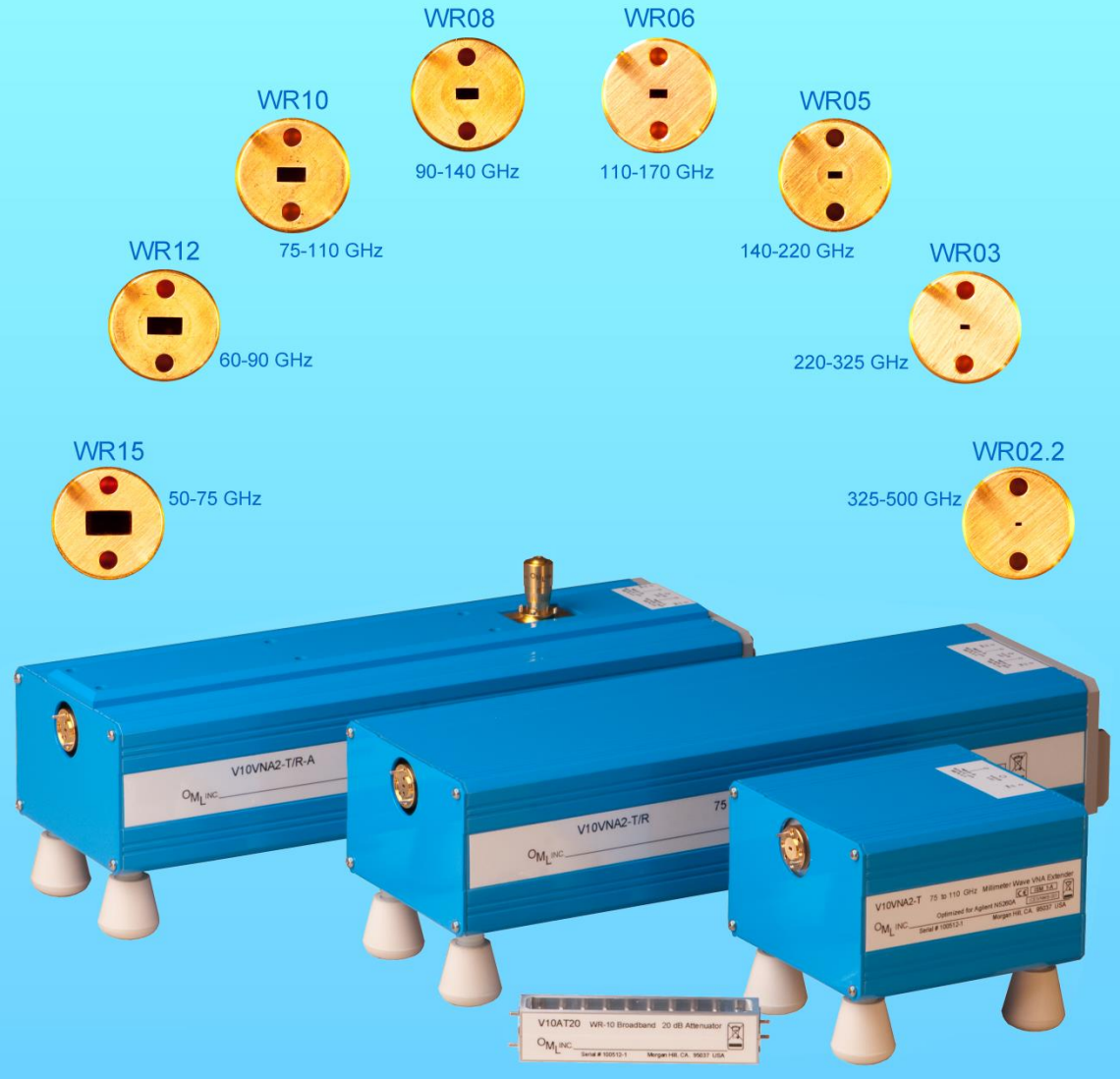
MILLIMETER WAVE VNA MODULE BROCHURE



"Innovation in Millimeter Wave Measurements"

OML Inc.
300 Digital Drive • Morgan Hill, CA 95037 • Tel: 408-779-2698 • Fax: 408-778-0491 • email: info@omlinc.com • www.omlinc.com

General Information

OML, founded in 1991, is an expert at millimeter wave (mm-wave) measurements. Our successful foundation is built on mm-wave S-parameter measurements, but our broad solution portfolio spans the full gamut of instrument classes: signal generator, spectrum analyzer, scalar network analyzer and vector network analyzer. Simply stated, we proudly enable engineers to use existing microwave instruments for mm-wave applications.

