Factors in Choosing a VNA for Microwave Applications in Manufacturing

Vector network analyzers (VNAs) are the standard tool for analyzing microwave networks in development and production. Scattering-parameters, or S-parameters, are measured by the VNA to characterize the frequency domain response of a network under test. These networks can be simple devices like cables to complex microwave systems with active gain and other characteristics. To fully characterize microwave devices in development, engineers typically use VNAs with very high-end specifications and broadband frequency coverage. This makes sense during development, as engineers are doing initial characterization to determine what the true device performance is and if that meets design specifications. These high-end VNAs tend to be in lab environments and shared by several engineers for characterizing different devices, however, because they typically need to cover a very wide variety of requirements, they tend to be very expensive, bulky, superset VNA solutions.

Many microwave test applications do not need the level of performance provided by an expensive, high-end VNA. This is particularly true in production, where testing is typically not as rigorous as in device characterization and cost-of-test is critical. VNAs integrated into manufacturing test systems where S-parameter measurements represent only a part of the test list, may also require only moderate performance. This application note will examine these requirements and how they factor in to deciding which VNA is appropriate for a production environment.

Qualifying a Production-Level VNA

There are several factors to consider when choosing a VNA for a production application. Let's look at a few of the key characteristics that should be taken in to account.

Performance

First and foremost, a VNA's performance must be adequate enough to make the desired measurements. Some production applications require the utmost in dynamic range and high-level noise performance to properly measure the device under test (DUT). For those applications, the right choice is a full featured, high-end VNA like the Anritsu VectorStar™ family of VNAs. However, many manufacturing applications do not need the highest levels of performance because they are using the VNAs to simply determine good devices from bad based on pass/fail limits applied to measured test results rather than characterizing the performance of each device to evaluate the DUT design. VNAs, like the ShockLine™ family, that provide very good performance with a targeted set of features can be used in place of high-end VNAs to reduce the cost-of-test without compromising quality in the right applications. Engineers must carefully consider the entire test list when evaluating the tradeoffs between different VNAs with varying price/ performance levels.

Application techniques can also help achieve better VNA measurement performance by optimizing setup parameters. For instance, a VNA's dynamic range is typically maximized by using the narrowest available intermediate frequency bandwidth (IFBW) selection. However, the narrower the IFBW the slower the frequency sweep, which reduces the sweep speed and overall measurement throughput.

Other techniques, like minimizing sweep frequency points or using only selected frequencies in a segmented sweep, can help offset the speed reduction when using narrow IFBWs but only to a limited extent. The VNA hardware must still have good enough performance overall to allow the engineer to make the application tradeoffs to get both the speed and measurements required.

Another way to improve the effective performance of a test setup is to reduce or eliminate the effect of interconnect and fixturing between the VNA and the DUT. One way to do this is to bring the VNA port as close to the device as possible, minimizing or eliminating any cables used to interface to the DUT (Figure 1).

