

Millimeter Wave Vector Network Analyzer



Measurement Solutions from 33 to 140 GHz



The Anritsu "Lightning" Millimeter

The Anritsu Millimeter Wave Vector Network Analyzer (VNA) extends the exceptional performance of the Lightning VNA family to 140 GHz. This improvement to our original mm-wave system, based on the 360B VNA, continues our commitment to providing the highest quality microwave and millimeterwave test equipment available while still maintaining an intuitive user interface. The minimum configuration for the millimeter-wave VNA has a 37147A VNA, a 3735B Test Set, two 680XXC synthesized sources, and a pair of millimeter beads (Table 1).

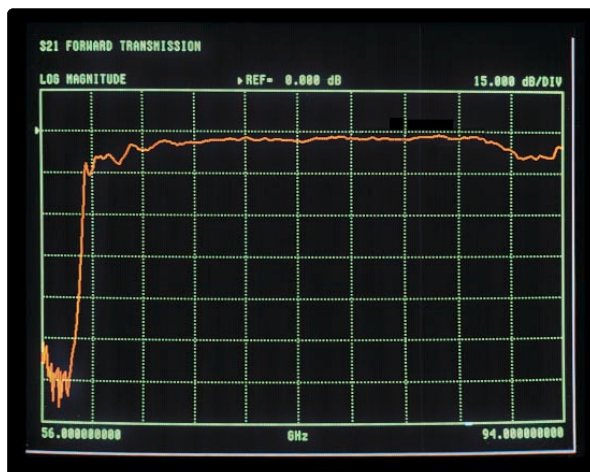
Measurement Speed and Accuracy



Anritsu's Millimeter VNA, based on our popular Lightning platform, offers the fastest measurement speed available in a millimeter VNA. Measurement speed of approximately 20ms per point for a 801 data point sweep means faster tuning and throughput for your millimeter devices. The Anritsu system also offers full auto-reversing, 12-term, error-corrected S-parameter measurements that enable advanced calibration techniques such as Line-Reflect-Line (LRL), Line-Reflect-Match (LRM), and Thru-Reflect-Match (TRM) to be used for maximum accuracy in your on-wafer measurements. For waveguide measurements, the mm-wave system supports all of the above methods as well as the offset short calibration technique. A 21cm., color Liquid Crystal Display (LCD) allows users to easily view the data traces for all four S-parameters while simultane-

ously displaying limit lines and trace memory functions. Built-in 3.5" MS-DOS® compatible Floppy Disk Drive (FDD) and 250 MByte, minimum, Hard Disk Drive (HDD) simplify the procedure to both store and recall calibrations, front panel setups and measurement data. The versatility of the Lightning platform allows data to be gathered using the *.s2p, *.txt, *.dat, *.bmp, *.hgl, and the *.wmf file format so data can be easily loaded into both circuit simulation and graphics programs.

The Most Dynamic Range in a Millimeter VNA



Increased dynamic range relates directly to increased measurement accuracy and confidence when measuring mm-wave components and subsystems. To achieve optimum measurement speed and dynamic range for your measurements, the Lightning millimeter wave VNA allows the number of measurement averages and video IF bandwidth to be varied. The Lightning millimeter wave VNA system dynamic range is typically 15 dB better than comparable VNAs and, noise floor specifications are measured with 512 averages not 1024 averages... an important point to consider when making comparisons*. Simply stated, the Lightning millimeter wave system provides the best dynamic range with sweep speeds twice as fast as comparable instruments.

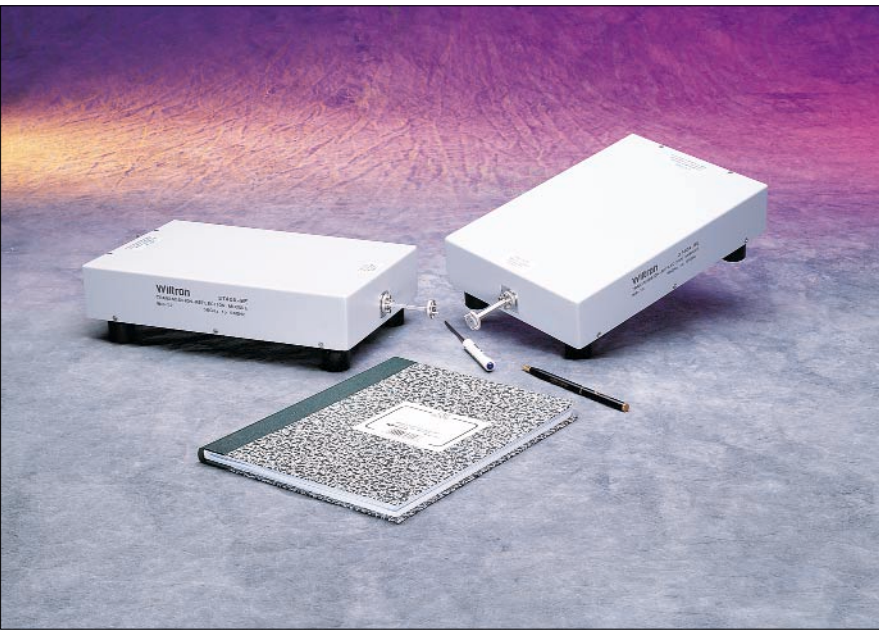
* System Dynamic Range is defined as the differential between the power available at port 1 and the system noise floor. The noise floor of the millimeter system is measured with full two-port error correction and 512 averages in a 100 Hz video IF bandwidth.

