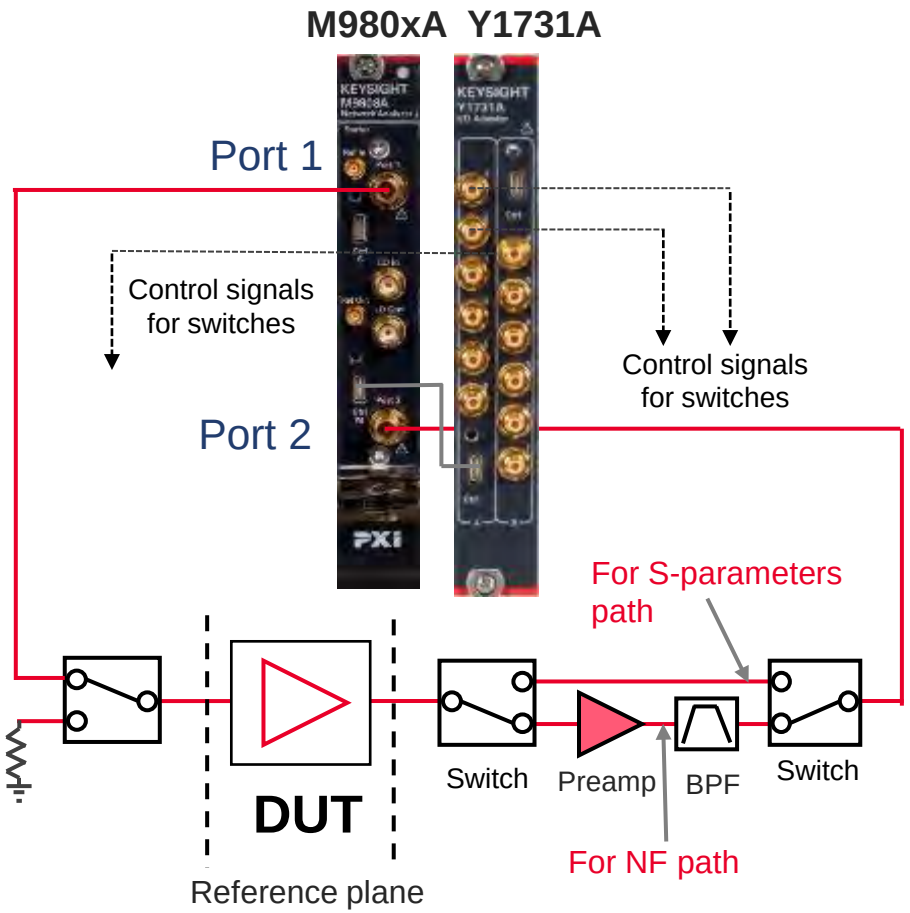
- Measure noise figure of amplifiers, mixers, and converters
- With a single connection, obtain fast, high accuracy measurements of S-parameters, noise figure, compression, harmonics, and more.
- Surpasses the accuracy provided by Y-factor-based noise-figure analyzers or spectrum analyzers
- Fast sweep times improve throughput in manufacturing
- Built-in low-noise receiver per test port eliminates the complexity of using external components (ex. preamp, switches)
- Same GUI and measurement science as trusted PNA-X
- Noise figure uncertainty calculator (Release Dec.2022)





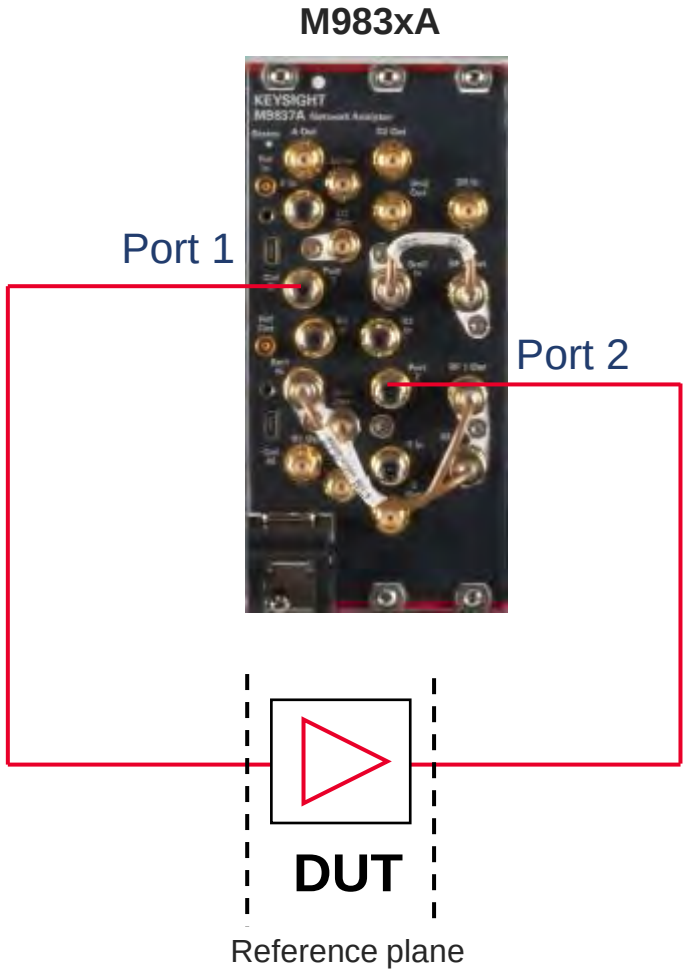
Simplified NF Test Setup (M980xA vs. M983xA PXI VNA)

M980xA: Standard PXI VNA



- ✓ Multiple external accessories are needed to configure a test system (ex. switches, preamp, or filter)
- ✓ Necessary to synchronize VNA and external hardware (ex. switches) via Y1731A I/O module.

