

The Increasing Importance of Increasing Ports

Addressing the Challenges of Multiport Test

Abstract

Modern devices are highly integrated. As a result, wireless and high-speed digital engineers often test devices with more than four ports. In wireless RF, front-end modules (FEM) for multi-band operation and multiple-input, multiple-output (MIMO) antennas require multiport characterization for all their components. Testing high-speed digital technologies like HDMI and USB 3.1 is even more tedious. Not only do digital cables have multiple internal cables and connectors, but each must undergo testing twice — once in the time domain and once in the frequency domain.

The need for multiport test accelerated the development of switch-based solutions for traditional vector network analyzers (VNAs). When switch-based solutions were not adequate to keep up with multiport test, the VNA itself was re-imagined and optimized for multiport test.

Simple Switch Test Sets

The traditional solution for multipoint test is switching matrixes for 2-port or 4-port VNAs. Simple switching test sets comprised of RF switches can route VNA ports to port pairs on the DUT.

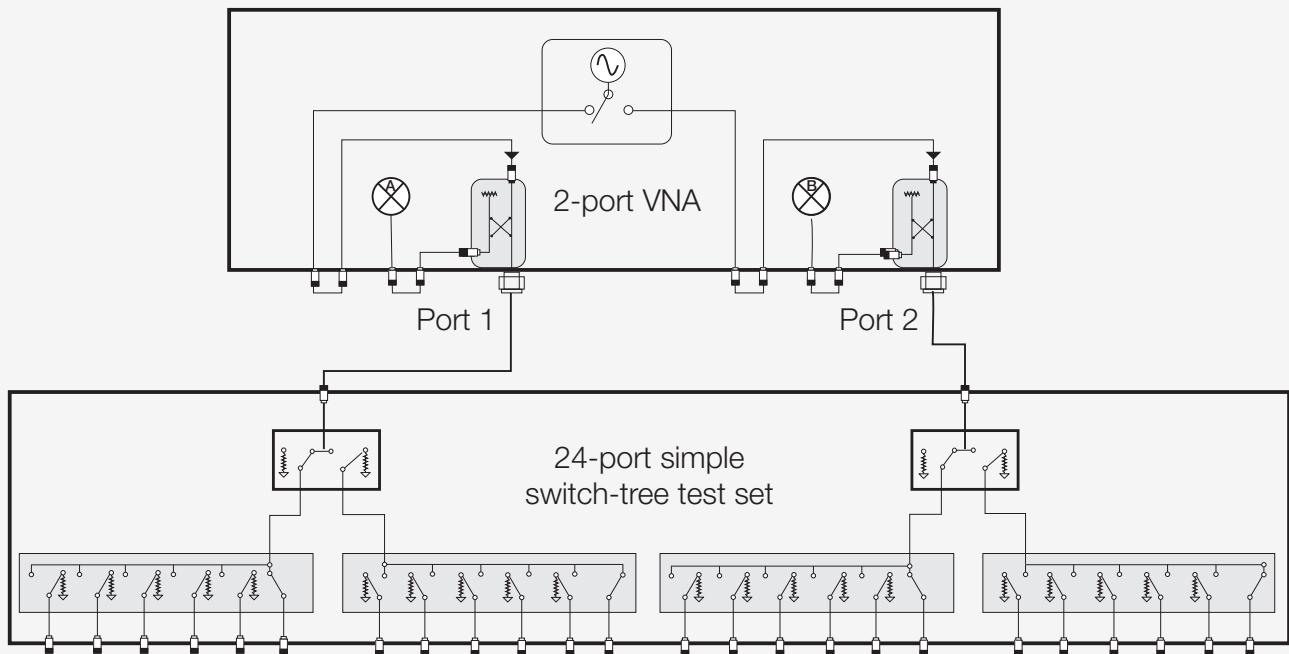


Figure 1: VNA with Simple Switch Test Set

In this setup, 12 ports branch from test port 1 of the VNA, and 12 ports from test port 2. Any path between the port 1 switches and the port 2 switches is measurable. However, many multipoint devices require a measurement from each port to every other port. In this simple switch matrix, no path exists between switches that branch from the same VNA port. Therefore, this 24-port setup supports only 144 paths — but a 24-port device has 276 paths.

Full Crossbar Switch Test Sets

Full crossbar switching test sets measure between every port of a device as well as apply a load termination to unused ports.