Wave Vector Network Analyzer

Model Number	Module Type	Frequency Range	Waveguide Designation
3741A-Q	Transmission Only	33-50 GHz	WR-22
3741A-V	Transmission Only	50-75 GHz	WR-15
3741A-E	Transmission Only	60-90 GHz	WR-12
3741A-EE	Transmission Only	56-94 GHz	WR-12
3741A-W	Transmission Only	75-110 GHz	WR-10
3741A-EW	Transmission Only	65-110 GHz	WR-10
3741A-F	Transmission Only	90-140 GHz	WR-8
3740A-Q	Transmission/Reflection	35-50 GHz	WR-22
3740A-V	Transmission/Reflection	50-75 GHz	WR-15
3740A-E	Transmission/Reflection	60-90 GHz	WR-12
3740A-EE	Transmission/Reflection	56-94 GHz	WR-12
3740A-W	Transmission/Reflection	75-110 GHz	WR-10
3740A-EW	Transmission/Reflection	65-110 GHz	WR-10
3740A-F	Transmission/Reflection	90-140 GHz	WR-8

Table 1 shows the available mm-Wave Modules

Flexible Configuration . . . Waveguide and Coax



Our flexible module configurations let you specify the capability of your millimeter wave VNA. We offer two versions of mm-wave heads that allow you to tailor the Lightning millimeter system to your exact measurement needs. The 3740A Transmission/Reflection modules have simultaneous transmission and reflection capability, while the 3741A transmission only modules are used when reflection measurements are not required. A pair of 3740A modules allows measurement of all four S-parameters of a two-port device. A 3740A Transmission/Reflection module combined with a 3741A Transmission Only module allows measurement of one-path/two port S-parameters (S_{11} and S_{21}). A single 3740A Transmission/Reflection module can be used for S_{11} reflection measurements. The 3740A series also

provides the smallest footprint and lightest weight of any millimeter-wave test head on the market today. This greatly simplifies your test setup; regardless of whether you are manually adjusting the head position for waveguide measurements or have attached them to a wafer probe station. In order to maximize the flexibility of your VNA, the system architecture provides for a smooth transition between waveguide and coaxial device measurements. Simply add a coaxial test set to your system and you have the capability to fully characterize your active and passive coaxial devices, up to 40 GHz.

System Operation and Solutions

System Operation

Two GPIB controlled synthesized sources are used to provide the RF and LO drives for the millimeter wave system. The LO input is used in the frequency range 8-19 GHz. It is divided in the test set to provide an LO to both Port 1 and Port 2 modules. The RF is used in the frequency range 9-23 GHz. The RF is switched in the test set using the transfer switch to provide RF to both the Port 1 and Port 2 modules. The internal source of the 37147A VNA is not used during millimeter wave measurements. The search for lock algorithm used with the internal source can result in crossing spurs which may hinder the ability of the VNA to lock on frequency. Using external phase locked synthesizers and setting up the VNA to track the synthesizers eliminates this problem.

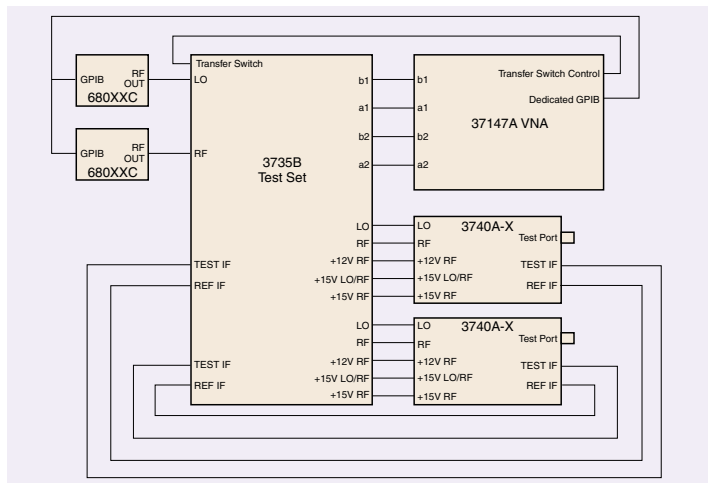


Figure 1 shows the basic configuration of the 37100A Millimeter Wave System.