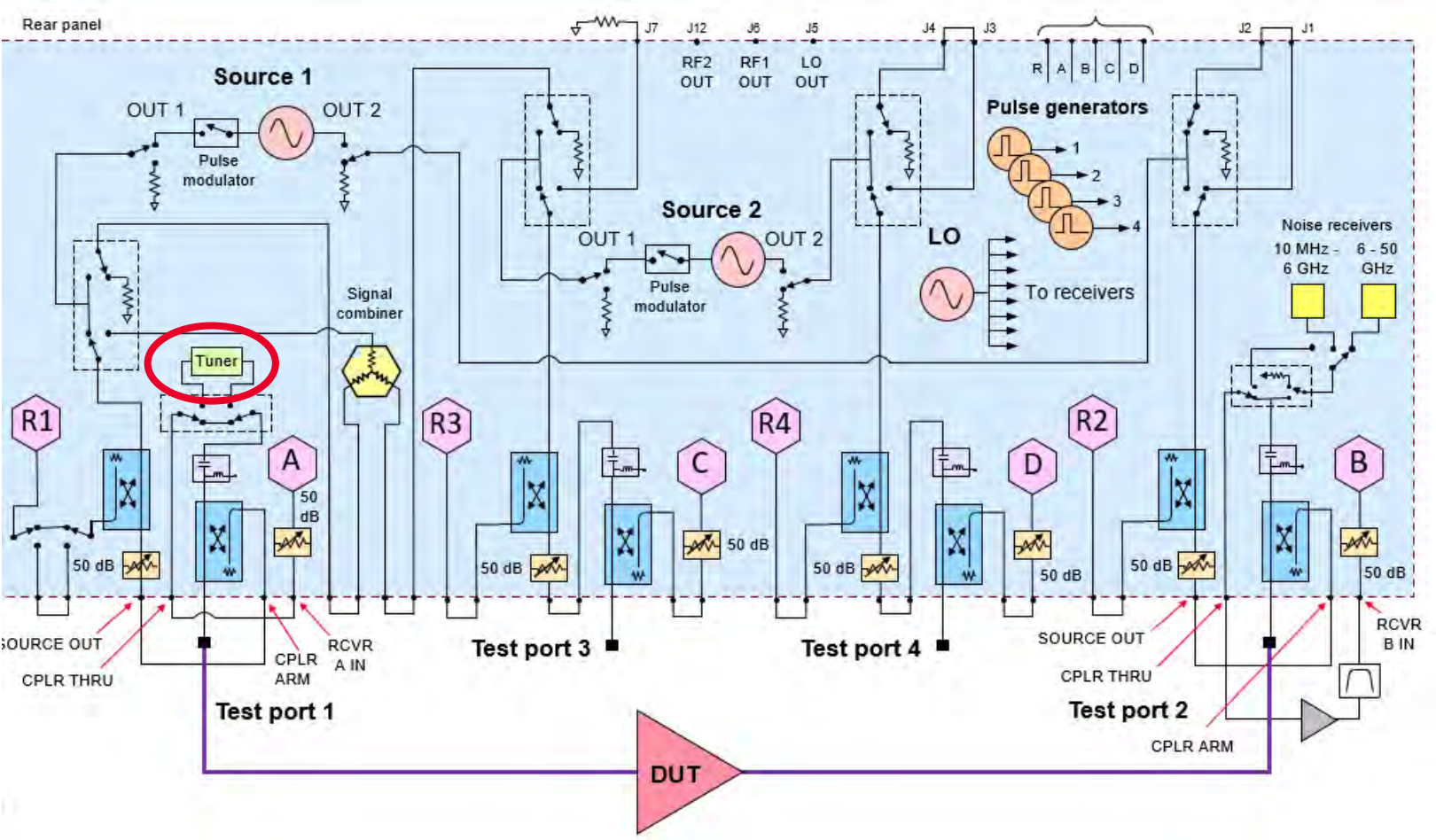
M983xA: Configurable PXI VNA



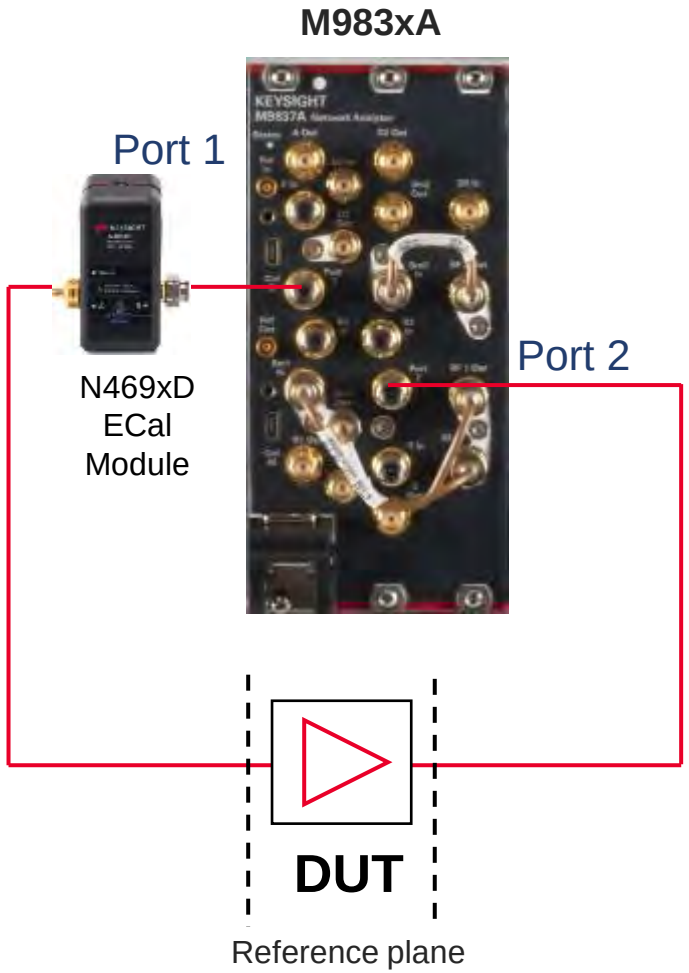
- ✓ S-parameter and NF measurements can be performed with simple test setup.
- ✓ Does not need an external switch to terminate with 50-ohm on the source path.