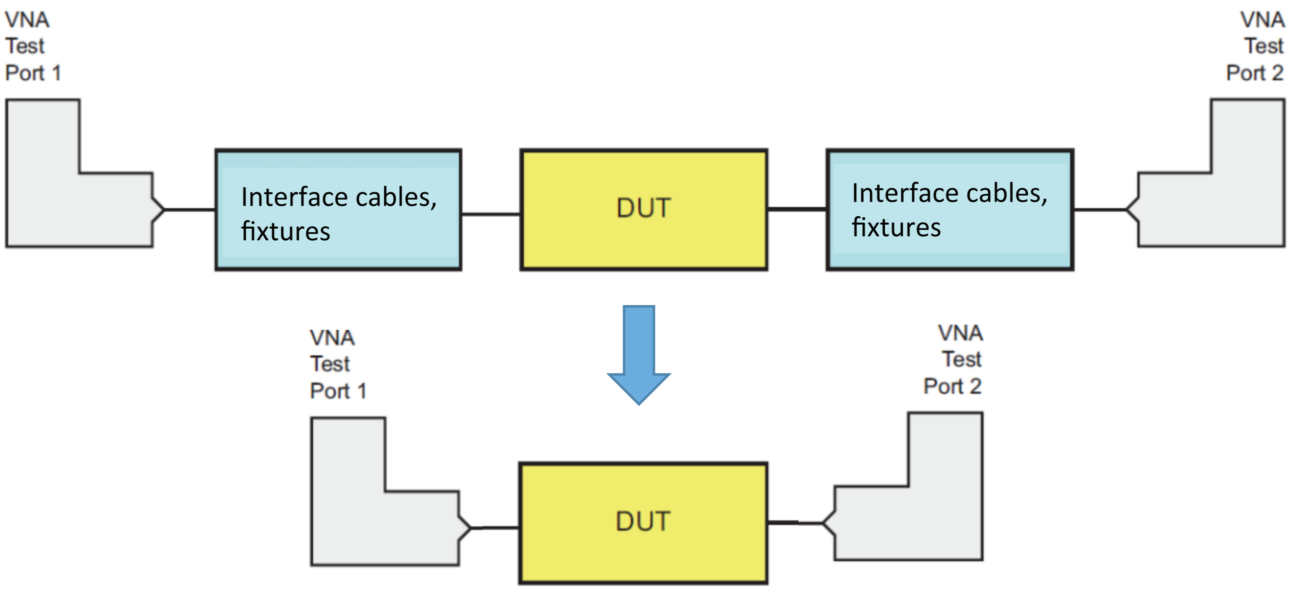

Figure 1. Bringing the port to the DUT simplifies setup

A couple examples of this strategy are illustrated in Figure 2. An instrument like the ShockLine MS46121B 6 GHz 1-port VNA is a power sensor sized device that is easily connected directly to the DUT. This architecture eliminates the need for, and any effects of, interfacing cables or fixtures between the VNA and the DUT, improving the overall quality of measurement. Ultimately, this improves device test time and reduces cost of test.

MS46121B 1-Port USB VNA

ShockLine MS46522B E-Band VNA with 1 meter tethers

Figure 2. ShockLine MS46121B and MS46522B E-band VNAs

In a similar fashion, an instrument like the ShockLine MS46522B E-band VNA tethers measurement modules to the VNA to create a single system whose architecture creates mobile VNA ports that can directly, or almost directly, connect to the DUT. This simplifies and improves the quality of the measurement by minimizing the detrimental effects of any interface cables, waveguides, or fixtures required to interface to the DUT, especially at these millimeter-wave (mmWave) frequencies. By bringing the calibration plane to the module, the small and portable VNA ports eliminate the need to do complex de-embedding. An additional significant benefit of having a self-contained tethered system is that the user is no longer required to purchase or perform factory calibrations for the module to VNA interface cables, making the E-band VNA ready to use out of the box.

When the VNA can't be connected directly to the DUT, removing the effects of interface cables and fixtures is a major way to enhance S-parameter measurement performance and improve test margins in manufacturing. Simple techniques, like reference plane extension, can be used to remove the effects of a cable interface to the DUT, but for more complex setups, additional de-embedding is required. Many VNAs have optional software to create S-parameter files for use in de-embedding an interface fixture from the measurement. This software is a function that should be included on all VNAs as it is critical to remove/de-embed the response of the fixture from the overall measurement so that the response of the DUT alone can be determined.

For very complex fixture de-embedding, solutions like Anritsu's Universal Fixture Extraction (UFX) software option allow engineers to effectively de-embed test setups for production environments (Figure 3). While access to this advance fixture removal capability is typically found within high-end VNAs, it is critical to VNAs used in production applications as complicated DUT fixtures are becoming more prevalent in manufacturing as devices get more complex. In many cases, a full set of calibration standards are not available with the only options being open and/or short standards for the in-fixture network extraction. Software like UFX becomes a valuable tool to more accurately de-embed the effects of the fixture on the measured results. This capability becomes more valuable as signal integrity and device verification migrate to higher frequencies to support higher data rates in 5G systems, backhaul, and data center applications.

