Use of OML Millimeter Wave Vector Network Analyzer Frequency Extension Modules with Anritsu "Lightning" and "Panorama" Vector Network Analyzers

OML, Inc. has developed a series of millimeter wave Frequency Extension Modules (Modules) designed to extend the frequency coverage of the Anritsu 37xxxA/C/D Vector Network Analyzers (VNA). These Modules cover the popular waveguide bands ranging from 50 to 325 GHz.

OML has assembled, with the aid of Anritsu, a basic understanding of the ME7808A/B Panorama and 37xxxA/C/D (Lightning) VNA systems aimed at allowing a user to expand their millimeter wave capabilities beyond those that Anritsu provides directly. Anritsu configures its typical system firmware to use certain Anritsu test instruments when making a given measurement. The firmware routine, when run, checks to see if these instruments are connected to the GPIB interconnect. It is possible to configure one's own system, using the appropriate Anritsu instruments, and save that configuration file for later use.

Necessary VNA system equipment

The OML Millimeter Wave VNA Modules can be used with the Anritsu Lightning and Panorama VNA systems. The OML Modules, with the exception of the outer housing, IF connectors and power connector, are electrically virtually identical to the Anritsu 3740A/41A series of millimeter wave modules. The OML "T/R" module is equivalent to the Anritsu 3740x module and the OML "T" module is equivalent to the Anritsu 3741x module.

Necessary Equipment

First, only the 371xxA/C, the 372xxC, the 373xxC VNAs with Option 12 (Option 12 is retrofitable, known earlier as SM5621 or SM5880), or the 372xxD or 373xxD can be used for millimeter wave frequency extension. Be aware that these groups of VNAs require different test sets. **The Wiltron 360 VNA system is not upgradable for use with OML millimeter wave modules.**

Second, the system requires two external sources, one for LO and one for RF. From its inception the Lightning millimeter wave system has used two of Anritsu 68xxx/69xxx series synthesizers. As of 2002 the MG369x synthesizers became the preferred synthesizers. VNA synthesizer firmware driver capability held over in the current design of Anritsu VNAs allows the use of two 20 GHz capable Wiltron 67xxB synthesizers. Anritsu has indicated that the VNA firmware will not support the use of a combination of a Wiltron 67xxB and a Anritsu 68xxx/69xxx or MG369x synthesizers. There is apparently a timing problem related to lockup and stepping time differences between the 67xxB and the later designs. The Lightning can operate with a mixture of 68xxx/69xxx and MG369x synthesizers. The LO synthesizer must be equipped with the high power option (Option 15). Note that many versions of the 37xxx software will not recognize the MG family of synthesizers. The fix for this is a 37xxx software upgrade or setting the MG synthesizer(s) to emulate the 68/69000 family of synthesizers. This can be done via the MG front panel controls by setting "68/69000 ID on". Other Anritsu synthesizers or sweepers and other manufacturer sources are not useable with the VNAs. All OML VNA Modules are designed to be used with 20 GHz capable synthesizers.

Third, the system needs an interface between the VNA and the millimeter wave modules, the Anritsu millimeter wave test set. This unit includes all the necessary switching and amplifiers to provide the capability for bi-directional, full S parameter testing. There are two versions of the test set controller available: the 3735A/B which is a component of the standard 371xxA/C Lightning Millimeter Wave (MMW) System, and the 3738A which is a component of the ME7808A/B Panorama System. As a special, the 3738A has been used with a 20 GHz or higher Lightning VNA equipped with Option 12. As Option 12 can be retrofitted to a 372xxC or 373xxC, a user with a 20, 40 50 or 65 GHz VNA should be able to expand to cover up to 325 GHz.

The 3735A/B has an IF input frequency of 40 MHz to 270 MHz, a LO frequency range of 8 GHz to 20 GHz, and a RF frequency of 8 to 20 GHz. It contains power supplies suitable for both the Anritsu and OML modules. It is supplied with coax cables for connection only to Anritsu millimeter wave modules. Only those MMW VNA systems that have been factory integrated with OML modules are factory equipped with cabling suitable for the OML modules.

The 3738A has an IF input frequency of 40 MHz to 270 MHz, a LO frequency range of 8 GHz to 20 GHz, and a RF frequency of 8 to 20 GHz. It contains power supplies suitable for both the Anritsu and OML modules. It is supplied with coax cables for connection only to Anritsu millimeter wave modules. Only those MMW VNA systems that have been factory integrated with OML modules are factory equipped with cabling suitable for the OML modules.

LO and RF output levels are correct for OML MMW Modules and no external LO and RF drive level optimization of the modules is required. The IF gains of OML modules have also been optimized. For this optimization to be correct, OML must know if the user intends to use a 3735B or 3738A/B. The IF input levels of the 3735A/B and the 3738A are different. OML compatible cable sets can be purchased from Anritsu or the user can supply his own cables.

OML recommends Micro-Coax Model # UFA210B-1-0480-000000 UTIFLEX cables for the RF and LO cables. Each OML MMW Module is normally supplied with a DC power cable terminated with a dual banana plug for use with a +12 to 15 volt 4 Amp lab type power supply. Anritsu supplies a special power cable, in place of the OML power cable, for those modules integrated by Anritsu for use with their test set controller.