Vector-Calibrated NF Test Setup (PNA-X vs. M980xA)

M980xA: Standard PXI VNA



M983xA: Configurable PXI VNA

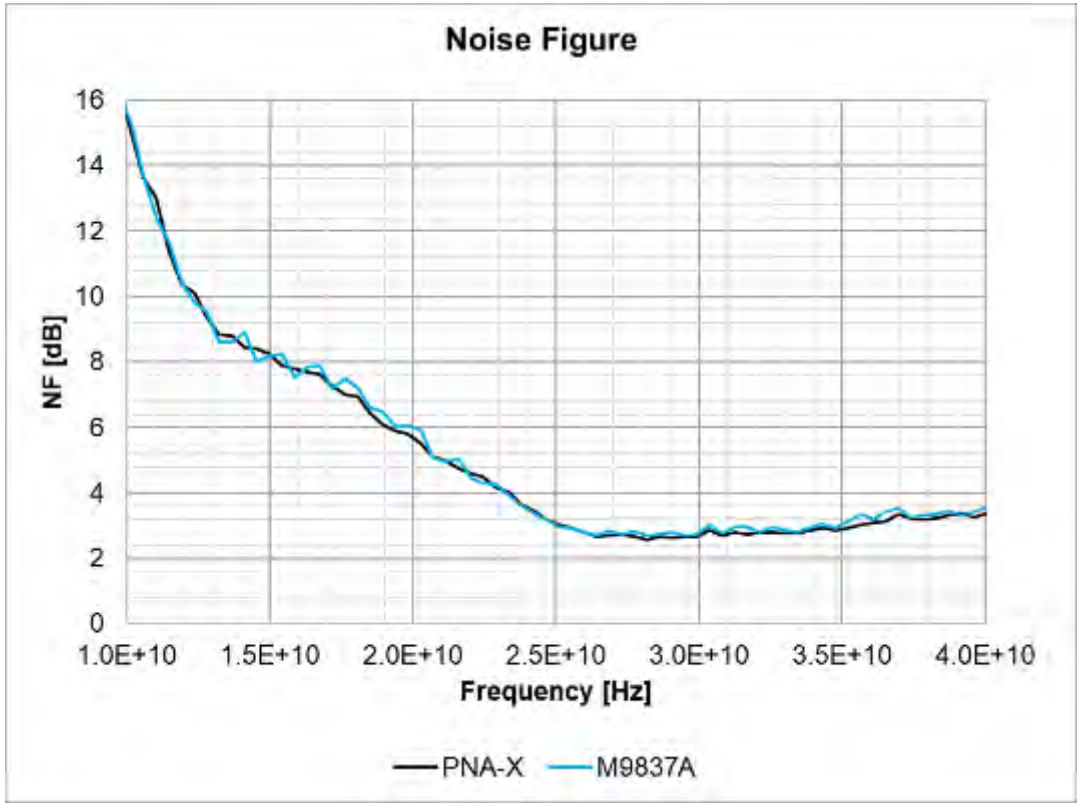


- ✓ S-parameter and NF measurements can be performed with simple test setup.

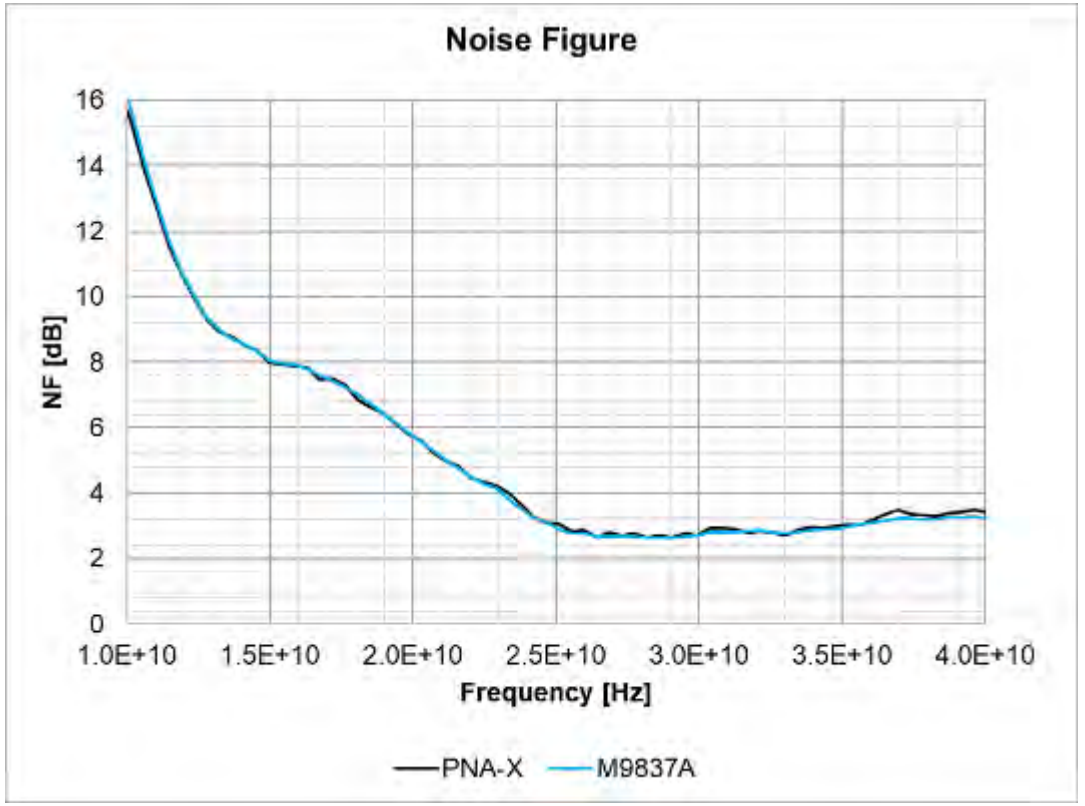
Correlation Study (Comparison with PNA-X)