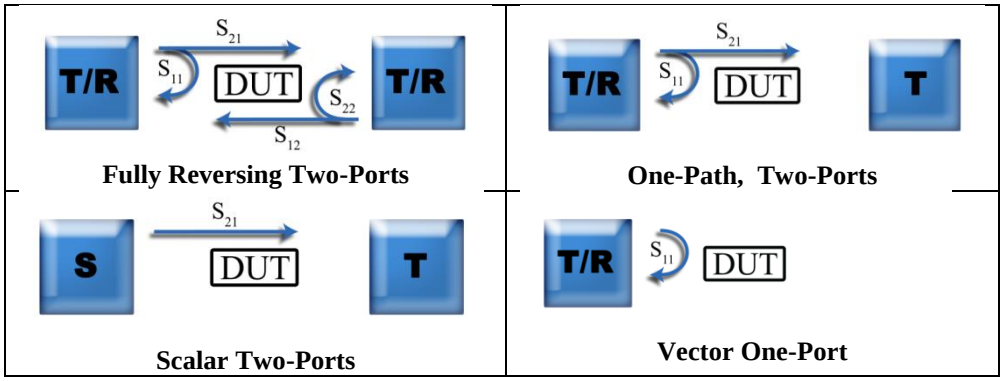
Our popular VNA modules enable engineers to conduct mm-wave S-parameters. The DUT interface is the standard waveguide flange that complies with MIL-DTL-3922/67D. Organized by waveguide bands, VNA modules are available from 50 GHz to 0.5 THz (and beyond).

As shown in the following side-by-side comparison, OML's VNA modules are compatible with modern vector network analyzers from Keysight, Anritsu and Rohde & Schwarz, respectively. As a general prerequisite, direct receiver access and 20 GHz are essential. Contact your local sales representative for order configuration support.

OML offers best-in-class solutions for a variety of millimeter wave applications: on-wafer, pulse (high power), amplifier, antenna, balanced/differential, mixer, multiport, and material. In addition, OML offers solutions for emerging modulated measurements.

Direct Connect Solutions for S-Parameters

OML modules are available in a variety of S-parameter configurations. Use the following table to translate your S-parameter requirements into the OML configuration: T/R, T and/or S.



For active measurements, the T/R module (except V02.2VNA2) is available with manual adjustable attenuator to vary output power by more than 25 dB. Electronic attenuation is also available (contact factory for more details).

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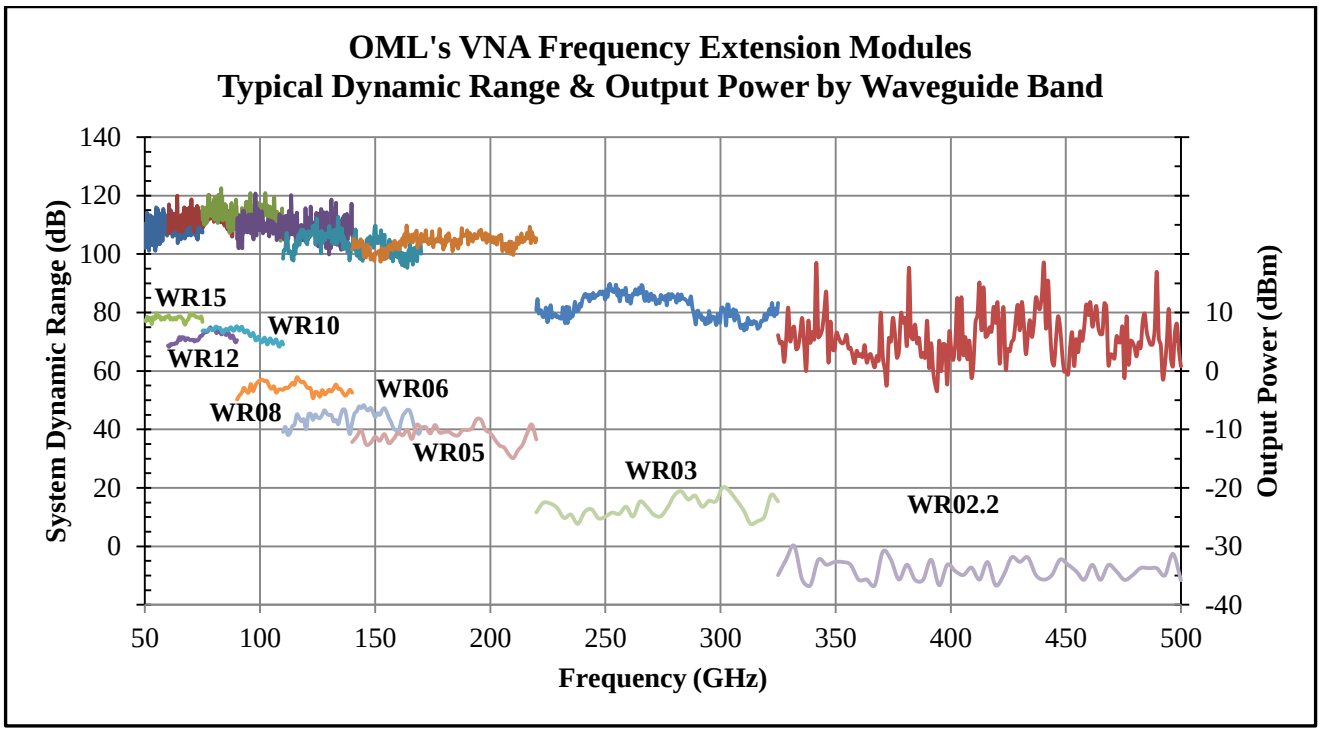
Typical S-Parameter Performance at a Glance

