Application Note

Using the OML Millimeter Wave Vector Network Analyzer Frequency Extension Modules with the HP 8510 Vector Network Analyzer

OML has developed a series of millimeter wave Frequency Extension Modules (Modules) designed to extend the frequency coverage of the Keysight 8510 Vector Network Analyzer (VNA). These Modules cover the popular waveguide bands ranging from 33 to 325 GHz.

OML has been piecing together, from various sources, a basic understanding of the Keysight 8510 VNA system aimed at allowing a user to expand the Keysight 8510's millimeter wave capabilities beyond those that Keysight has provided. Keysight configures its typical system software to use certain Keysight test instruments when making a given measurement. The software routine, when run, checks to see if these instruments are connected to the HPIB interconnect. It is possible to configure one's own system, using the appropriate Keysight instruments, and save that configuration file for later use.

OML, with technical assistance from Keysight and others, has developed a method for using the Keysight 8510 VNA with test systems other than those manufactured by Keysight. For our purposes, only the use of the Keysight 8510 with millimeter wave test systems will be examined. A functional millimeter wave system requires the VNA (Keysight 8510), two sources, a test set interface and the millimeter wave test sets. A procedure for manually entering the necessary setup steps via the Keysight 8510 front panel controls is available in the OML document, "User Control of the Keysight 8510 for Millimeter Wave Configurations". The following describes alternative system configurations that have been successfully used.

Necessary HP 8510 Equipment

First, only Keysight 8510C, or latest revision Keysight 8510B VNA should be used for this effort. All revisions of the Keysight 8510C operating system have been found to support millimeter wave measurements. A 8510A is upgradable to a 8510C (LCD), (Keysight # 85103E). A 8510B can be upgraded to a 8510C (LCD) (Keysight # 85103F). The 8510C (CRT) can be upgraded to a 8510C (LCD) (Keysight # 85103G). The minimum acceptable Keysight 8510B Operating System Revision is Rev. B.05.13. Keysight was shipping Keysight 8510B Rev. B.05.14 software free of charge in the U.S. Some hardware upgrades may be necessary to your analyzer to use Rev. B.05.14.

The Keysight 11575F Performance Upgrade package upgrades a Keysight 8510B from any revision operating system to 8510B Rev. B.06.54, the latest and most desirable revision available. The Upgrade includes all necessary software and hardware.

Second, the system requires two sources, one for L.O. and one for R.F. The Keysight 8510 millimeter system software requires that **at least one of the sources must be a synthesizer.** Based on OML's experience**, the use of one synthesizer and one sweeper (Keysight 8350B) has been found to be less than satisfactory** [1]. It is possible to use a Keysight 8340 series/8350B or Keysight 8360 series/8350B combination. However, care should be exercised in inspecting the test data for discontinuities caused by momentary loss of lock of the sweeper due to spurious signals crossing through the phase lock aperture [2]. Keysight no longer offers or supports a synthesizer and sweeper based millimeter wave system and has discontinued the manufacture of the Keysight 8350B plug-ins required for an Keysight 8510 millimeter wave system. Keysight is discontinuing the 8510 firmware driver for the 8350 in 2002. See "Source Notes" [1] at the end of this paper for a list of the Keysight 8350 plug-ins with comments concerning the usability of each. **OML strongly recommends against the use of a synthesizer/sweeper combination.**

Synthesizer software driver capability held over in the current design from earlier Keysight 8510 millimeter wave systems allows the use of two Keysight 8341A/B 20 GHz synthesizers or two Keysight 8340A/B 26 GHz synthesizers or a combination of Keysight 8340/8341 (internal modifications to older serial number synthesizers may be necessary for use with the Keysight 8510). Keysight plans to discontinue the 8510 firmware driver for the 8340/8341 in 2005. However, Keysight now recommends, sells and supports a two synthesizer system using Keysight 8360 synthesizers. Keysight has indicated that **the Keysight 8510 firmware will not support the use of a combination of a Keysight 8340/41 and a Keysight 8360 synthesizer.** There is apparently a timing problem related to lockup and stepping time differences between the Keysight 8340 and the Keysight 8360 designs. The **Keysight 8510 software allows operation only with Keysight 8360 series or Keysight 8340 series synthesizers and/or the Keysight 8350B series sweepers**. Other Keysight synthesizers or sweepers and other manufacturer sources are not useable with the Keysight 8510.

The OML WR-10 and lower T/R Modules and OML WR-08 and higher T/R Modules equipped with the OML "x2" Option can be used with a 20 GHz capable Keysight 8341A/B or Keysight 8360 as a R.F. source. The basic OML WR-08 and WR-04 T/R Modules require the use of the 26.5 GHz capable Keysight 8340A/B or Keysight 8360 as a R.F. source. Basic OML WR-06, 05 and WR-03 T/R Modules require the use of a 40 GHz or higher capability Keysight 8360 as a R.F. source.

The Keysight 8340A/B, 8341A/B synthesizers and most Keysight 8350B sweeper plug-ins[1] cause some degradation to the test data because of the interruption of the output signal at the frequency sweep switch points and insufficiently suppressed subharmonics (spurs) [3]. The spur problem can be addressed by using a pair of back-to-back waveguide to coax transitions, of the appropriate waveguide band, as a high pass filter. The following chart indicates the waveguide high pass filter which can be used for each millimeter wave band. Alternatively, the user can employ a suitable bandpass filter (BPF) whose low frequency cutoff is just below the lower end of the R.F. drive frequency range. If a BPF is used, attention should be focused on the passband ripple which should be no more than 1 dB. In the following chart item: 1) represents the millimeter wave band, 2) is the R.F. drive frequency (GHz) range for which lower subharmonics should be filtered, 3) is the waveguide which can be used as a high pass filter, and 4) is the cutoff frequency (GHz) for that waveguide.

