White Paper

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Optimizing Your Millimeter-Wave Test Capability

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Introduction

Applications are being discovered and developed across a broad range of millimeter-wave (mm-wave) frequencies ranging from 50 GHz to 1 THz. Faster data rates are driving commercial communication applications, while medical, security, and other research areas are investigating the use of ever higher frequencies. Assuring performance and measurement accuracy while minimizing cost are critical in the development of new millimeter-wave applications, if they are to become commercially viable. Testing at millimeter-wave frequencies brings new and different measurement challenges, so minimizing measurement uncertainty is critical in the development of these new technologies.

This white paper discusses the challenges associated with millimeter-wave testing and how to optimize your Vector Network Analyzer (VNA) measurement capability to provide the confidence required to make performance/cost tradeoffs.

Broad Range of Commercial and Research Applications

In the past, millimeter-wave products were often both specialized and expensive. Today with the increased need for bandwidth, 4G systems are pushing demands for higher data throughput particularly in the backhaul infrastructure (Figure 1). Corporate bandwidth needs are driving a market for E-band (71 GHz to 86 GHz) point-to-point solutions that offer enterprise connections up to 1.25 Gbps.

In addition, there are several other millimeter-wave applications that are broadening their commercial use. While having started in the luxury car market, 77 GHz automotive radar systems are beginning to move mainstream. A new WiFi or WiGig standard, IEEE 802.11ad, is in development that will offer very high data rates over the 57 GHz to 64 GHz frequency range. As millimeter-wave applications become more main stream, optimizing cost-of-test becomes important to bringing these new technologies to market.