The overall system performance of dynamic range and output power are shown in the following chart. On the left primary vertical axis is dynamic range in dB while on the right secondary axis is output power in dBm. These attributes highlight the excellent performance available for S-parameter measurements.



Raw Match & Raw Directivity Deliver Superior Calibration Stability

In our VNA modules, OML designs and manufacturers their own high performance coupler for the signal separation function necessary for the S-parameter ratio measurements. In addition, OML includes a mm-wave isolator (except WR-03, WR-02.2) in the RF path. These two differentiated features ensure OML's VNA module has the industry's best raw source match, raw load match and raw directivity specifications.

Often overlooked and taken for granted, these raw specifications should not be confused with other published residual or corrected terms found elsewhere. The reason to compare the raw specifications is because they impact calibration stability and uncertainty when measuring non-ideal devices such as amplifiers and mixers. In general, better raw performance yields improved calibration stability and reduced uncertainties.

Given these advantages, OML's industry leading raw characteristics deliver ultra-stable calibrations and ultra-precise measurements. This is why OML is the preferred solution for metrology-grade measurements.

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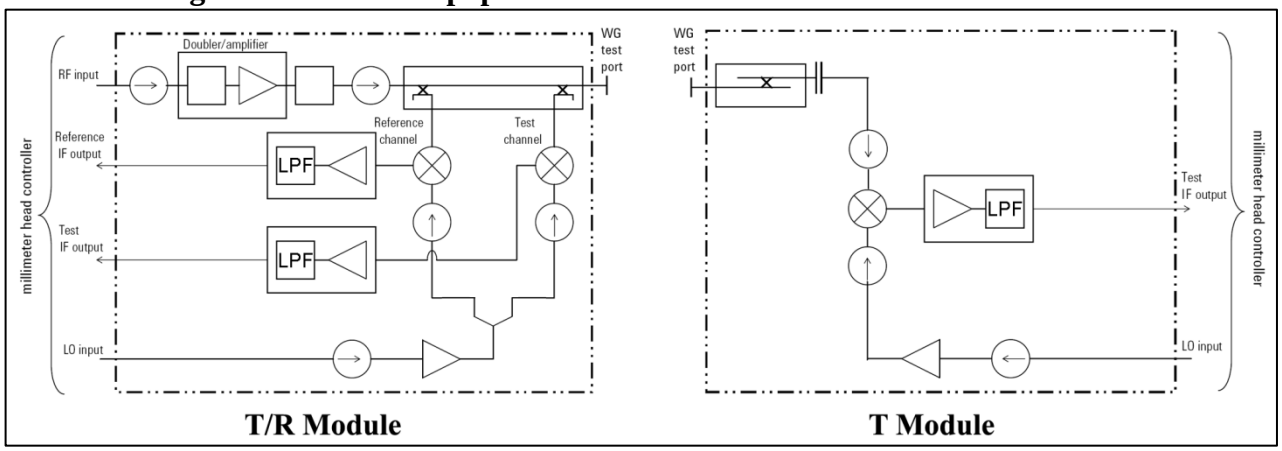
Block Diagrams of T/R and T Modules

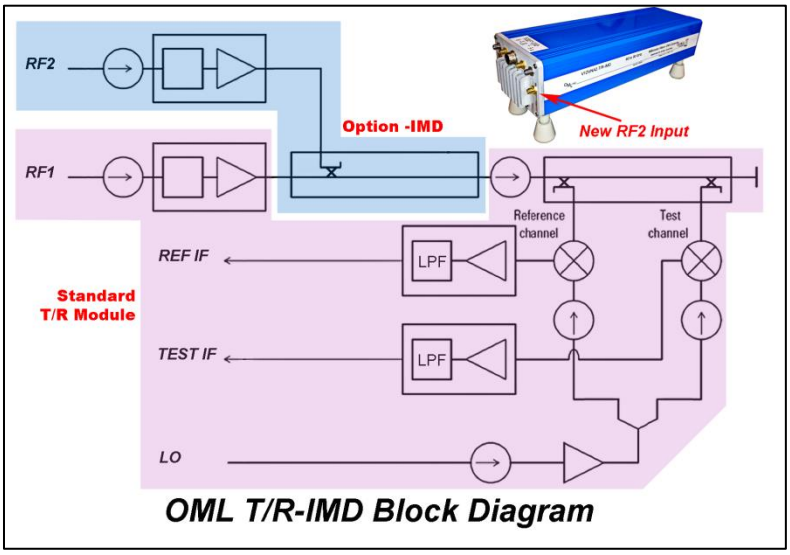
The block diagrams of our most popular OML modules are shown below.