Fourth, calibration kits, one for each band to be operated, are required. The following vendors are possible sources of calibration kits and components:

OML	**HP**	**Maury**	**Flann**	**Aerowave**
Kits	Kits	Kits	Kits	Components
WR-15	WR-15	WR-15	WR-15	WR-15
WR-12		WR-12 ?	WR-12	WR-12
WR-10	WR-10	WR-10	WR-10	WR-10
WR-08			WR-08	
WR-06				
WR-05				
WR-04 (*Future*)				
WR-03				
Cal. Data Provided:				
Disk	Disk	Disk	Disk	User Derived

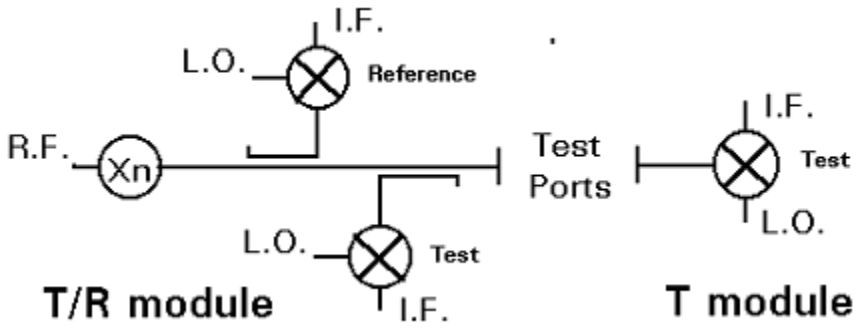
The routines built into the Anritsu VNA will allow the user to characterize his own set of components as standards.

OML has available the following millimeter wave Frequency Extension Modules: V Band / WR-15, E Band / WR-12, W Band / WR-10, F Band / WR-08, D Band / WR-06, G Band / WR-05 and H Band / WR-03. Expanded bands are possible subject to waveguide frequency response limits. There are two types of OML Modules that can be used to construct a millimeter wave test system. A "T/R" Module, equivalent to the Anritsu 3740x module, contains an RF multiplier for a signal source, a reference signal down-converter, and a test signal downconverter, all incorporated with a dual, high directivity, directional coupler. The "T" Module, equivalent to the Anritsu 3741x module, contains a single test signal downconverter with a precision, ultra-flat, low VSWR attenuator in place of the directional coupler used in the T/R Module.

The least expensive test set to configure would enable the user to make uni-directional measurements, measuring the reflection and transmission properties of a "device under test" (DUT), yielding two of the four traditional S parameters, S11 and S21. The DUT can then be physically turned around to measure the other two S parameters, S22 and S12. This type of test set consists of a T/R Module and a T Module. The T/R reference signal downconverter provides the system reference I.F. signal for ratioed measurements. The T/R test signal downconverter provides the reflected signal I.F. for reflection coefficient measurements. The T Module test signal downconverter provides the transmission signal I.F. signal for insertion gain/loss measurements.

A more expensive, bi-directional test system, capable of measuring all four S parameters, can be configured using two T/R Modules. In this case, the T Module is replaced by a second T/R Module. The test signal downconverter of the second T/R Module is used as a transmission signal downconverter. To reverse the signal path, the RF synthesizer signal is transferred to the second T/R Module's multiplier and its reference signal downconverter output is used as the system reference signal by the Lightning. The test signal downconverter of the second T/R Module is used as a reflection signal downconverter. The test signal downconverter in the first T/R Module then becomes the transmission signal downconverter.

A block diagram of the two types of Modules used in the OML Millimeter Wave VNA Test Set Modules is shown below.



The Modules for the OML Millimeter Wave VNA test systems are designed to be more efficient than those previously available. All of the amplifiers necessary for the operation of the OML Modules are integral to each Module. The downconverters operate with higher LO frequencies than do competing designs. The use of higher LO frequencies allows the harmonic mixers in the downconverters to function at a correspondingly lower LO multiple which significantly improves conversion loss and reduces the number of spurious responses. These mixers are multiple diode balanced mixers and receive LO power, set to the optimum level, from a built-in LO limiting amplifier. The performance of the downconverters is further enhanced by a 1.7 dB noise figure I.F. amplifier. Because of this higher level of integration, the OML Millimeter Wave VNA Test Set Modules do not require an external "controller" unit to function. The RF synthesizer signal, at the proper sub-harmonic for the chosen band, is supplied directly to the OML Millimeter Wave Module without further need for external amplification.

The Module multiplier's average output power is typically several dB higher than is available from competing designs. Hundreds of OML and customer tests of the OML Millimeter Wave Test Sets have demonstrated average dynamic range more than 10 dB better than competing units. The Modules are engineered to run continuously in a typical laboratory environment (+20 to +30 deg. C.). OML has delivered over 560 Modules for millimeter wave VNA test sets. OML supports existing customer owned units, in and out of warranty. OML will also quote special new designs as needed to address advanced customer applications. All OML Modules are upgradeable to a higher function level, i.e. a T Module can be upgraded into a T/R module.