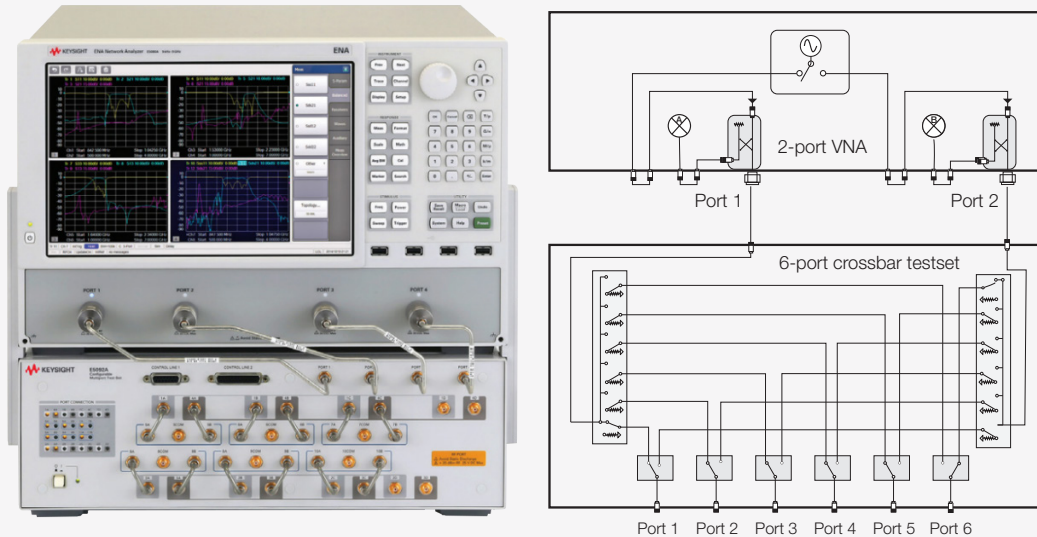


Figure 2: Full Crossbar Test Set

The full crossbar setup offers complete measurements between each of the ports, but also introduces new challenges. Each of the six test ports in Figure 2 has two possible 1x6 switches to use as a load termination. The switch used for termination on each port varies depending on which ports are active. The varying termination of the ports makes full N-by-N calibration difficult because you need to calibrate for every case.

External switches significantly affect measurement performance. The switching hardware is beyond the VNA's directional couplers that sample the test signal. Interference from the switching hardware creates a mismatch between the signal reaching the DUT and what the VNA measures. Calibration can help, but a switch matrix can never achieve the dynamic range, temperature stability, and trace noise performance of a standalone VNA.

Switch matrixes provide a low-cost solution for multiport testing, but require significant operator intervention for setup, calibration, and adjusting configurations. The operator time investment in addition to decreased measurement performance impacts throughput. Modern multiport devices demand faster and more accurate measurements than a switch-based solution can give you.



On a 16-port device, a 2-port VNA using a full crossbar switch matrix would require 240 sweeps to obtain 256 S-parameters, while a 16-port true multiport VNA would require only 16 sweeps.

PXI VNAs

Rather than using a 2-port or 4-port VNA for multiport measurements, use a VNA optimized for multiport measurements. PXI VNAs provide modular flexibility and measurement integrity necessary for modern multiport devices.



Figure 3: Modular PXI VNA

Each PXI module is a full VNA, and modules cascade and synchronize to create a single multiport VNA. You can also configure the modules into a multi-site configuration with multiple independent VNAs. The flexibility in configurations means you can easily change your setup to fit your measurement needs and optimize your throughput.

In addition to the ease of configuration, multiport VNAs hold significant measurement performance advantages over switch-based systems. A VNA with switching test sets needs to perform many individual sweeps to route test signals to each of the DUT ports. As the number of ports increases, the number of sweeps necessary on a 2-port or 4-port VNA increases drastically.