The waveguide (WG) test ports connect to the device under test when the RF, IF, and LO inputs are connected to the millimeter test set controller (or VNA).

***** NEW Block Diagram of T/R-IMD Module *****

Responding to the needs of engineers characterizing active devices, OML is proud to announce the availability of the industry's first mm-wave IMD module. In this T/R-IMD module, a single connection to the DUT can reveal S-parameters, gain compression and intermodulation distortion (IMD) performance. As the following block diagram illustrates, the T/R-IMD module contains the functionality of standard VNA and standard Source modules along with a coupler for combining the two tones.



Additional options for electronic or manual attenuation are available. Contact the factory for more details on how to optimize this new T/R-IMD module for your swept power requirements, including the possibility of upgrading existing VNA modules.

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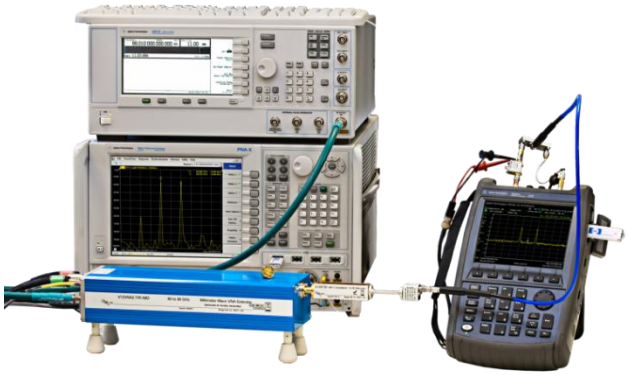
IMD Performance Discussion

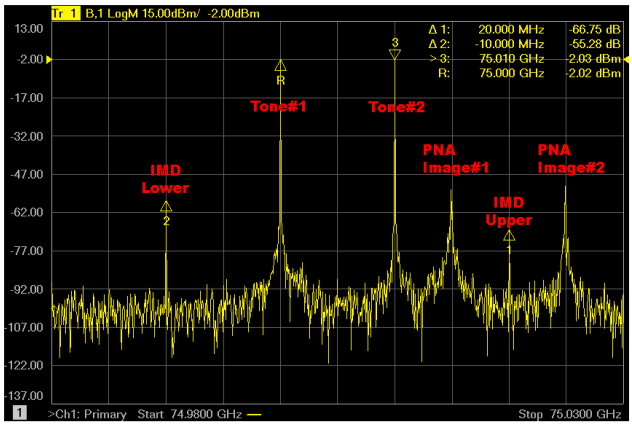
This mm-wave IMD capability is an industry's first with potential to conduct single connection multiple measurement (SCMM) scenarios. The benefit of this approach is faster and more thorough characterization that increases throughput and lowers overall cost-of-test. The following table summarizes the available configurations and key specifications of the T/R-IMD module.



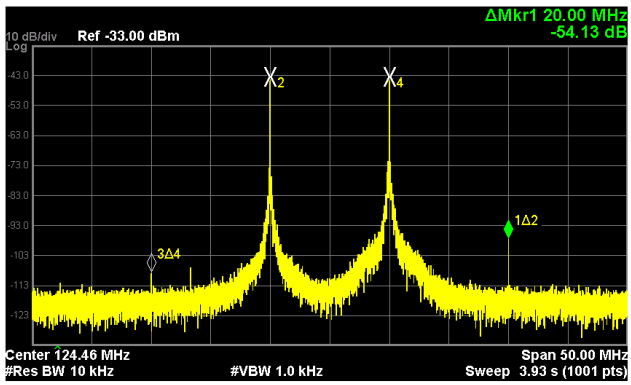
SPECIFICATIONS	V15VNA2-T/R-IMD	V12VNA2-T/R-IMD	V10VNA2-T/R-IMD
System Operating Freq. (GHz)	50 to 75	60 to 90	75 to 110
RF1 Max Output Power, typical	+8 dBm	+5 dBm	+5 dBm
RF1 range, typical (20 dB using Pin/Pout)	+8 dBm to -18 dBm	+5 dBm to -15 dBm	+5 dBm to -15 dBm
RF2 Max Output Power, typical	-2 dBm	-4 dBm	-5 dBm
RF2 range, typical (20 dB using Pin/Pout)	-2 dBm to -22 dBm	-4 dBm to -24 dBm	-5 dBm to -25 dBm
TOI, typical (T/R, T) -10 dBm, 10 MHz offset	+15 dBm	+15 dBm	+15 dBm
0.1 dB compression, typical	+ 8 dBm	+8 dBm	+6 dBm
DC Power, typical	+12VDC @ 2.5A	+12VDC @ 2.5A	+12VDC @ 2.5A