M983xA offers good correlation with NF measurements using high-performance PNA-X.

Scalar noise cal



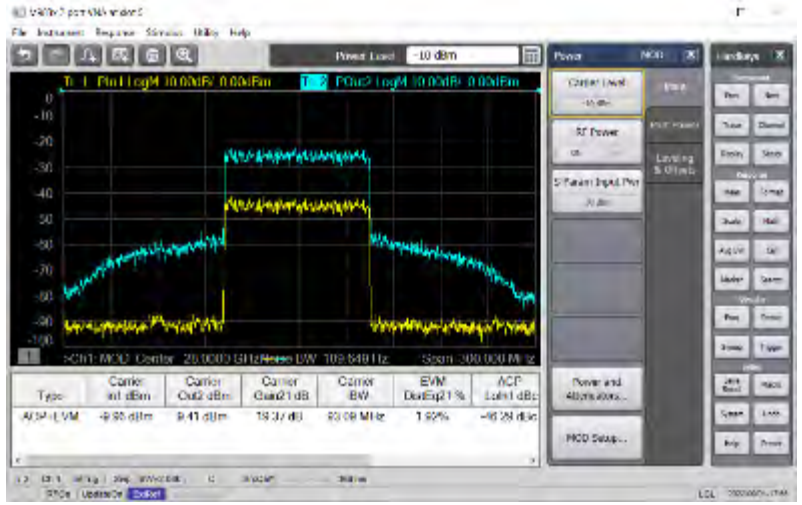
Vector noise cal

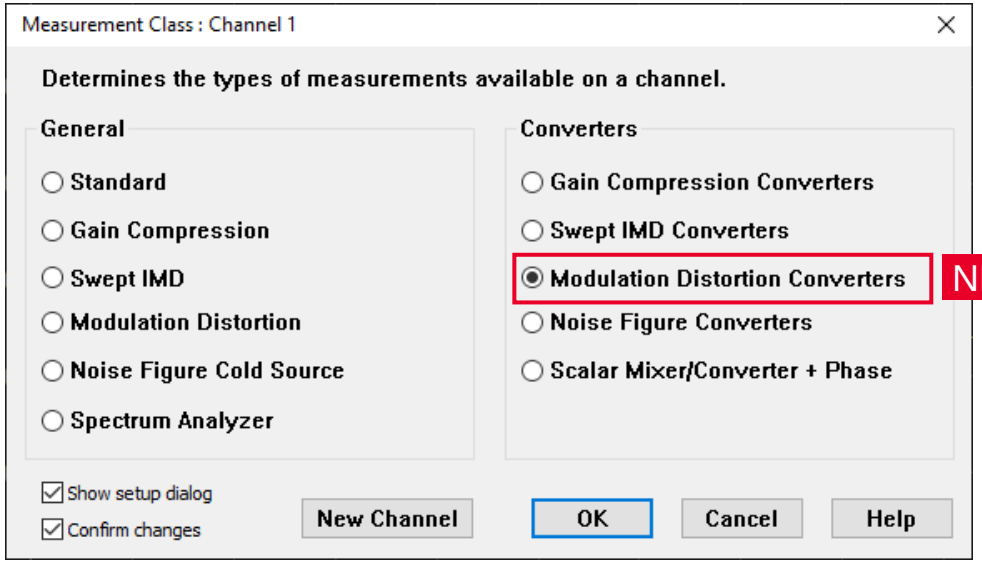


DUT = LNA (Analog Devices HMC1040), 10 to 40 GHz, scalar & vector noise cal with noise source (346CK01). PNA-X: noise averaging = 10. M9837A: Receiver gain = High, noise averaging = 150, Receiver attenuator = 18 dB. 3 dB attenuator is inserted on DUT's output for vector noise cal to avoid receiver compression.

Modulation Distortion Analysis using M983xA

- Measure mmwave, wideband modulation distortion (ex. EVM, ACP) of amplifiers, **mixers, and converters**
- With a single connection, obtain both S-parameters and modulation parameters
- Low residual EVM with vector correction
- Repeatable and correlated results with PNA-X solution
- Half price of standalone benchtop instruments (ex. VSG, VSA and VNA)
- Optimized throughput with PXI technology
- Fast sweep times improve throughput in manufacturing