The following documents will aid the user in operating an Anritsu VNA millimeter wave test system:

The Operating Manual for the 37xxxC/D VNA, Chapter 14 "Millimeter Wave System"
The Operating Manual for 37xxxC/D VNA, Chapter. 15 "ME7808A Broadband Measurement System"
The Operating Manual for the 37xxxA/C/D VNA, Chapter 11 "Millimeter Wave System"
"A Broadband Vector Network Analyzer", Microwave Journal , July 2001
"Development of Broadband VNA Makes High Frequency Component and Device Characterization Easier and Faster at a Fraction of the Cost", MPD, August 2001

Notes:

1) The current least expensive, Anritsu recommended, millimeter wave system capable of supporting the OML Modules includes the following: (based on the 2005 Anritsu U.S. prices).

A) The standard Lightning Millimeter Wave VNA System capable of supporting the OML Modules includes the following:

37xxxD Vector Network Analyzer (20 GHz or higher) (Option 12 not needed)
3738A Test Set
MG3692A/B 20 GHz Synthesizer (Option MG3690A/15A High Power) (LO) (*)
MG3692A/B 20 GHz Synthesizer (RF) (*)
Misc. accessories (cal kits, cables, etc.)

(*) Option 3 Ultra Low Phase Noise is highly recommended especially above 110 GHz

B) The most powerful Anritsu millimeter wave system, 40 MHz to 110 GHz, capable of supporting the OML Modules includes the following:

ME7808B Broadband VNA System (Panorama)
37397D 65 GHz Vector Network Analyzer
3738A Test Set
MG3692A/B 20 GHz Synthesizer (LO)
MG3692A/B 20 GHz Synthesizer (RF)
(the synthesizers include Option 3 Ultra low Noise Phase Noise and Option 15A High Power)
Misc. accessories (cal kits, cables, etc.)

2) Obsolete Anritsu millimeter wave systems that support the OML Modules include the following:

A) Previous generation ME7808A Broadband VNA System (Panorama)

37397C 65 GHz Vector Network Analyzer (Option 12 automatically included)
3738A Test Set
68xxx/69xxx 20 GHz Synthesizer (Option MG3690A/15A High Power) (LO) (*)
68xxx/69xxx 20 GHz Synthesizer (RF) (*)
Misc. accessories (cal kits, cables, etc.)

B) The previous Lightning Millimeter Wave VNA system

37xxxC Vector Network Analyzer (20 GHz or higher) Option 12
3738A Test Set
68xxx/69xxx 20 GHz Synthesizer (Option MG3690A/15A High Power) (LO) (*)
68xxx/69xxx 20 GHz Synthesizer (RF) (*)
Misc. accessories (cal kits, cables, etc.)

Anritsu millimeter wave systems that of support the OML Modules include the following:

C) The original Lightning Millimeter Wave VNA system

371xxA/C Vector Network Analyzer Option 3700/13A/B
3735A/B Test Set
68xxx/69xxx 20 GHz Synthesizer (Option 3690/15A High Power) (LO) (*)
68xxx/69xxx 20 GHz Synthesizer (RF) (*)
This earlier systems sold with 67xxB series synthesizers (Option 3 not applicable)(**)
Misc. accessories (cal kits, cables, etc.)

(*) Option 3 Ultra Low Phase Noise is highly recommended especially above 110 GHz
(**) See the discussion on page 1 for synthesizer interchangeability.

3) A list of the waveguide frequency bands and their waveguide cutoff frequencies is shown below:

W/G Band	Freq. GHz	Cutoff GHz	W/G Band	Freq. GHz	Cutoff GHz
WR-15	50-75	39.86	WR-06	110-170	90.84
WR-12	60-90	48.35	WR-05	140-220	115.75
WR-10	75-110	59.05	WR-04	170-260	137.52
WR-08	90-140	73.84	WR-03	220-325	173.28

4) In response to numerous inquiries regarding flange compatibility issues received by OML, the following waveguide flange compatibility information has been developed.

Waveguide	Current Designation	Mil-F-3922/ Number	Flange Configuration	Historical Flange (UG)
WR-15	V	67B-008	0.750” rd.	385/U
WR-12	E	67B-009	0.750” rd.	387/U
WR-10	W	67B-010	0.750” rd.	387/U-M (10)
WR-08	F	67B-08	0.750” rd.	387/U-M (08)
WR-06	D	67B-06	0.750” rd.	387/U-M (06)
WR-05	G	67B-05	0.750” rd.	387/U-M (05)
WR-04	Y	67B-04	0.750” rd.	387/U-M (04)
WR-03	H (J)	67B-03	0.750” rd.	387/U-M (03)

Disclaimer:

All information contained in this paper is correct to the best of OML’s knowledge, and is current as of date below. All possible effort has been expended to ensure the accuracy of this information and it is intended that this paper will be continually updated. The information presented was obtained through the gracious co-operation of Anritsu and OML first hand knowledge gained through use of and experimentation with the subject Anritsu equipment. OML would appreciate any comments the user may have on this document. Also please do not hesitate to contact OML with any questions.