The following side-by-side comparison between network analyzer (left) and spectrum analyzer (right) demonstrates the flexibility to use the T/R-IMD module for both of these popular configurations. For more application examples, please visit the following site to download our new application note:

https://www.omlinc.com/solutions/test-a-measurement/imd



Network Analyzer (801 pts)



Spectrum Analyzer (1001 pts)

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SPECIFICATIONS[1]	"T/R" MODELS							
	V15VNA2-T/R	V12VNA2-T/R	V10VNA2-T/R	V08VNA2-T/R	V06VNA2-T/R	V05VNA2-T/R	V03VNA2-T/R	V02.2VNA2-T/R
System Operating Freq. (GHz)	50 to 75	60 to 90	75 to 110	90 to 140	110 to 170	140 to 220	220 to 325	325 to 500
RF Input Freq. (GHz)	12.5 to 18.8	10.0 to 15.0	12.5 to 18.4	11.2 to 17.5	9.1 to 14.2	11.6 to 18.4	12.2 to 18.1	10.8 to 16.7
RF Input Power (dBm)	+10 ± 1.5 dB							
RF Input Damage Level (dBm)[2]	+20							
RF Multiplication Factor	4	6	6	8	12	12	18	30
LO Input Freq. (GHz)	10.0 to 15.0	12.0 to 18.0	9.3 to 13.8	11.2 to 17.5	11.0 to 17.0	11.6 to 18.4	12.2 to 18.1	11.6 to 17.9
LO Input Power (dBm)	+10 ± 1.5 dB							
LO Input Damage Level (dBm)[2]	+20							
LO Multiplication Factor	5	5	8	8	10	12	18	28
Test Port Output Power[3] Minimum (dBm) Typical (dBm)	 +5 +8	 +2 +5	 +3 +5	 -8 -4	 -15 -10	 -18 -13	 -23	 -35
Test Port Input Power @ 0.1 dB comp. (dBm) typ.[2]	+8	+8	+6	+4	-5	-5	-5	-10
Test Port Input Damage Level (dBm)[2]	+20	+20	+20	+20	+20	+13	+13	+13
Test Port Match (dB), typ.[2]	> 17	> 17	> 17	> 17	> 15	> 15	> 9	> 6
Residual Source & Load Match (dB), typ.	> 35	> 35	> 35	> 35	> 35	> 35	> 33	> 30
Test Dynamic Range[4] Minimum (dB) Typical (dB)	 92 > 105	 92 > 105	 95 > 110	 90 > 105	 80 > 95	 80 > 95	 60 > 75	 40 > 55
Reflection & Transmission Tracking[5] Magnitude (dB) Phase (deg)	 ± 0.2 ± 2	 ± 0.2 ± 2	 ± 0.2 ± 2	 ± 0.3 ± 3	 ± 0.4 ± 5	 ± 0.4 ± 6	 ± 0.4 ± 8	 ± 0.6 ± 10
IF Output Freq. (MHz)	5 to 300							
Coupler Directivity[2] Minimum (dB) Typical (dB)	 35 > 37	 35 > 37	 35 > 37	 33 > 35	 30 > 35	 30 > 35	 30 > 35	 20 > 25
Residual Directivity[2] Typical (dB)	> 40	> 40	> 40	> 40	> 40	> 40	> 35	> 35
Manually Adjustable Attenuator[6]	0 to 25 dB min							N/A
System Input Interface RF LO IF DC	 SMA(f) SMA(f) SMA(f) 7 Pin Circular Jack							
System Output Interface[7] (Test Port)	WR-15	WR-12	WR-10	WR-08	WR-06	WR-05	WR-03	WR-02.2
DC Power	+12VDC @ 1.5A typ.							+12VDC @ 3.0A typ.
Operating Temperature	+20 to +30°C							
Weight	≤ 6 lbs							≤ 6.5 lbs
Size[8] (L x W x H)	13.0" x 4.3" x 2.7"							
RoHS Compliance	No	No	Yes	No	No	Yes	Yes	Yes

[1] Specifications are typical and subject to change without notice
[2] Not tested
[3] As there are no internationally recognized power standards above 110 GHz, any power data supplied above 110 GHz is traceable only to OML's calorimeter.
[4] Measured with Keysight PNA-X (N524xA) at 10 Hz IF bandwidth
[5] At +25°C. Measured for 1 hr after 1 hr warm-up. Based on "perfect" RF &LO test cables not moved after warm-up and calibration. Not tested.
[6] Available as an option (Option A)
[7] Test Port Flange Configuration is compatible with MIL-DTL-3922/67D (UG 387/U-M)
[8] Height excludes the adjustable rubber feet length and depth dimension excludes the output waveguide length