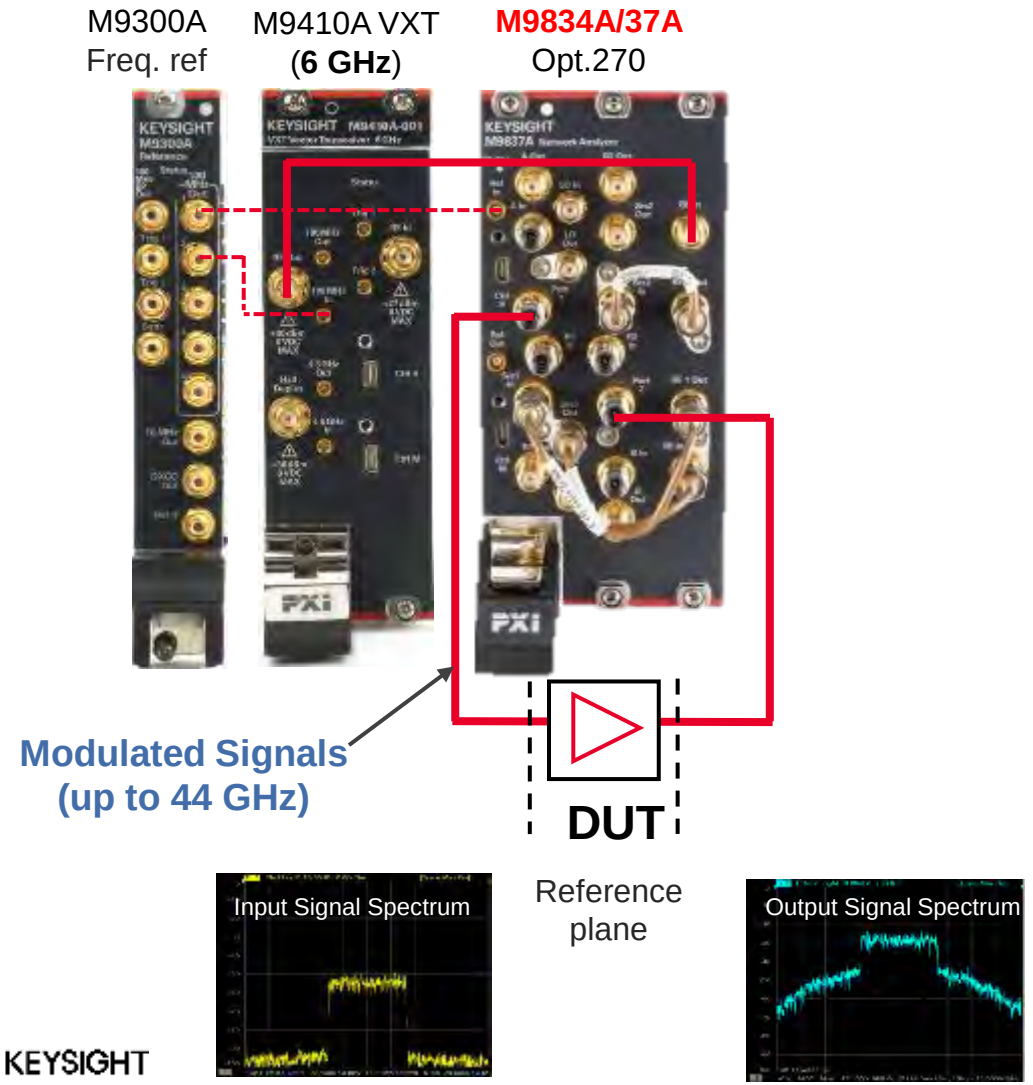




NEW!

Modulation Distortion Analysis Test Setup (MOD)