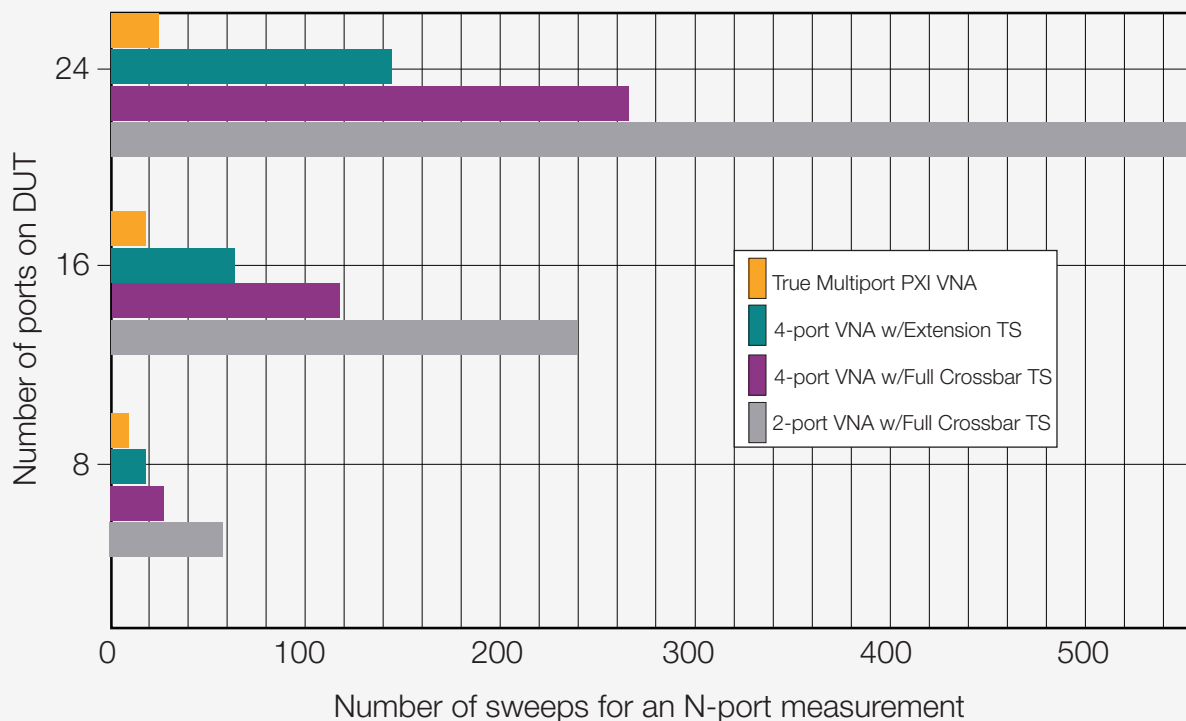


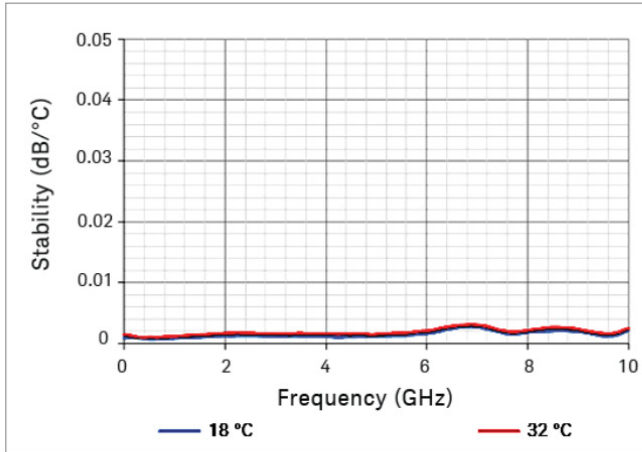
Figure 4: Sweeps Required for Multiport Devices

The multiport VNA makes sweeps quickly due to the superior dynamic range of multiport VNAs. The attenuation of the switches in a switch-based system degrades dynamic range, especially at higher frequencies. The consistently wide dynamic range of a multiport VNA means you can use a wider IF bandwidth and capture your sweeps faster. Making fast measurements at higher frequencies becomes crucial to keep up with the trend of higher data rates in both high-speed digital and RF.

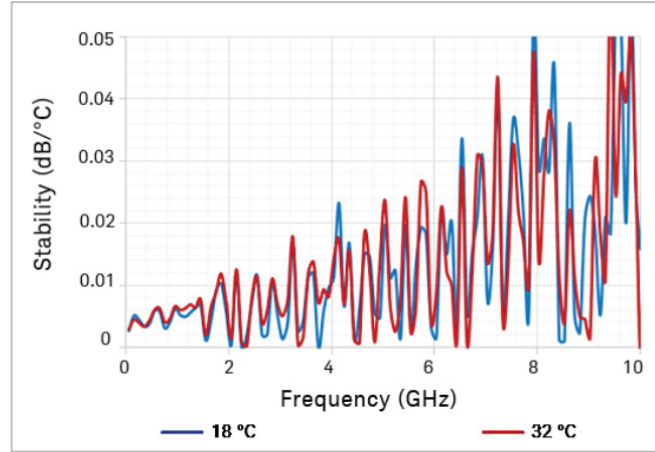
Multiport setups require significant calibration time. Switched test sets with solid-state switches are easily affected by temperature and must undergo frequent calibration to ensure accurate measurements. Calibration downtime drastically impacts throughput; a system with longer calibration intervals reduces your test time and your cost of test.



If dynamic range is increased by 20 dB, then a 100-times wider IFBW can be selected, thus 100-times faster measurement speed can be achieved, with the same trace noise, to get the same measurement result.



(a) True multiport VNA



(b) Switched test set based VNA

Figure 5: Temperature stability for a true multiport VNA (left) and a switched test set VNA (right)

Conclusion

A multiport VNA significantly reduces your test time to give you highly accurate measurements on multiport devices. The flexible modular configuration, fast measurement times, and high performance make VNAs the right tool for multiport testing. VNAs with up to 50 ports on a single chassis have the flexibility and performance to take on the toughest multiport challenges.

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