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SPECIFICATIONS[1]	"T" MODELS							
	V15VNA2-T	V12VNA2-T	V10VNA2-T	V08VNA2-T	V06VNA2-T	V05VNA2-T	V03VNA2-T	V02.2VNA2-T
System Operating Freq. (GHz)	50 to 75	60 to 90	75 to 110	90 to 140	110 to 170	140 to 220	220 to 325	325 to 500
LO Input Freq. (GHz)	10.0 to 15.0	12.0 to 18.0	9.3 to 13.8	11.2 to 17.5	11.0 to 17.0	11.6 to 18.4	12.2 to 18.1	11.6 to 17.9
LO Input Power (dBm)	+10 ± 1.5 dB							
LO Input Damage Level (dBm)[2]	+20							
LO Multiplication Factor	5	5	8	8	10	12	18	28
Test Port Input Power @ 0.1 dB comp. (dBm) typ.[2,3]	+8	+8	+6	+4	-5	-5	-15	-20
Test Port Input Damage Level (dBm)[2,3]	+20	+20	+20	+20	+20	+13	+3	+3
Test Port Match (dB) typ.[2]	> 17	> 17	> 17	> 17	> 15	> 15	> 6	> 6
Test Dynamic Range[4]								
Minimum (dB)	92	92	95	90	80	80	60	40
Typical (dB)	> 105	> 105	> 105	> 105	> 95	> 95	> 75	> 55
Stability[5]								
Magnitude (dB)	± 0.2	± 0.2	± 0.2	± 0.3	± 0.4	± 0.4	± 0.4	± 0.6
Phase (deg)	± 2	± 2	± 2	± 3	± 5	± 6	± 8	± 10
IF Output Freq. (MHz)	5 to 300							
System Input Interface								
LO	SMA(f)							
IF	SMA(f)							
DC	7 Pin Circular Jack							
System Output Interface[6] (Test Port)	WR-15	WR-12	WR-10	WR-08	WR-06	WR-05	WR-03	WR-02.2
DC Power	+12VDC @ 0.5A typ.							+12VDC @ 1.5A typ.
Operating Temperature	+20 to +30°C							
Weight	≤ 3 lbs							≤ 4.5 lbs
Size[7] (L x W x H)	4.7" x 4.3" x 2.7"							5.7" x 4.3" x 2.7"
RoHS Compliance	No	No	Yes	No	No	Yes	Yes	Yes

[1] Specifications are typical and subject to change without notice
[2] Not tested
[3] With external attenuator attached to test port. No external attenuator is available for V03VNA2-T & V02.2VNA2-T
[4] Measured with Keysight PNA-X (N524xA) at 10 Hz IF bandwidth
[5] At +25°C. Measured for 1 hr after 1 hr warm-up. Based on "perfect" RF &LO test cables not moved after warm-up and calibration. Not tested.
[6] Test Port Flange Configuration is compatible with MIL-DTL-3922/67D (UG 387/U-M)
[7] Height excludes the adjustable rubber feet length and depth dimension excludes the output waveguide length

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SPECIFICATIONS[1]	"S" MODELS							
	V15VNA2-S	V12VNA2-S	V10VNA2-S	V08VNA2-S	V06VNA2-S	V05VNA2-S	V03VNA2-S	V02.2VNA2-S
System Operating Freq. (GHz)	50 to 75	60 to 90	75 to 110	90 to 140	110 to 170	140 to 220	220 to 325	325 to 500
RF Input Freq. (GHz)	12.5 to 18.8	10.0 to 15.0	12.5 to 18.4	11.2 to 17.5	9.1 to 14.2	11.6 to 18.4	12.2 to 18.1	10.8 to 16.7
RF Input Power (dBm)	+10 ± 1.5 dB							
RF Input Damage Level (dBm)[2]	+20							
RF Multiplication Factor	4	6	6	8	12	12	18	30
LO Input Freq. (GHz)	10.0 to 15.0	12.0 to 18.0	9.3 to 13.8	11.2 to 17.5	11.0 to 17.0	11.6 to 18.4	12.2 to 18.1	11.6 to 17.9
LO Input Power (dBm)	+10 ± 1.5 dB							
LO Input Damage Level (dBm)[2]	+20							
LO Multiplication Factor	5	5	8	8	10	12	18	28
Test Port Output Power[3]								
Minimum (dBm)	+5	+2	+3	-8	-15	-18		
Typical (dBm)	+8	+5	+5	-4	-10	-13	-23	-35
Test Port Input Damage Level (dBm)[2]	+20	+20	+20	+20	+20	+13	+13	+13
Test Port Match (dB) typ.[2]	> 17	> 17	> 17	> 17	> 15	> 15	> 9	> 6
IF Output Freq. (MHz)	5 to 300							
Manually Adjustable Attenuator[4]	0 to 25 dB min							N/A
System Input Interface								
RF	SMA(f)							
LO	SMA(f)							
IF	SMA(f)							
DC	7 Pin Circular Jack							
System Output Interface[5] (Test Port)	WR-15	WR-12	WR-10	WR-08	WR-06	WR-05	WR-03	WR-02.2
DC Power	+12VDC @ 1.5A typ.							+12VDC @ 3.0A typ.
Operating Temperature	+20 to +30°C							
Weight	≤ 6 lbs							≤ 6.5 lbs
Size[6] (L x W x H)	13.0" x 4.3" x 2.7"							
RoHS Compliance	No	No	Yes	No	No	Yes	Yes	Yes