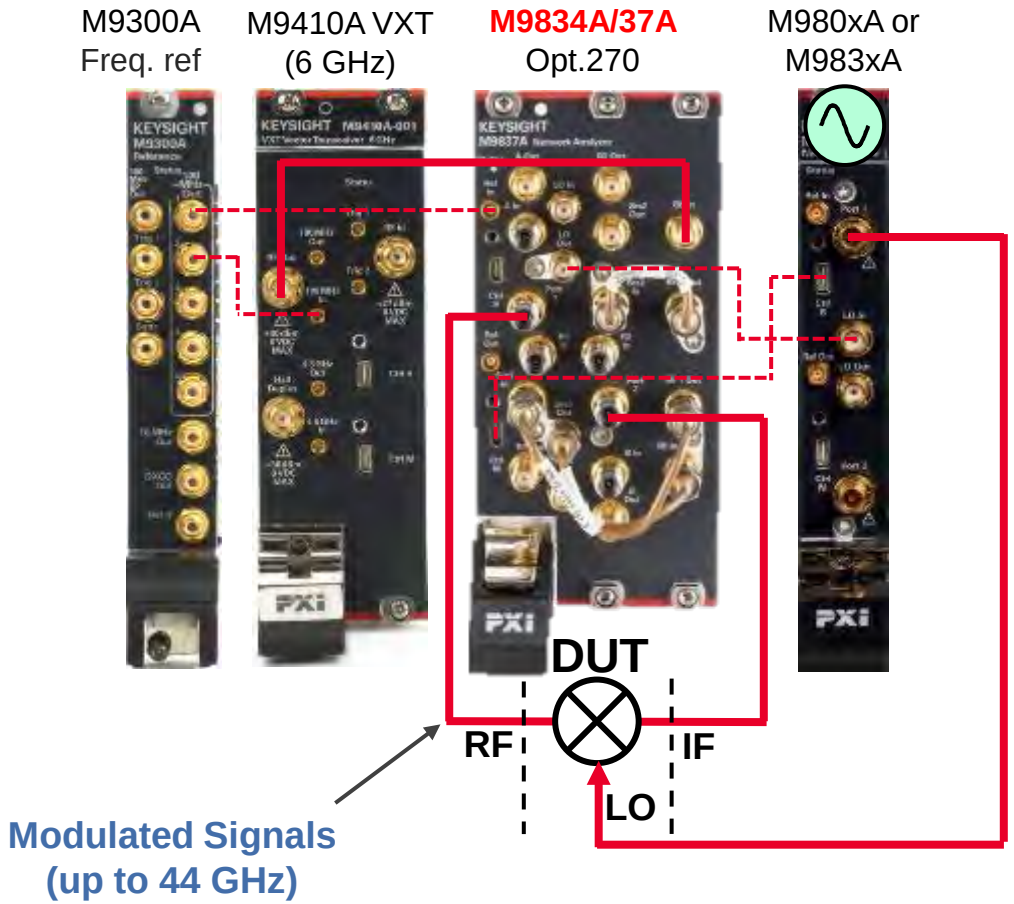
Ex) Amplifiers



- ✓ Low-frequency modulated signals from RF VSG (ex. 6 GHz M9410A, or VSG) is upconverted to 44 GHz with the M983xA's built-in upconverter.
- ✓ High-frequency VSG is NOT needed for creating mmwave modulation signals.
- ✓ S-parameter and EVM can be measured with a single connection.
- ✓ S95070B (modulation distortion analysis) SW is required.

Modulation Distortion Analysis Test Setup (MODX) NEW!

Ex) Frequency Converters / Mixers



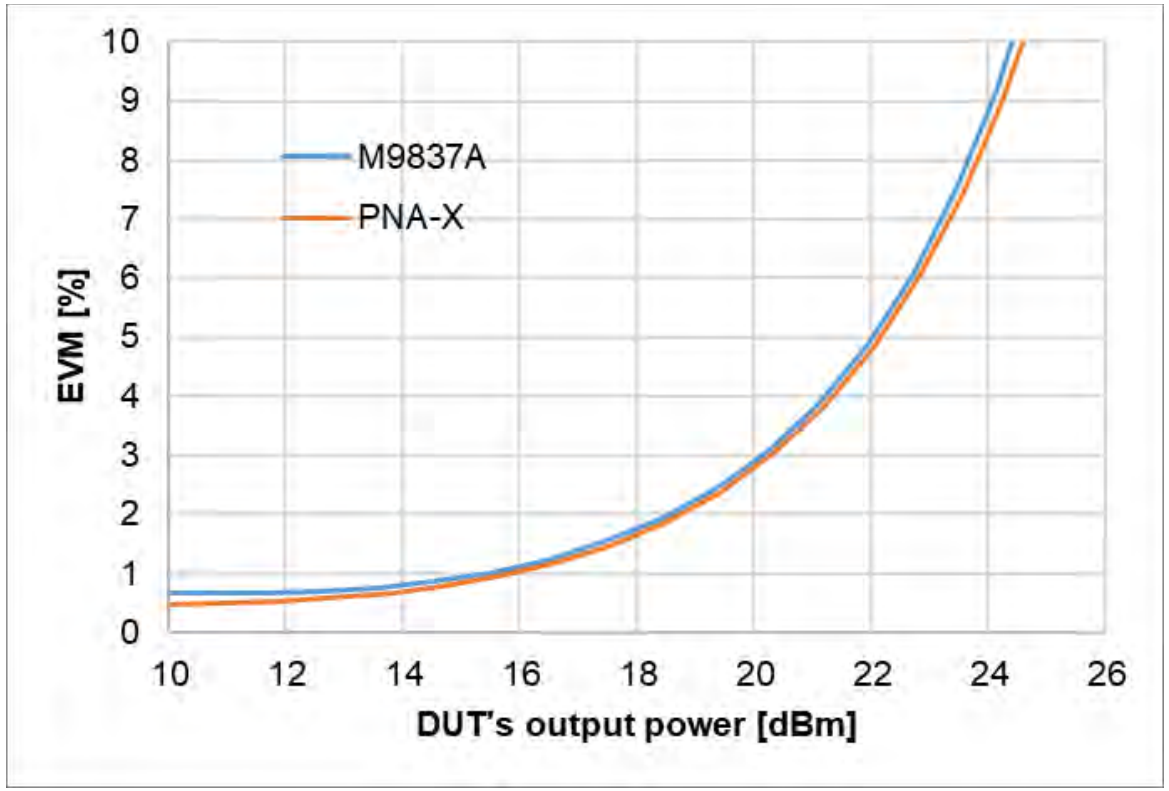
- ✓ Released with A.16.70 (Feb 2023)
- ✓ S95070B (modulation distortion analysis) SW is required.
- ✓ S95083B (Vector and scalar mixer measurements) SW is required. S95082B (Scaler mixer measurements) SW is not supported for MODX.
- ✓ An additional PXI VNA (ex. M983xA or M980xA *) and S95551B “multi-module” SW are required to generate synchronized LO signals for DUT.
- ✓ Comb generator is not needed for MODX using M983xA.

* M980xA Standard PXI VNA can be used for DUT’s LO signals only. M983xA configurable PXI VNA must be used for DUT’s RF and IF ports.