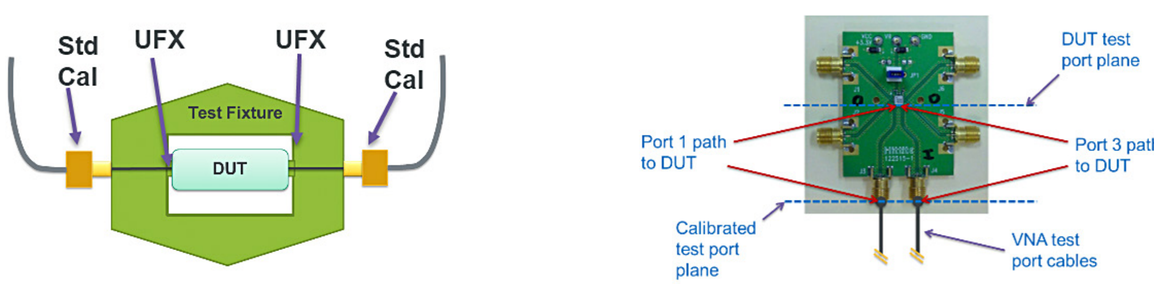

Figure 3. Universal Fixture Extraction (UFX)

Toughness and Size

Manufacturing environments are typically tough on equipment. Buttons, screens, knobs, and any other human interface on instruments tend to get abused and broken due to hard use. Some production applications require an integrated instrument with a screen and keypad but many manufacturing setups do not, especially applications where the VNA is remote controlled in an integrated test system.

Size is also a key factor for production environments. Space on a production floor is an expensive and scarce commodity. Instrumentation that takes up less space on the bench or in a rack lowers test costs as it minimizes production floor space required for a given test cell.

Production VNAs benefit from a headless architecture (no embedded keypads or screens), making them more robust since the fragile human interface components are eliminated. They should also come standard with ruggedized test port connectors and a durable chassis, ensuring the unit can withstand a manufacturing floor. Whether it is a 1-, 2-, or 4-port solution, it is also critical that the VNAs are space efficient and able to fit easily on a test bench or within a rack (Figure 4).