[1] Specifications are typical and subject to change without notice
[2] Not tested
[3] As there are no internationally recognized power standards above 110 GHz, any power data supplied above 110 GHz is traceable only to OML's calorimeter.
[4] Available as an option (Option A)
[5] Test Port Flange Configuration is compatible with MIL-DTL-3922/67D (UG 387/U-M)
[6] Height excludes the adjustable rubber feet length and depth dimension excludes the output waveguide length

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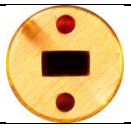
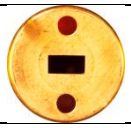
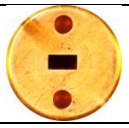
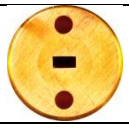
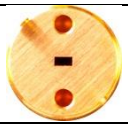
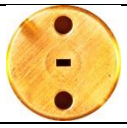
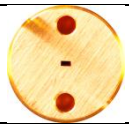
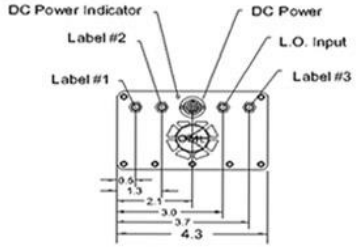
Ordering Information

Band	WR15	WR12[1]	WR10[1]	WR08	WR06	WR05	WR03	WR02.2
Waveguide Interface								
Frequency (GHz)	50-75	60-90	75-110	90-140	110-170	140-220	220-325	325-500
Part Number (VxxVNA2)	V15VNA2	V12VNA2	V10VNA2	V08VNA2	V06VNA2	V05VNA2	V03VNA2	V02.2VNA2

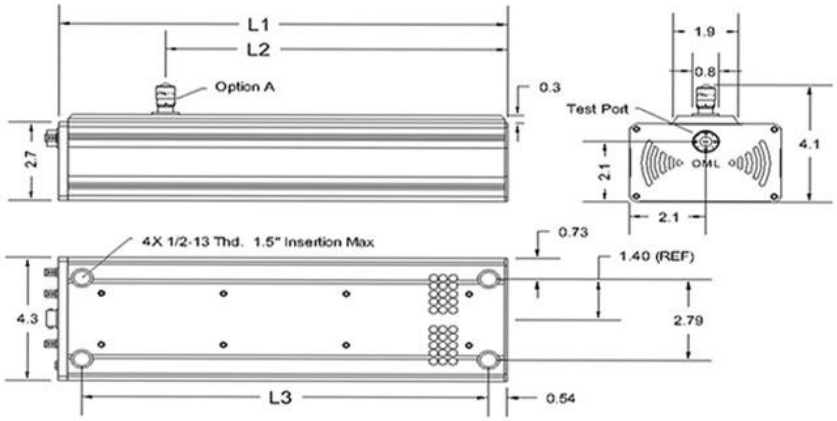
S-parameters {Architecture}	S_{11}, S_{21}, S_{12}, S_{22} {Full 2-port}	(S_{11}, S_{21}) or (S_{12}, S_{22}) {1-path / 2-port}	S_{21} or S_{12} only {Scalar 2-port}	S_{11} or S_{22} only {Vector 1-port}
Test Port Module(s)	VxxVNA2-T/R VxxVNA2-T/R	VxxVNA2-T/R VxxVNA2-T	VxxVNA2-S VxxVNA2-T	VxxVNA2-T/R
Option A	In T/R or S module, adds 0 to 25 dB Manually Adjustable Attenuator to RF Path.[2]			
Option RLA	In T/R or S module, adds amplifier (15 dB gain) in RF&LO paths for drive input of -5 dBm			
Option LOA	In T module, adds amplifier (15 dB gain) in LO path for drive input of -5 dBm			