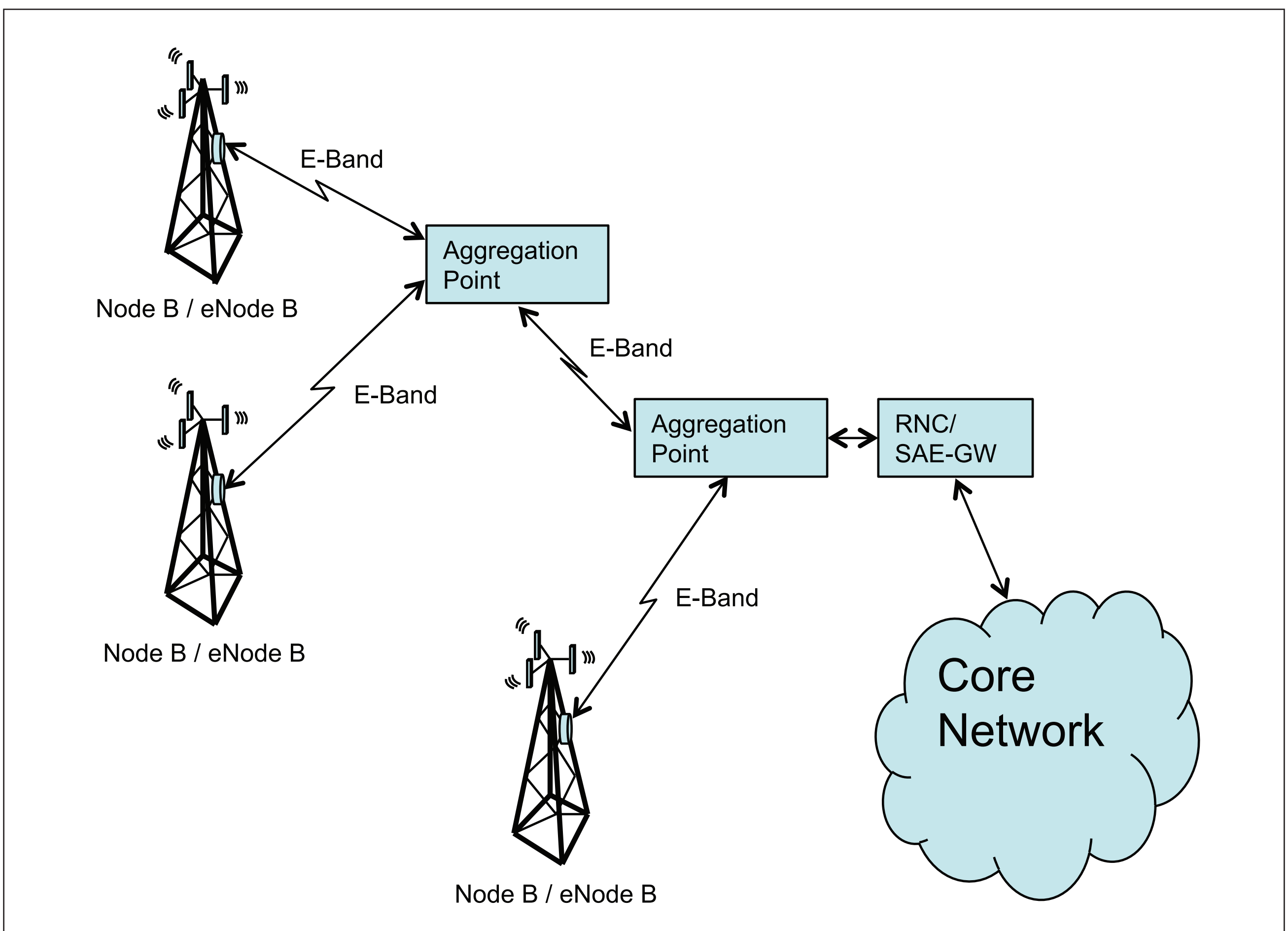


Figure 1. Higher volumes of data are pushing the need for faster data rates and use of E-band links in cellular backhaul.

Table 1 highlights the many areas where applications are being developed at frequencies ranging from 50 GHz up to 1 THz.

Frequency	Application
57 GHz to 64 GHz	WiGig unlicensed band, 2.5 Gbps 802.15, 802.11ad Wireless HD
60 GHz	Wireless backhaul, 100 Mbps to 300 Mbps
71 GHz to 76 GHz	Point-to-point licensed communications links, 1.25 Gbps to 10 Gbps (planned)
77 GHz	Automotive radar
81 GHz to 86 GHz	Point-to-point licensed communications links, 1.25 Gbps to 10 Gbps (planned)
92 GHz to 95 GHz	Point-to-point licensed communications links, 1.25 Gbps to 10 Gbps (planned)
94 GHz	100 MHz band reserved for space-borne radios
	Imaging radar
	Airport ground control
	Cloud profiling radar
110 GHz to 500 GHz	Materials imaging
120 GHz to 124 GHz 138 GHz to 144 GHz	Local networking
122 GHz	Automotive radar
180 GHz to 210 GHz	Atmospheric radar
180 GHz to 300 GHz	Security and healthcare
225 GHz to 750 GHz	Experimental radar
30 GHz to 1 THz	Radio astronomy

Table 1. Millimeter- and Submillimeter-Wave Applications.

Protecting Early Prototypes

Getting to market quickly often means making the most of your millimeter-wave prototypes. Unknown and unstable power levels can easily damage devices under test. In the past, millimeter-wave test systems had relied on software leveling techniques that were less stable and may damage devices due to power level variations. Today, real-time leveling techniques are available which offer very accurate power level control to frequencies as high as 750 GHz. The ability to protect sensitive devices with power sweep control to levels as low as –55 dBm provides amplifier designers the best power accuracy and stability (Figure 2).