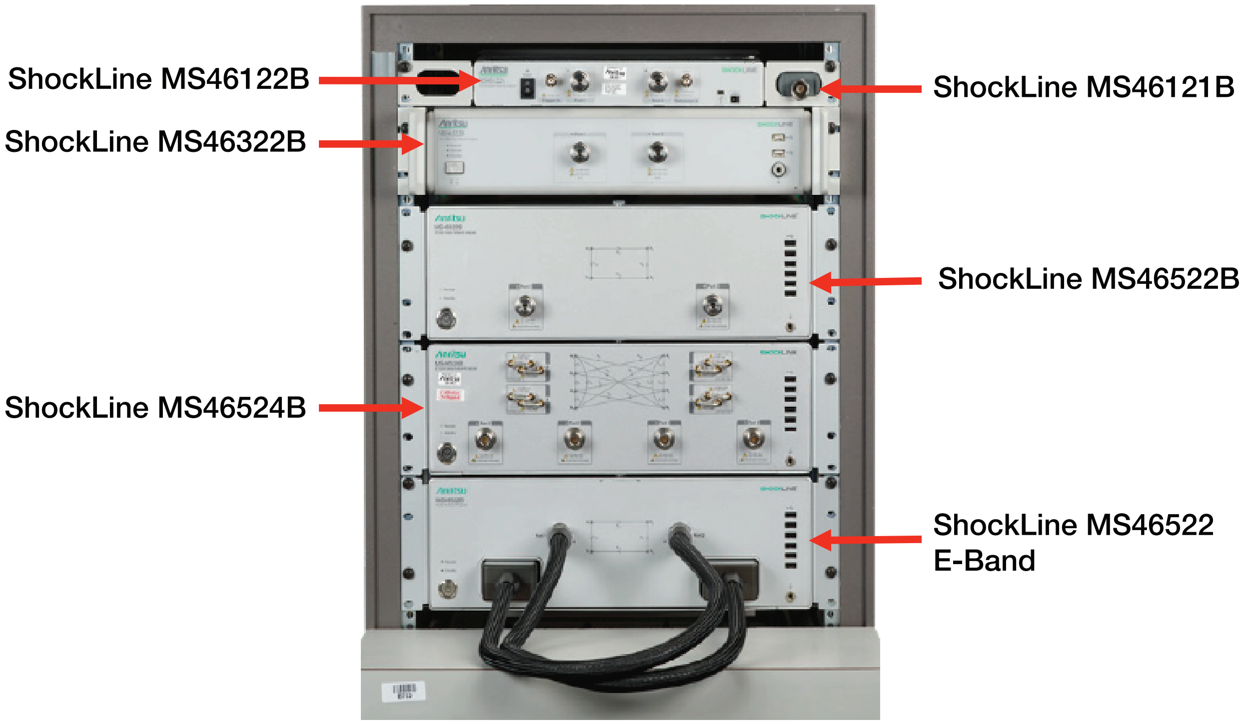

Figure 4. Rack mounted ShockLine VNAs

Software and ease-of-use

Another consideration for a production VNA is how easy it is to program and use in a test application. For automated test setups using remote control programming, comprehensive SCPI commands and/or other remote interfaces are required. Reuse of program code is a key way to improve efficiency in getting devices from design to production as fast as possible. For example, Anritsu's benchtop VNAs share SCPI remote control interfaces, enabling programs to migrate easily between platforms. Programs that run on the high-end VectorStar VNA in the lab can easily transition to ShockLine VNAs in production with little or no modification.

For manufacturing environments where operators control the VNA, like in connectorized microwave device testing, the Anritsu benchtop VNAs also share a common GUI interface with comprehensive production functionality. This is beneficial as operator training is minimized as once they train on one Anritsu benchtop VNA they will be proficient with both ShockLine and VectorStar systems. The GUI software should also be customizable to suit a particular production environment and the needs of various operators. It is important to have adjustable fonts, trace thickness, selectable limit line colors, and other display options to help ensure all are able to view results easily (Figure 5).

Some applications require operators to configure complex setups that require extensive training and perhaps written procedures that can be difficult for operators to complete correctly. When looking at a production VNA, it is ideal to have software that enables expert users to create a guided, graphical step-by-step procedure for operators for a given test setup and measurement. This will simplify complex VNA measurements by clearly guiding users through the process. Anritsu's solution to this requirement is called easyTest™ and was developed with extensive experience on instruments used in installation and maintenance applications (Figure 6). This graphical tool can easily create very complex procedures with support for scripts up to 100 steps long.