[1]**Also Available are Extended WR12 (56-94 GHz) and Extended WR10 (65-110 GHz)**
[2]**Modules with output power attenuation are not currently available in WR02.2**

Mechanical Dimension (If necessary, contact OML for more detailed drawings)



Module	Label Description		
	#1	#2	#3
T/R, S	Ref. I.F.	R.F. Input	Test I.F.
T	N/A	Test I.F.	N/A



Module	L1	L2	L3
T/R, S	12.7	X.X	11.44
T	4.7	N/A	3.37

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MILLIMETER WAVE RECTANGULAR TE_{10} WAVEGUIDE INFORMATION

WG Band	Waveguide Frequency Range (GHz)	Wavelength Range λo (mil)	Wavelength Range λo (mm)	Guide Wavelength Range (λg/λo)	Waveguide Impedance Range (Ω)	TE_{10} Cutoff Freq (GHz)	TE_{10} Cutoff λc (mil)	TE_{10} Cutoff λc (mm)	Internal Dimensions (mils)	Internal Dimensions (mm)
WR-28	26.5 - 40.0	445.4 - 295.1	11.313 - 7.495	1.650 - 1.177	621.9 - 443.6	21.1	560.0	14.22	280.0 x 140.0	7.112 x 3.556
WR-22	33.0 - 50.0	357.7 - 236.1	9.085 - 5.996	1.661 - 1.177	626.0 - 443.6	26.3	448.0	11.38	224.0 x 112.0	5.690 x 2.845
WR-19	40.0 - 60.0	295.1 - 196.7	7.495 - 4.997	1.613 - 1.173	608.3 - 442.4	31.4	376.0	9.55	188.0 x 94.0	4.775 x 2.388
WR-15	50.0 - 75.0	236.1 - 157.4	5.996 - 3.997	1.657 - 1.181	624.8 - 445.1	39.9	296.0	7.52	148.0 x 74.0	3.759 x 1.880
WR-12	60.0 - 90.0	196.7 - 131.1	4.997 - 3.331	1.690 - 1.186	637.2 - 447.1	48.4	244.0	6.20	122.0 x 61.0	3.099 x 1.549
WR-10	75.0 - 110.0	157.4 - 107.3	3.997 - 2.725	1.620 - 1.185	610.9 - 446.7	59.0	200.0	5.08	100.0 x 50.0	2.50 x 1.270
WR-08	90.0 - 140.0	131.1 - 84.3	3.331 - 2.141	1.746 - 1.177	658.1 - 443.6	73.8	160.0	4.06	80.0 x 40.0	2.032 x 1.016
WR-06	110.0 - 170.0	107.3 - 69.4	2.725 - 1.763	1.771 - 1.183	667.7 - 445.9	90.8	130.0	3.30	65.0 x 32.5	1.651 x 0.826
WR-05	140.0 - 220.0	84.3 - 53.6	2.141 - 1.363	1.777 - 1.176	669.7 - 443.3	115.7	102.0	2.59	51.0 x 25.5	1.295 x 0.648
WR-04	170.0 - 260.0	69.4 - 45.4	1.763 - 1.153	1.695 - 1.177	638.8 - 443.9	137.2	86.0	2.18	43.0 x 21.5	1.092 x 0.546
WR-03	220.0 - 325.0	53.6 - 36.3	1.363 - 0.922	1.627 - 1.183	613.5 - 445.9	173.6	68.0	1.73	34.0 x 17.0	0.864 x 0.432
WR-02.8	260.0 - 400.0	45.4 - 29.5	1.153 - 0.749	1.708 - 1.177	643.8 - 443.6	210.8	56.0	1.42	28.0 x 14.0	0.711 x 0.356
WR-02.2	325.0 - 500.0	36.3 - 23.6	0.922 - 0.600	1.771 - 1.185	667.7 - 446.7	268.2	44.0	1.12	22.0 x 11.0	0.559 x 0.279
WR-01.9	400.0 - 600.0	29.5 - 19.7	0.749 - 0.500	1.587 - 1.169	598.3 - 440.6	310.6	38.0	0.97	19.0 x 9.5	0.483 x 0.241
WR-01.5	500.0 - 750.0	23.6 - 15.7	0.600 - 0.400	1.620 - 1.175	610.9 - 442.8	393.4	30.0	0.76	15.0 x 7.5	0.381 x 0.191
WR-01.2	600.0 - 900.0	19.7 - 13.1	0.500 - 0.333	1.746 - 1.194	658.1 - 450.1	491.8	24.0	0.61	12.0 x 6.0	0.305 x 0.152
WR-01.0	750.0 - 1100.0	15.7 - 10.7	0.400 - 0.273	1.620 - 1.185	610.9 - 446.7	590.1	20.0	0.51	10.0 x 5.0	0.254 x 0.127

VNA2 Brochure: Rev. D
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