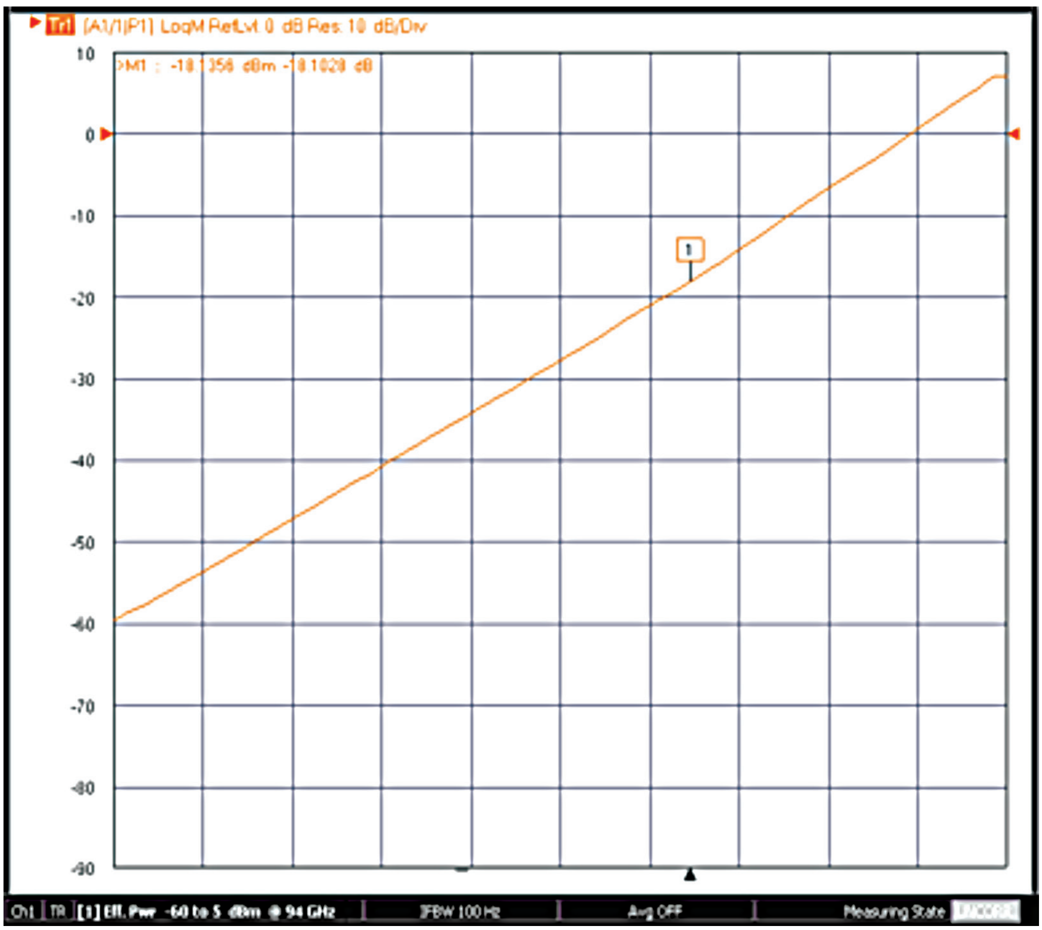


Figure 2. Accurate control of power sweeps, such as this one at 94 GHz from –60 dBm to +5 dBm, minimize potential damage during early prototype development.

Ensuring a Linear Start for Gain Compression Measurements

Millimeter-wave signals often are at lower power levels than traditional RF or microwave applications. For amplifiers, it is important that power measurements begin in the linear region of the amplifier, which may require a very low power level start for one's power sweep. Accurate power sweep measurements utilizing real-time power level control up to 55 dB enables accurate linear gain and 1 dB compression measurements (Figure 3).