The 3735B test set contains the transfer switch as well as the power supply to provide DC voltage to the millimeter wave modules, and a printed circuit board to provide logic for transfer switch control and front panel LED's.

The 3740A-X module contains the RF components to up-convert the RF input to the desired test port frequency. Harmonic mixers are used to generate the 270 MHz Test and Reference IF signals which are sent to the VNA via the test set. The 3740A-X module contains a dual directional coupler needed to make transmission and reflection measurements.

The 3741A-X module contains the harmonic mixer necessary to generate the Test IF signal. An external waveguide attenuator is used in conjunction with the 3741A-X.

The 37147A provides direct access to the four channel sampler. The Test IF and Reference IF signals generated in the millimeter wave modules are sent to the four inputs, a1, b1, a2, b2 of the VNA via the millimeter wave test set. Since the internal source is not used in millimeter wave measurements, it may be removed from the VNA as an option. In that case the standard Source Lock Out, RF Out, RF In, and Internal Source Output connectors of the 37147A are removed. Transfer switch control is provided via the connector located on the rear panel of the VNA. The VNA is used in tracking mode and controls the two external synthesizers via the GPIB.

3740A-X Transmission/Reflection Millimeter Wave Module

The 3740A-X Transmission/Reflection module is the heart of the millimeter wave system. It contains all the frequency conversion, mixers and signal routing necessary to make millimeter wave frequency S-parameter measurements. The RF chain differs between the waveguide bands. The E Band module, Extended E Band, W Band, Extended W Band, and F Band use a times six multiplication scheme for the RF path. The V Band module uses a times four multiplication scheme and the Q Band module, a times three multiplier.

Operation of the E Band (3740A-E) Module

The external synthesizer used as the RF source is programmed to one-sixth (1/6) of the desired DUT frequency. The RF signal enters the millimeter wave module, is doubled and amplified in the Doubler/Amplifier and then tripled in the Tripler. The RF signal, now up-converted to the desired DUT frequency is sent to the Dual Directional Coupler. The through path of the coupler is tied to the Test Port. The output RF signal is coupled off and sent to the first harmonic mixer, which is used to generate the Reference IF signal. The dual directional coupler also couples off the RF signal reflected or transmitted from the DUT which provides the RF input to the second harmonic mixer. This is used to generate the Test IF signal.

The external synthesizer being used as the LO source is programmed to one-fifth (1/5) of the desired DUT frequency offset by 270 MHz. The LO signal enters the millimeter wave module into a limiting amplifier, which is used to keep the LO power at a fixed level into the Harmonic Mixer. The LO signal is then split to provide inputs to both of the Harmonic Mixers. The Harmonic Mixers in the case of E Band use the fifth harmonic of the LO signal. In the first harmonic mixer, the fifth harmonic of the LO is mixed with the coupled off RF signal to create the 270 MHz Reference IF input to the VNA. In the second harmonic mixer, the fifth harmonic of the LO is mixed with the RF signal reflected or transmitted from the DUT creating the 270 MHz Test IF.

The VNA receives a fixed 270 MHz test and reference IF from the millimeter wave modules. The samplers are operated in direct (bypass) mode.

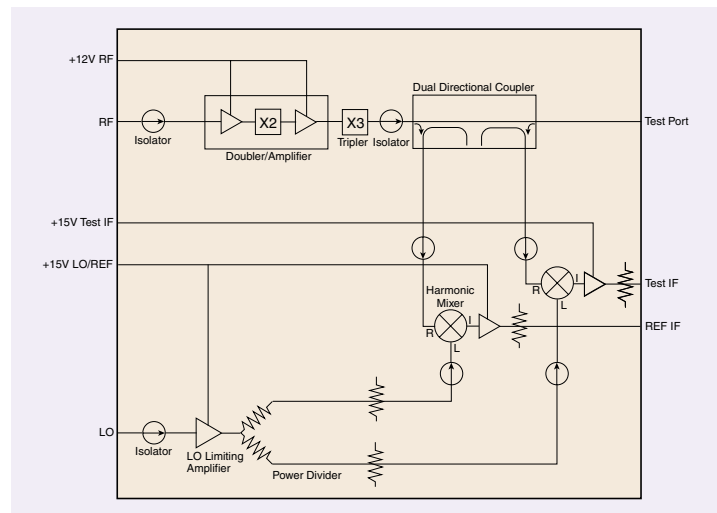
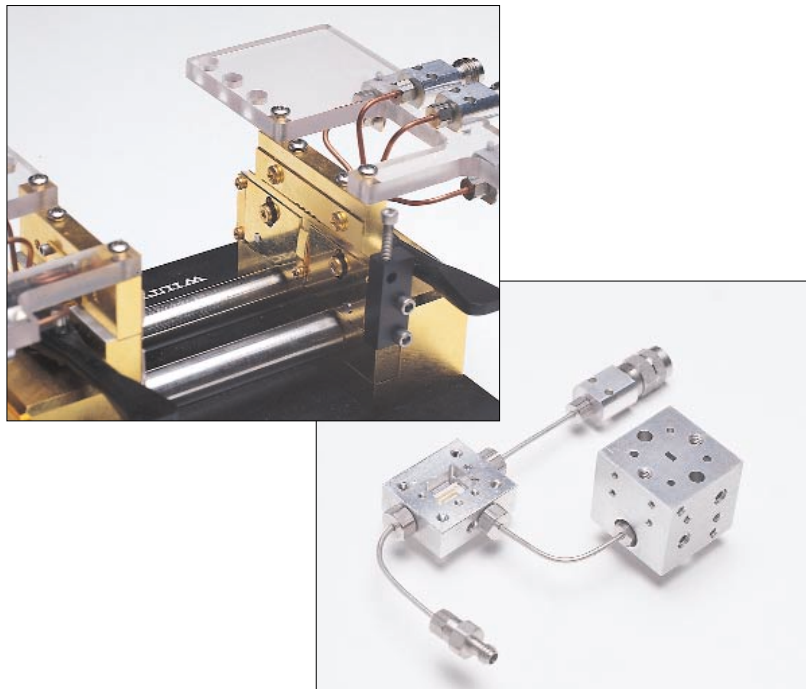