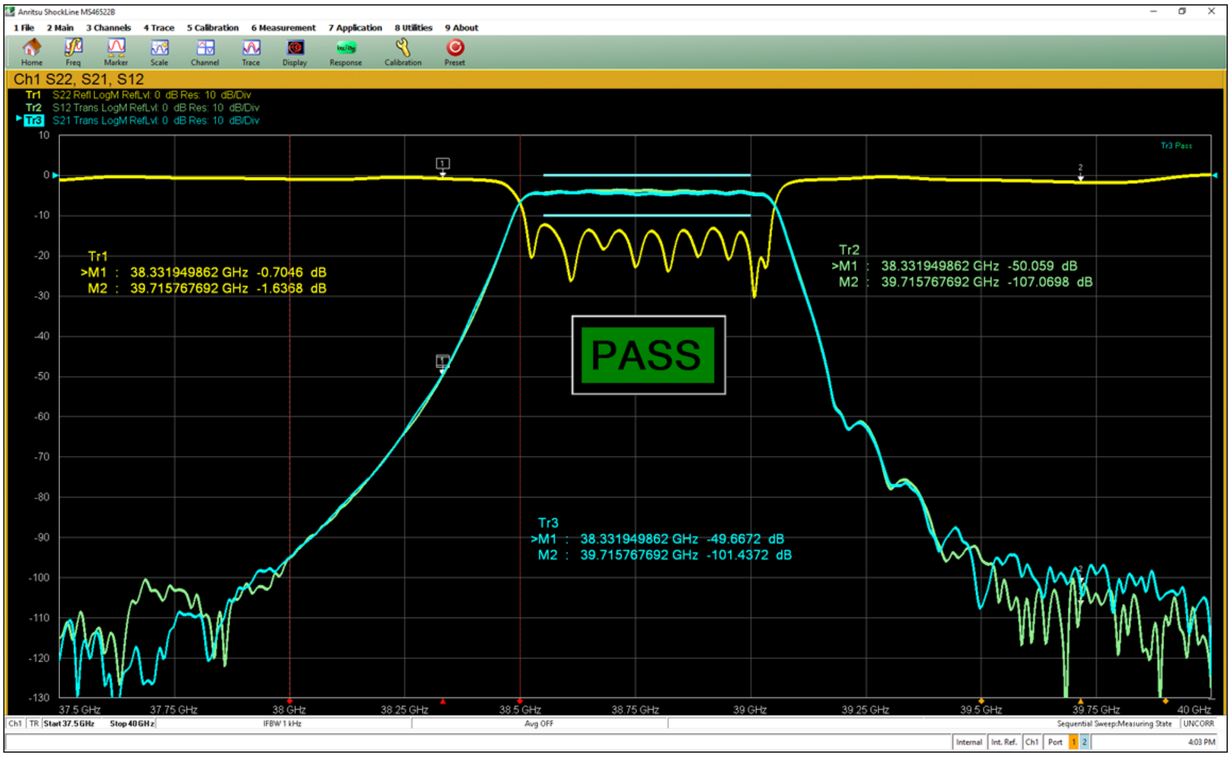

Figure 5. ShockLine GUI with configured font, trace thickness, markers, and limit line color

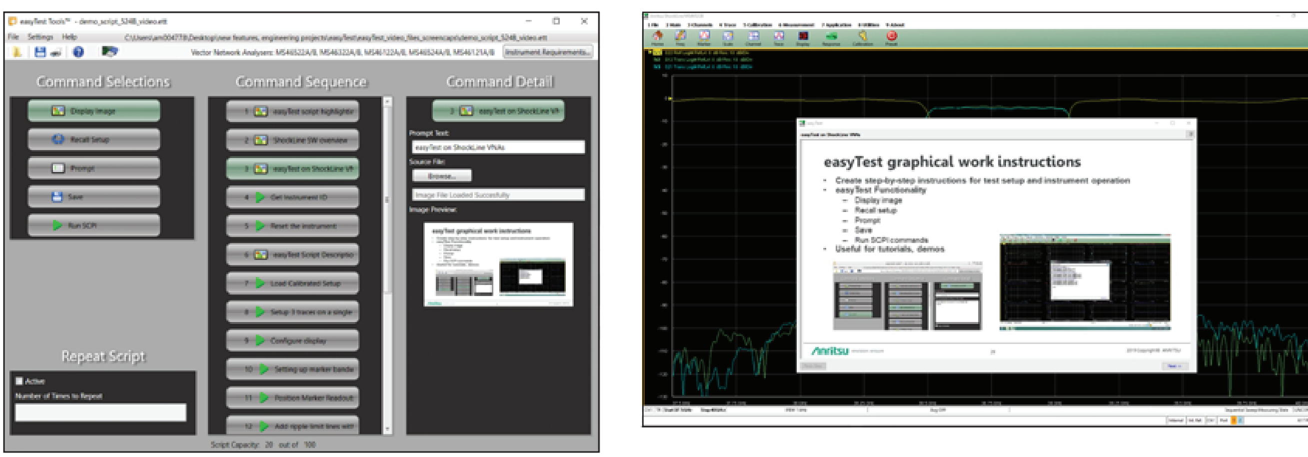

Figure 6. easyTest creation tools and script execution on ShockLine VNAs

Finally, to optimize efficiency, engineers should be able to work offline with the VNA software. Running in simulation mode enables them to continue working on a project without tying up live hardware, which can then be used by another engineer for another project.

Summary

There are many aspects to consider when selecting a VNA for microwave S-parameter testing in production. Cost-of-test needs must be balanced with performance requirements and different tradeoffs can be made depending on the specific application. Anritsu's ShockLine family of VNAs target manufacturing applications by providing a combination of performance, robustness, configurability, and ease-of-use at a lower cost than the typical high-end VNA.

Specifications are subject to change without notice.

• United States
Anritsu Company
450 Century Parkway, Suite 190, Allen,
TX 75013 U.S.A.
Phone: +1-800-Anritsu (1-800-267-4878)

• Canada
Anritsu Electronics Ltd.
700 Silver Seven Road, Suite 120,
Kanata, Ontario K2V 1C3, Canada
Phone: +1-613-591-2003
Fax: +1-613-591-1006

• Brazil
Anritsu Electrônica Ltda.
Praça Amadeu Amaral, 27 - 1 Andar
01327-010 - Bela Vista - Sao Paulo - SP - Brazil
Phone: +55-11-3283-2511
Fax: +55-11-3288-6940