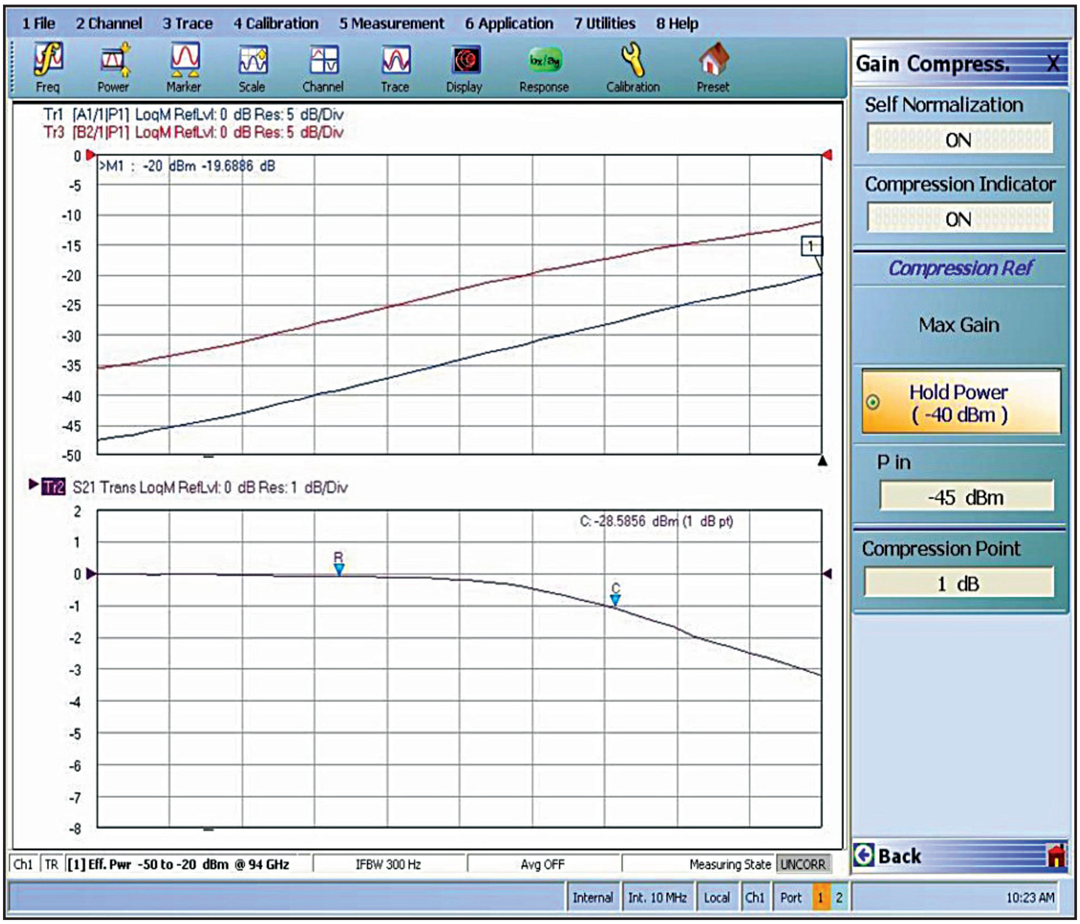
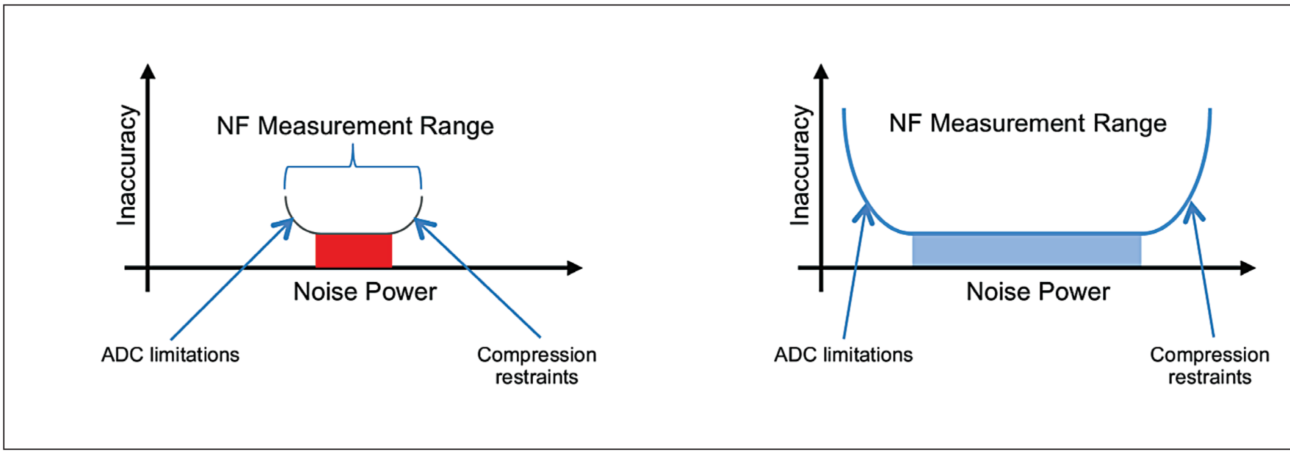


Figure 3. A wide power sweep range allows for clear identification of linear and compressed regions.

Optimizing Noise Figure Measurement Range

Configuring a noise figure test setup at millimeter-wave frequencies can be particularly challenging. It is often necessary to add pre-amplification and filtering in front of the measurement receiver to ensure the sensitivity required to make a quality measurement. If too little amplification is used, there may be too much jitter from the instrument A/D converter (Figure 4). If too much power or amplification is applied, compression can impact the measurements. Selecting a test system that provides a wide noise figure measurement range enables greater configuration flexibility, simplifying the setup and offering the ability to more accurately test a wider variety of devices (Figure 5).



(a) Tight ranges limit accuracy. *(b) Optimized NF measurement range.*

Figure 4. It is important that your millimeter-wave test system has a wide noise figure measurement range over which noise power is low enough not to compress the receiver, but high enough to minimize noise contributions from ADC jitter.