Figure 2 shows the millimeter head block diagram

Complete Measurement Solutions

In addition to the millimeter wave VNA measurement system, Anritsu offers a full line of power meters and synthesized signal generators up to 110 GHz. To complete your millimeter measurement setup, Anritsu also offers solutions for waveguide, on-wafer, and even coaxial applications. With our custom design and manufacturing capabilities, we have developed 110 GHz coaxial connectors, couplers, adapters, and even test fixtures for use in your millimeter test set-ups.



Specifications

All specifications are guaranteed at $23^{\circ} \pm 3^{\circ} C$

System Performance

The table below gives dynamic range in two formats. System Dynamic Range is defined as the ratio of the power at Port 1 and the system noise floor (forward measurements only). Receiver Dynamic Range is defined as the ratio of the Maximum Signal into Port 2 for 0.1 dB compression to the system noise floor. The noise floor measurement is made using 512 averages in a 100 Hz video IF bandwidth.

Waveguide Designation	Q-Band (WR-22)	V-Band (WR-15)	E-Band (WR-12)	Extended E-Band	W-Band (WR-10)	Extended W-Band	F-Band (WR-8)
Frequency Range (GHz)	33-50	50-75	60-90	56-60 60-85 85-94	75-100 100-110	65-75 75-100 100-110	90-115 115-140
Max Signal into Port 2 (dBm)	+10	+8	+8	+8	+6	+6	+4
Noise Floor (dBm)	-93	-90	-90	-85 -90 -76	-90 -90	-90 -89 -87	-88 -87
Receiver Dynamic Range (dB)	103	98	98	93 98 84	96 96	96 95 93	92 91
High Level Noise (dB, typical)	.02	.05	.06	.08	.06	.08	.08
Power @ DUT (dBm, typical)	+7	+7	+6	+5 +6 +4	+5 +2	-5 +5 +2	-3 -7
System Dynamic Range (dB)	100	97	96	90 96 80	95 92	85 94 89	85 90

Test Port Characteristics

The specifications in the table below apply when the proper high precision waveguide adapters are connected to the module ports and calibrated with the appropriate calibration kit at $23^{\circ} \pm 3^{\circ}$ C using the Offset Short calibration method with a sliding load or LRL calibration method (as noted) to achieve 12-term error correction.

Offset Short Calibration

Waveguide Designation	Q-Band WR-22	V-Band WR-15	E-Band WR-12	Extended E-Band	W-Band WR-10	Extended W-Band	F-Band WR-8
Frequency (GHz)	33 to 50	50 to 75	60 to 90	56 to 94	75 to 110	65 to 110	90 to 140
Directivity (dB)	>50	>50	>46	>44	>46	>40	>45
Source Match (dB)	>45	>37	>36	>33	>36	>30	>34
Load Match (dB)	>50	>50	>46	>44	>46	>40	>45
Reflection Frequency Tracking (dB)	+/-0.010	+/-0.030	+/-0.040	+/-0.080	+/-0.040	+/-0.080	+/-0.060
Transmission Frequency Tracking (dB)	+/-0.010	+/-0.060	+/-0.060	+/-0.10	+/-0.070	+/-0.10	+/-0.10
Isolation (dB)	>100	>90	>90	>80	>90	>80	>80