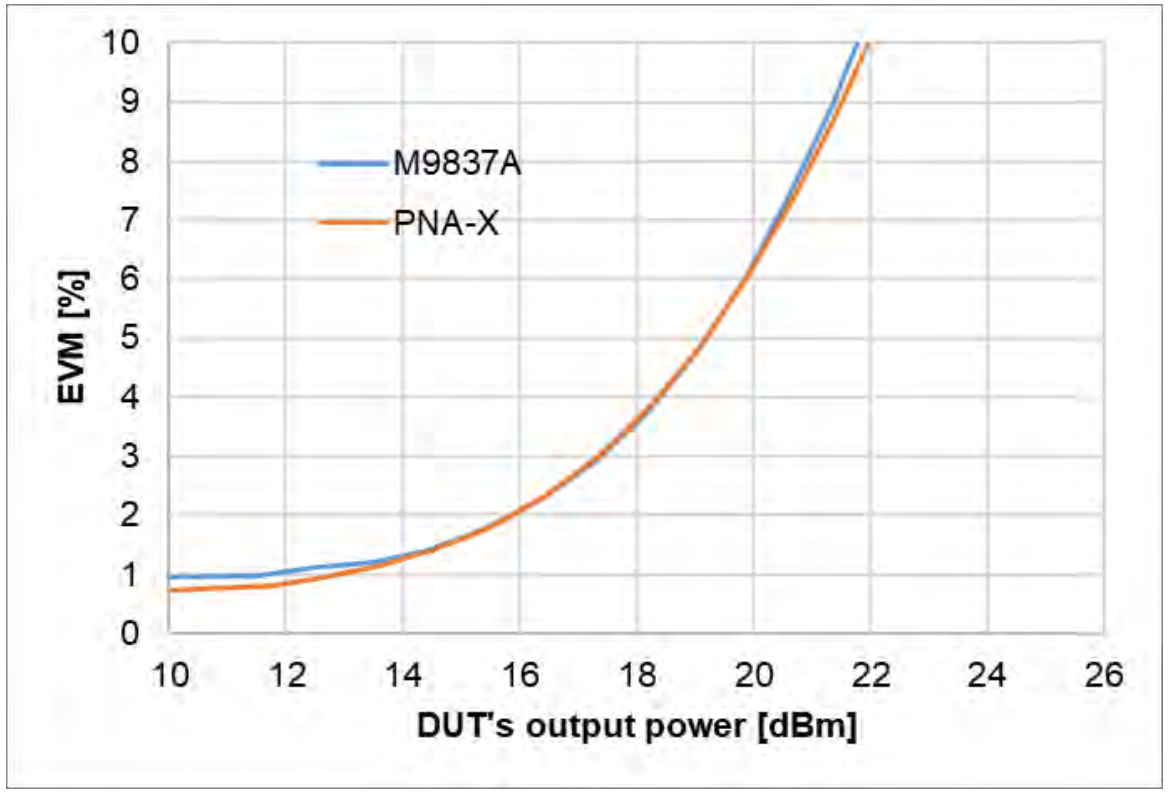
Correlation Study (Comparison with PNA-X)

M983xA has good correlation with MOD analysis using PNA-X and VXG.

28 GHz



39 GHz



DUT: N4985A power amp, 5GNR 64QAM SCS 60 kHz (waveform period 8 us (compact)), 100 MHz modulation BW

KEYSIGHT

PNA-X vs ENA-X: The Real Story

Nick Caira

Direct Comparison of PNA-X and ENA-X

Key Applications Same components, same time

- Standard Channel Filter Characterization
  - ENA has lower noise floor, but
  - ENA switch gain will have noise variation on the filter skirt
- Mixer Measurement using SMC + Phase
  - Both show almost identical amplitude response
  - PNA has somewhat worse raw performance
    - We will compare raw performance such as source match and load match
  - PNA DDS is 30 times better noise in phase and delay measurements
    - ENA is similar to PNA before the DDS source came along
    - PNA supports absolute phase (NEW!), ENA SMC+phase has absolute delay but with fixed phase offset.

Direct Comparison of PNA-X and ENA-X

Key Applications Same components, same time

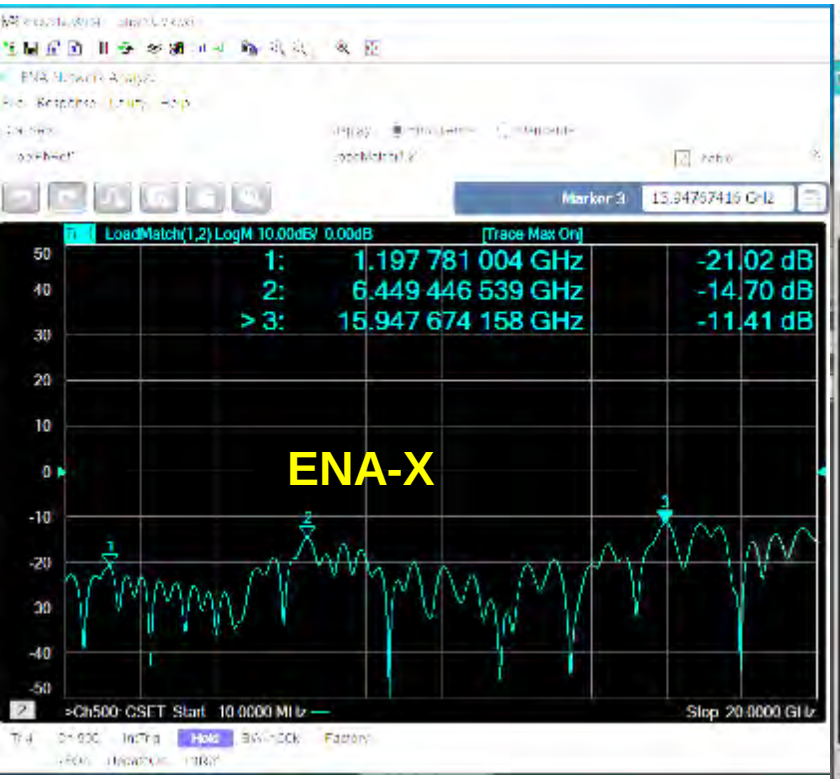
- Noise Figure Measurement
  - ENA and PNA are quite similar for scalar noise measurements
  - ENA requires an in-line Ecal to support vector noise figure, much less convenient.
  - ENA can do noise figure on BOTH ports 1 and 2: identical block diagrams
- Standard Channel Amplified High-Dynamic Range Filter
  - ENA shows higher noise when measuring below the channel
    - This is due to noise from the DUT on the image side of the LO
    - This can be eliminated using the segment sweep
- Spectrum Analysis
  - Harmonic Measurements
    - ENA has higher source harmonics but lower receiver harmonics (banded filters on the receiver)
    - PNA-X has lower source harmonics (banded filter on the source) but no filters on receivers
  - Spurious Measurements
    - ENA has higher spurious signals, and phase noise prevents measuring close-in spurious