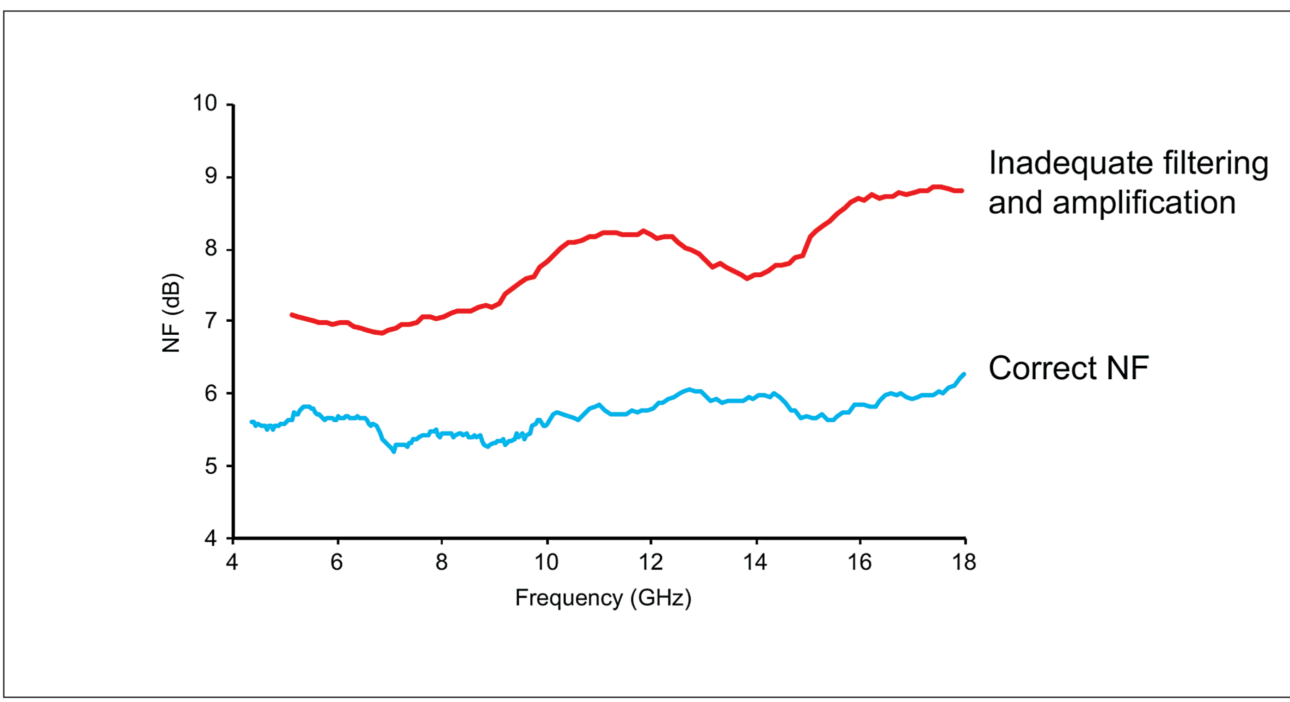


Figure 5. Wide noise figure measurement range enables greater configuration flexibility and offers more accurate measurements to improve your measured vs. predicted outcomes.

Banded Solutions – Get What You Need

Broadband millimeter-wave test equipment can be expensive. Today, test engineers may decrease test instrument expenses with banded millimeter-wave modules for application specific testing. For example, for applications up to 110 GHz, a single millimeter-wave module may be driven by a VNA with a frequency range as low as 40 GHz. For frequencies ranging from 110 GHz up to 750 GHz, waveguide banded millimeter-wave modules can be driven by a VNA with a frequency range as low as 20 GHz. Millimeter-wave modules may be added as interest in new frequency bands occurs.

Conclusion

As the commercialization of millimeter-wave technology continues, there will be many more applications that take advantage of the benefits of these frequency ranges. Measurement tools must help shorten design times and provide the confidence needed to make performance/cost decisions. Vector Network Analyzers play a key role in helping the millimeter-wave test engineer protect early prototypes by performing accurate measurements, whether testing at 50 GHz or 750 GHz. When selecting a VNA, engineers should be looking at characteristics such as accurate power control, wide power sweeps, optimum noise figure range, and cost effective solutions for the frequency range they require.

Specifications are subject to change without notice.

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