LRL Calibration

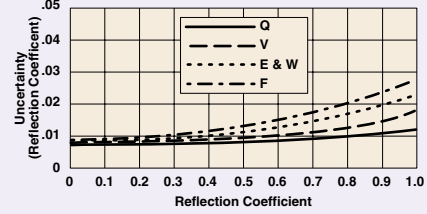
Waveguide Designation	Q-Band WR-22	V-Band WR-15	E-Band WR-12	Extended E-Band	W-Band WR-10	Extended W-Band	F-Band WR-8
Frequency (GHz)	33 to 50	50 to 75	60 to 90	56 to 94	75 to 110	65 to 110	90 to 140
Directivity (dB)	>50	>50	>46	>44	>46	>40	>45
Source Match (dB)	>50	>50	>46	>43	>46	>40	>45
Load Match (dB)	>50	>50	>46	>44	>46	>40	>45
Reflection Frequency Tracking (dB)	+/-0.002	+/-0.002	+/-0.002	+/-0.006	+/-0.002	+/-0.006	+/-0.004
Transmission Frequency Tracking (dB)	+/-0.002	+/-0.002	+/-0.002	+/-0.006	+/-0.002	+/-0.006	+/-0.004
Isolation (dB)	>100	>90	>90	>80	>90	>80	>80

Measurement Uncertainty Curves

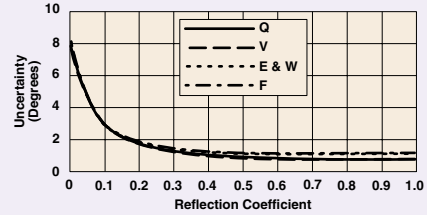
3740A & 3741A Series mm-wave modules (Q, V, E, EE, W, EW, & F bands) Using Offset Short Calibration Method

Q, V, E, W, F Band Reflection and Transmission Measurements:

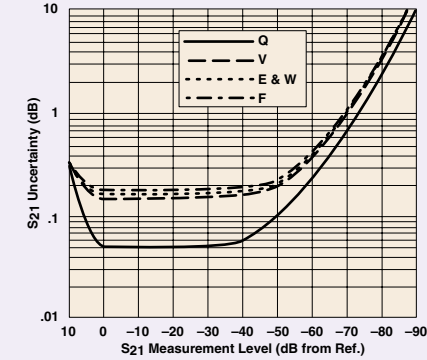
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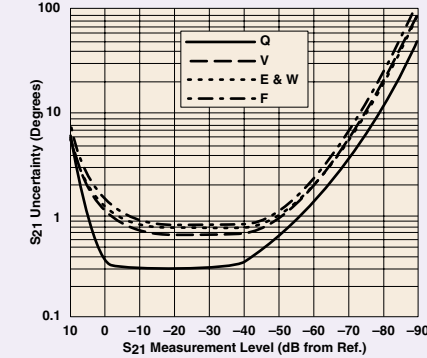
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TRANSMISSION MEASUREMENTS:
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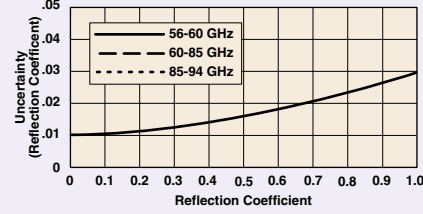


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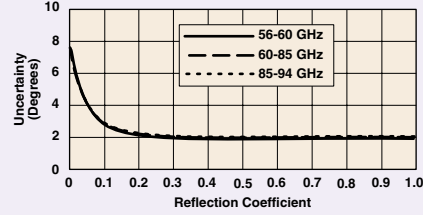


Extended E Band Reflection and Transmission Measurements:

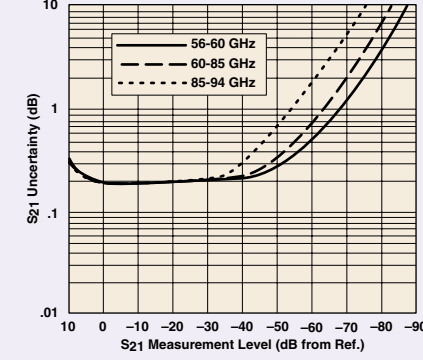
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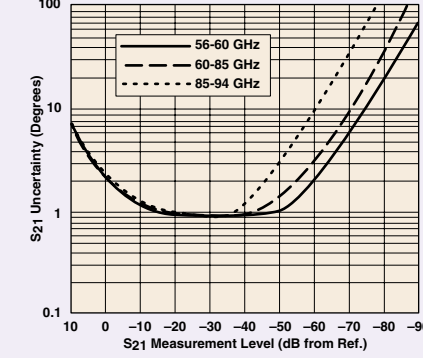
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TRANSMISSION MEASUREMENTS:
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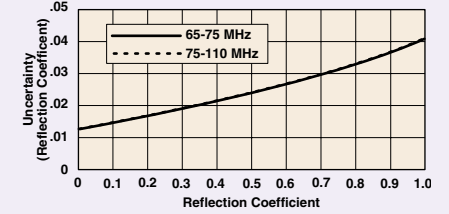