• Mexico
Anritsu Company, S.A. de C.V.
Blvd Miguel de Cervantes Saavedra #169 Piso 1, Col. Granada
Mexico, Ciudad de Mexico, 11520, MEXICO
Phone: +52-55-4169-7104

• United Kingdom
Anritsu EMEA Ltd.
200 Capability Green, Luton, Bedfordshire LU1 3LU, U.K.
Phone: +44-1582-433200
Fax: +44-1582-731303

• France
Anritsu S.A.
12 avenue du Québec, Batiment Iris 1-Silic 612,
91140 VILLEBON-SUR-YETTE, France
Phone: +33-1-60-92-15-50
Fax: +33-1-64-46-10-65

• Germany
Anritsu GmbH
Nemetschek Haus, Konrad-Zuse-Platz 1
81829 München, Germany
Phone: +49-89-442308-0
Fax: +49-89-442308-55

• Italy
Anritsu S.r.l.
Via Elio Vittorini 129, 00144 Roma Italy
Phone: +39-06-509-9711
Fax: +39-6-502-2425

• Sweden
Anritsu AB
Isafjordsgatan 32C, 164 40 KISTA, Sweden
Phone: +46-8-534-707-00

• Finland
Anritsu AB
Teknobulevardi 3-5, FI-01530 VANTAA, Finland
Phone: +358-20-741-8100
Fax: +358-20-741-8111

• Denmark
Anritsu A/S
Torveporten 2, 2500 Valby, Denmark
Phone: +45-7211-2200
Fax: +45-7211-2210

• Russia
Anritsu EMEA Ltd.
Representation Office in Russia
Tverskaya str. 16/2, bld. 1, 7th floor.
Moscow, 125009, Russia
Phone: +7-495-363-1694
Fax: +7-495-935-8962

• Spain
Anritsu EMEA Ltd.
Representation Office in Spain
Edificio Cuzco IV, Po. de la Castellana, 141, Pta. 5
28046, Madrid, Spain
Phone: +34-915-726-761
Fax: +34-915-726-621

• United Arab Emirates
Anritsu EMEA Ltd.
Dubai Liaison Office
902, Aurora Tower,
P O Box: 500311- Dubai Internet City
Dubai, United Arab Emirates
Phone: +971-4-3758479
Fax: +971-4-4249036

• India
Anritsu India Pvt Ltd.
6th Floor, Indiqube ETA, No.38/4, Adjacent to EMC2,
Doddanekundi, Outer Ring Road, Bengaluru – 560048, India
Phone: +91-80-6728-1300
Fax: +91-80-6728-1301

• Singapore
Anritsu Pte. Ltd.
11 Chang Charn Road, #04-01, Shriro House
Singapore 159640
Phone: +65-6282-2400
Fax: +65-6282-2533

• P. R. China (Shanghai)
Anritsu (China) Co., Ltd.
Room 2701-2705, Tower A,
New Caohejing International Business Center
No. 391 Gui Ping Road Shanghai, 200233, P.R. China
Phone: +86-21-6237-0898
Fax: +86-21-6237-0899

• P. R. China (Hong Kong)
Anritsu Company Ltd.
Unit 1006-7, 10/F., Greenfield Tower, Concordia Plaza,
No. 1 Science Museum Road, Tsim Sha Tsui East,
Kowloon, Hong Kong, P. R. China
Phone: +852-2301-4980
Fax: +852-2301-3545

• Japan
Anritsu Corporation
8-5, Tamura-cho, Atsugi-shi, Kanagawa, 243-0016 Japan
Phone: +81-46-296-6509
Fax: +81-46-225-8352

• Korea
Anritsu Corporation, Ltd.
5FL, 235 Pangyoyeok-ro, Bundang-gu, Seongnam-si,
Gyeonggi-do, 13494 Korea
Phone: +82-31-696-7750
Fax: +82-31-696-7751

• Australia
Anritsu Pty Ltd.
Unit 20, 21-35 Ricketts Road,
Mount Waverley, Victoria 3149, Australia
Phone: +61-3-9558-8177
Fax: +61-3-9558-8255

• Taiwan
Anritsu Company Inc.
7F, No. 316, Sec. 1, NeiHu Rd., Taipei 114, Taiwan
Phone: +886-2-8751-1816
Fax: +886-2-8751-1817

11410-01158, Rev. A Printed in United States 2019-12