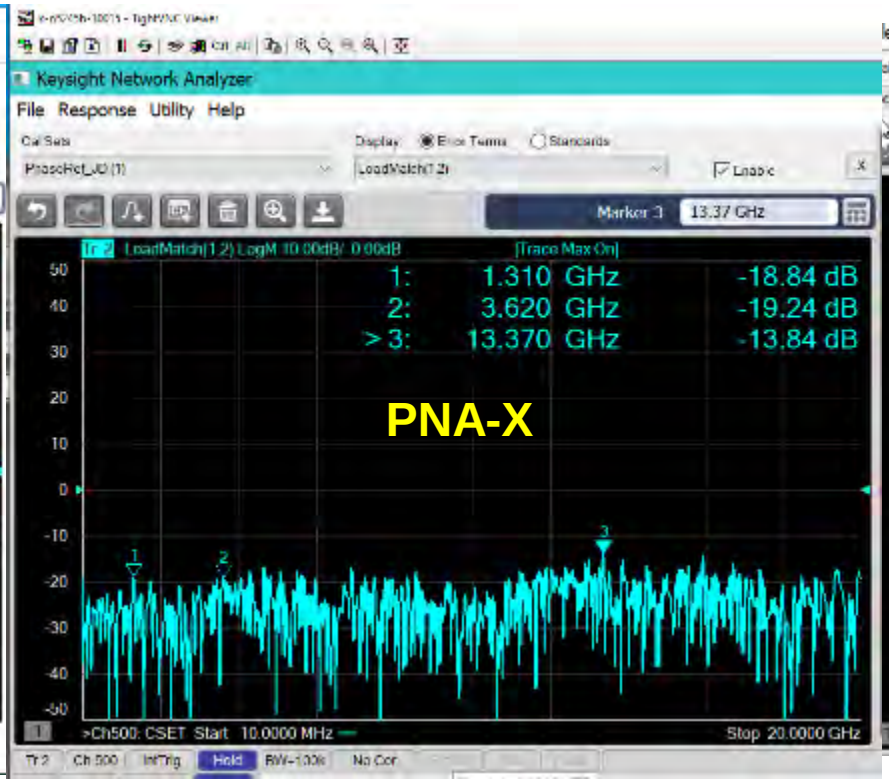
Using Cal All

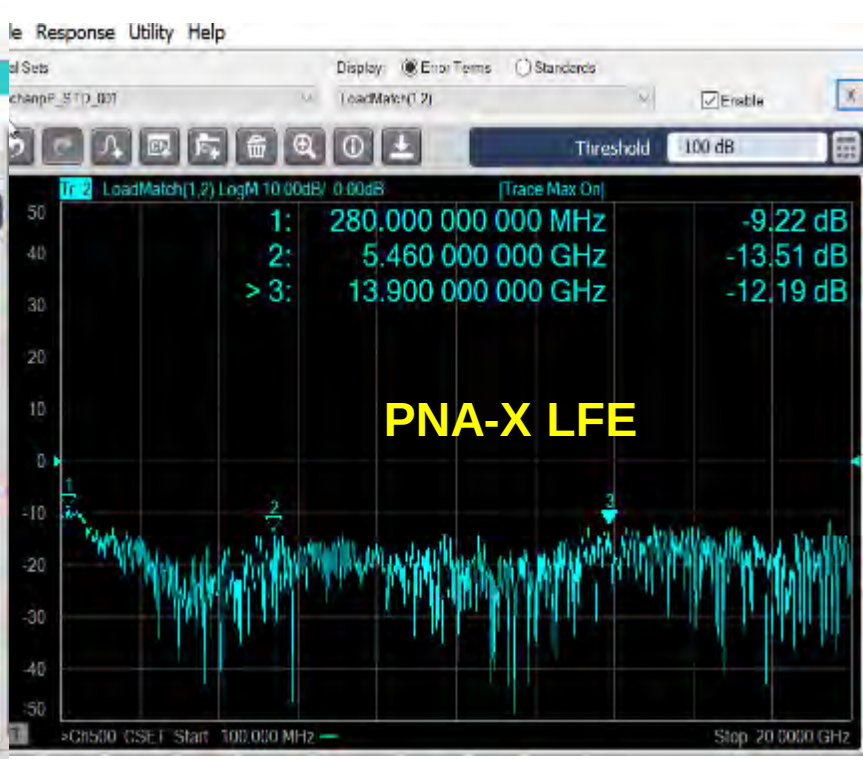
Note the change in density, very dense for the SMC frequency ranges

Load Match

ENA-X, PNA-X, PNA-LFE







Comparing Mixer Measurements: Trace Noise on Delay and Phase

PNA-X first, then ENA-X: Note the noise on PNA-X with DDS source is about 30x lower than ENA-X

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Comparing Mixer Measurements: Trace Noise on Phase Compression

PNA-X first, then ENA-X: This time with swept power gain compression

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ENA-X: SMC+Phase (after 1000 sweep averages)

Steps in phase, spikes in Delay; not sure of the cause

Two Tone SA Measurements (using 2-tone from PNA)

Phase Noise Limits Separation; and SA sweep is substantially slower