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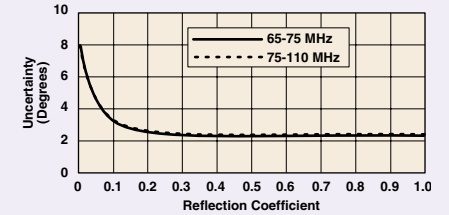


Extended W Band Reflection and Transmission Measurements:

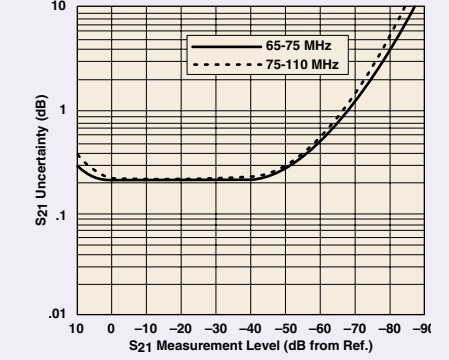
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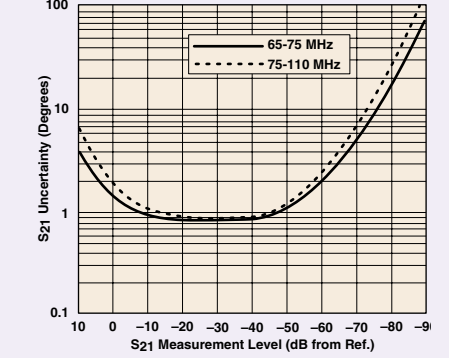
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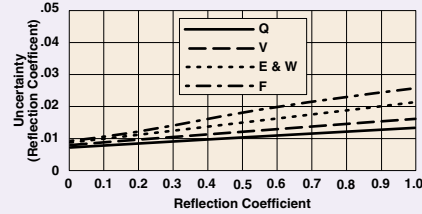
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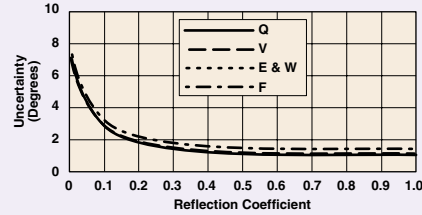
3740A & 3741A Series mm-wave modules (Q, V, E, EE, W, EW, & F bands) Using LRL Calibration Method

Q, V, E, W, F Band Reflection and Transmission Measurements:

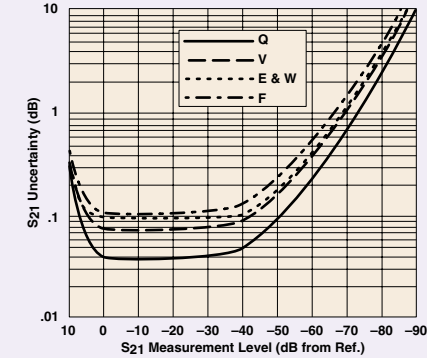
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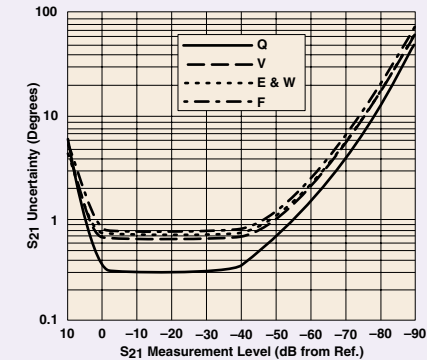
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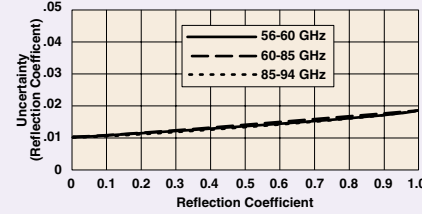


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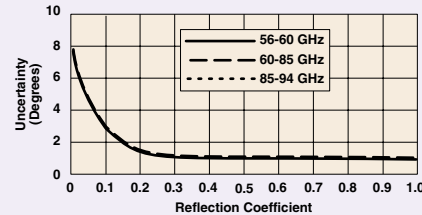


Extended E Band Reflection and Transmission Measurements:

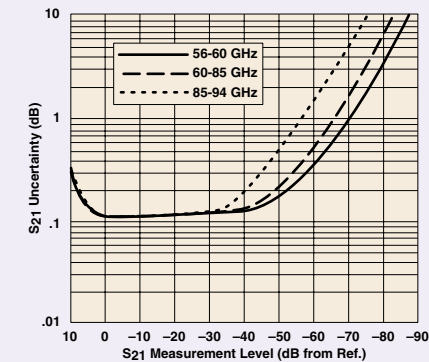
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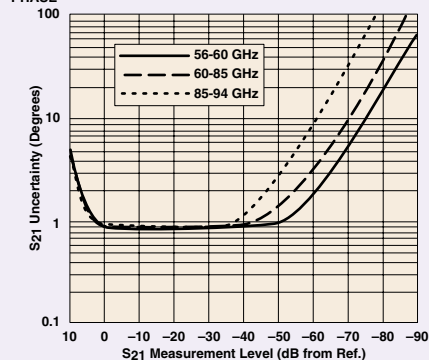
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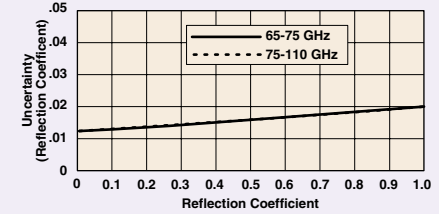


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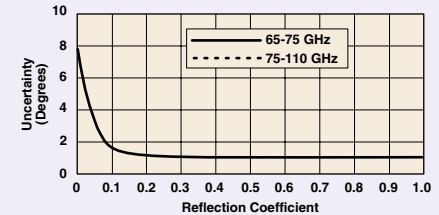


Extended W Band Reflection and Transmission Measurements:

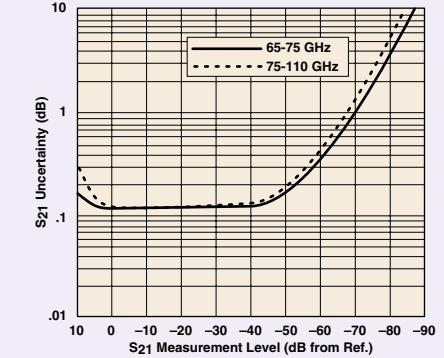
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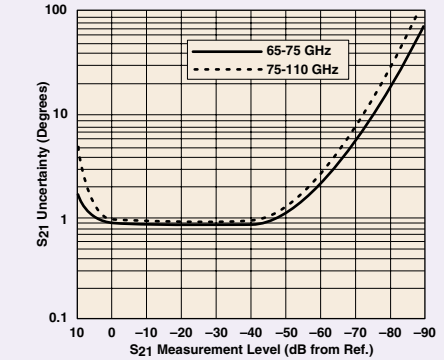
REFLECTION MEASUREMENTS: PHASE



TRANSMISSION MEASUREMENTS: MAGNITUDE



TRANSMISSION MEASUREMENTS: PHASE



Ordering Guide

Calibration Kits

The 3655 Calibration Kit contains all the precision components and tools required to calibrate for 12-term error-corrected measurements of test devices with the appropriate waveguide designation. Components are included for calibrating both module ports. The kit supports calibration with fixed broadband loads, as well as sliding loads (Option 1).

Consisting of:

- Short, Fixed (2 each)
- Shim, 1/8 Wavelength
- Shim, 3/8 Wavelength
- Termination, Fixed (2 each)
- Test Port Section (2 each)

Option 1:

Adds Sliding Termination

Verification Kits

The 3665 Verification Kit contains precision waveguide components with characteristics that are traceable to the National Institute of Standards and Technology (NIST). Used primarily by the metrology laboratory, these components provide the most dependable means of determining system accuracy. A disk containing factory-measured test data for all components is supplied for comparison with customer-measured data by our Service personnel.

Consisting of:

- Attenuator, 20 dB
- Attenuator, 40 dB
- Section, Precision Straight
- Mismatch Section

Option 1:

Adds Sliding Termination

Recommended Sources

Millimeter Wave systems require two external sources from the 68C or 69B family, minimum configuration is two 68037C* sources. At least one of the sources must be ordered with Option 15*. See the 68C and 69B Series Synthesizer Data Sheets for detailed specifications.

**Note that for WR-8 F Band operation, both sources must be ordered with Option 15, and one of the sources must be at least a 68067C since the RF Source is used over 20 GHz.*

68037C (2 GHz - 20 GHz)

- Option 1, Rack Mounting with Track Slides
- Option 1A, Rack Mounting
- Option 11, 0.1 Hz Frequency Resolution
- Option 15A, High Power Output (required for all LO Sources)
- Option 17B, Delete Front Panel

68067C (10 GHz - 40 GHz) – Required for WR-8 F Band operation as RF Source

- Option 1, Rack Mounting with Track Slides
- Option 1A, Rack Mounting
- Option 11, 0.1 Hz Frequency Resolution
- Option 15A, High Power Output (required for WR-8 F Band Operation)
- Option 17B, Delete Front Panel

Console

The millimeter-wave VNA system has the option of being installed in a rack mount configuration in a custom enclosure.

3700C3, System Console

Console includes all necessary cables and a removable 117 cm. x 46 cm. work table.

Network Analyzer

Select one of the following two Network Analyzers. See the 37100A Series Data Sheet for detailed specifications.

37147A (40 MHz - 20 GHz)

37169A (40 MHz - 40 GHz)

- Option 1, Rack Mounting with Track Slides
- Option 1A, Rack Mounting
- Option 2A, High Speed Time (Distance) Domain
- Option 4, External SCSI-2 Hard Disk Drive Compatibility
- Option 13, Delete Internal Source

Test Set

3735B Millimeter Test Set

The standard configuration is table-top. The test set includes all the necessary interface cables.

- Option 1, Rack Mounting with Track Slides
- Option 1A, Rack Mounting

Millimeter-Wave Modules

The millimeter-wave VNA requires a minimum of one Transmission/Reflection module for operation.

Transmission/Reflection Modules

3740A-Q (33 to 50 GHz)
3740A-V (50 to 75 GHz)
3740A-E (60 to 90 GHz)
3740A-EE (56 to 94 GHz)
3740A-W (75 to 110 GHz)
3740A-EW (65 to 110 GHz)
3740A-F (90 to 140 GHz)

Transmission Only Modules

3741A-Q (33 to 50 GHz)
3741A-V (50 to 75 GHz)
3741A-E (60 to 90 GHz)
3741A-EE (56 to 94 GHz)
3741A-W (75 to 110 GHz)
3741A-EW (65 to 110 GHz)
3741A-F (90-140 GHz)

Approximate module dimensions:

3740A-Q ; 35 cm. x 20 cm. x 8 cm. (L x W x H), 3.2 kg.
All other 3740A ; 28 cm. x 18 cm. x 6 cm., 2.25 kg.
All 3741A modules ; 11 cm. x 14 cm. x 6 cm., .91 kg.

Calibration Kits

3655Q (33-50 GHz) Calibration Kit

Option 1; Adds Sliding Termination

3655V (50-75 GHz) Calibration Kit

Option 1; Adds Sliding Termination

3655E (60-90 GHz) Calibration Kit

Option 1; Adds Sliding Termination

3655W (75-110 GHz) Calibration Kit

Option 1; Adds Sliding Termination

3655F (90-140 GHz) Calibration Kit

Option 1; Adds Sliding Termination

Verification Kits

3665Q (33-50 GHz) Verification Kit

3665V (50-75 GHz) Verification Kit

3665E (60-90 GHz) Verification Kit

3665W (75-110 GHz) Verification Kit

Product Support

Reliability and Serviceability

The Anritsu millimeter-wave VNA system has been designed with performance, long term reliability, ease-of-use, and serviceability in mind. Extensive environmental, safety, and EMC testing has been performed to ensure compliance with all industry standards. This extensive testing and resulting system refinements help guarantee that user productivity is optimized via maximum system up-time.

Built-in Diagnostics

Every time the system is powered up, an extensive internal diagnostic routine is initiated. This routine checks the operation of many of the critical paths in the power supply, the source and the receiver. Once in operation, a periodic self calibration takes place that maintains the accuracy and reliability of your millimeter measurements. Should the diagnostics indicate an irregularity, the process of identifying the cause is further facilitated by an extensive internal troubleshooting program and an internal service log that automatically records all system occurrences.

Warranty

The Anritsu millimeter-wave VNA is covered by a one-year, return-to-factory warranty (two years on YIG-tuned oscillators). In most cases, by taking advantage of Anritsu's Exchange Assembly Service, unit or system repair can be completed either on-site or at your local service center. Extended warranty options for two, three, and five years are also available for your Anritsu millimeter system. The extended warranties may only be ordered at the time of system purchase.

Service Agreements

Annual Repair and/or Calibration Service Agreements are also available on most Anritsu products. With an Anritsu Service Agreement, you know in advance exactly what your support costs will be. You also have the assurance of knowing that your equipment will be serviced by qualified personnel using factory-approved procedures and instrumentation. Several Service Agreement options (detailed below) are available to meet your specific needs.

Repair Agreement: Includes all labor and material required to maintain your system in good working condition. Should repair be required, the product is returned to the nearest Anritsu Service Center where it will be repaired and returned within the time span stated on the agreement. Does not include calibrations.

Calibration Agreement: Provides periodic calibrations at factory recommended intervals. More economical than per incident calibrations and includes return freight.

Full Service Agreement: Combines all the features of both the Repair Agreement and the Calibration Agreement in one convenient package.

Military Agreements: Both the Calibration and Full Service Agreements may be available in versions that comply with the requirements of ANSI/NCSI Z540-1-1994.

Contact your local Anritsu Customer Service Center for additional details on these support options.

Training

A comprehensive, customized training course covering such topics as Front Panel Operation, Calibration, Measurement Applications, and Time Domain operation is available with your millimeter-wave VNA. Contact your local Anritsu Sales office for more information.



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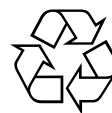
US (800) ANRITSU
Canada (800) ANRITSU
South America 55 (21) 286-9141

Anritsu

Microwave Measurements Division • 490 Jarvis Drive • Morgan Hill, CA 95037-2809
<http://www.global.anritsu.com> • FAX (408) 778-0239

Sales Centers:

Europe 44 (01582) 433200
Japan 81 (03) 3446-1111
Asia-Pacific 65-2822400



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