Waveguide High Pass Filters for R.F. Subharmonics (needed when using HP 8340/41)

1) Band	WR-22	WR-19	WR-15	WR-12	WR-10	WR-08L	WR-08H
2) Freq.	11-16.7	TBD	10-05	12-18	12.5-18.3	15-20	20-23.3
3) W/G	WR-62		WR-62	WR-51	WR-51	WR-42	WR-34
4) Cutoff	9.49		9.49	11.54	11.54	14.08	17.28

Third, the system needs an interface between the Keysight 8510 and the millimeter wave test set Modules, such as a Keysight 85105A millimeter wave test set controller. This unit includes all the necessary switching and amplifiers to provide the capability for bi-directional, full S parameter testing. There are four versions of the controller available and one simplistic IF interface approach that can be used. These versions of the controller are formal options offered by Keysight. Please consult the 85105A Options list so that the proper version and option are correctly identified when ordering.

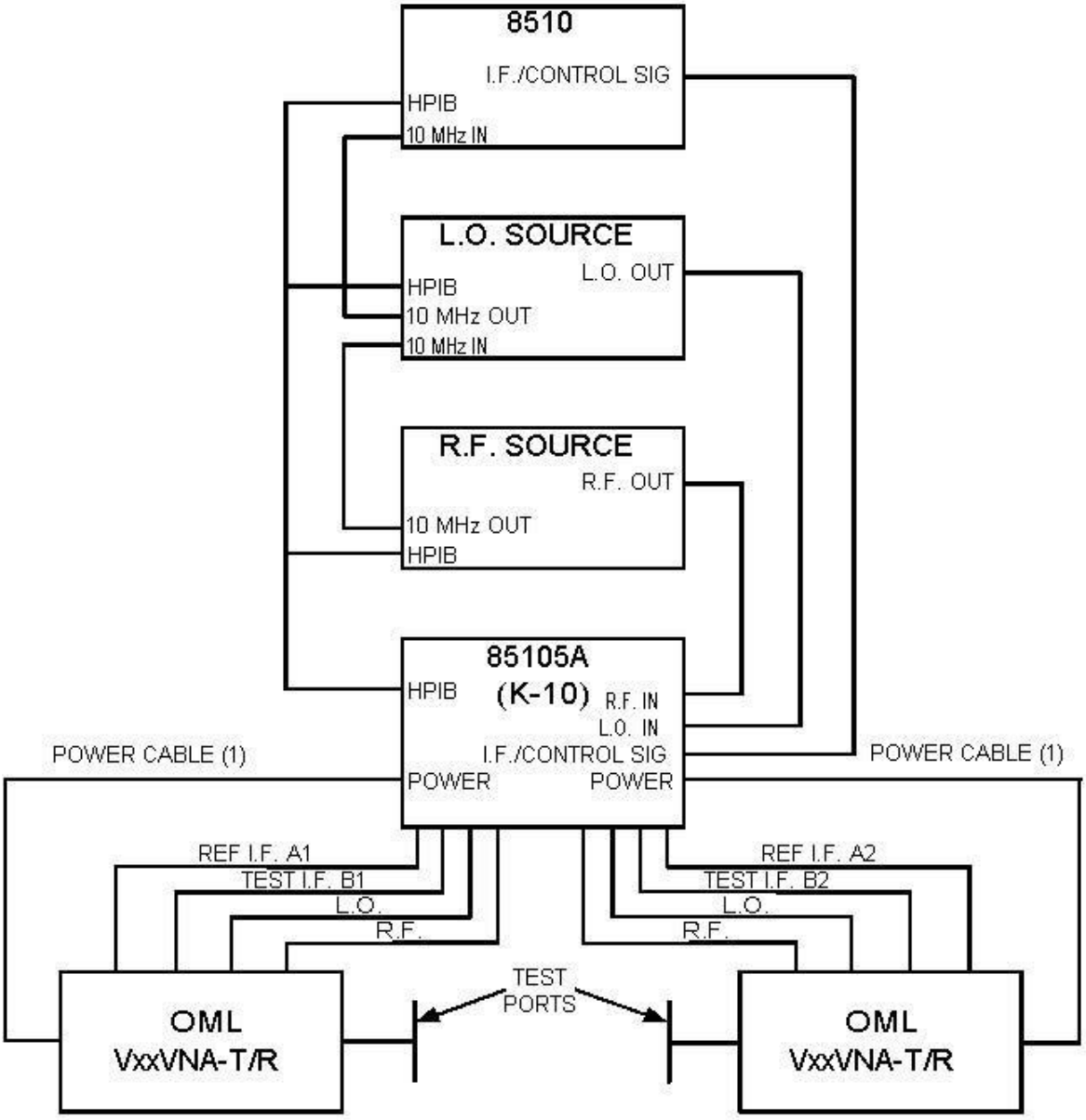
Keysight 85105A

The standard **Keysight 85105A** has an IF input frequency of 20 MHz with 30 dB internal gain, a LO frequency range of 2 GHz to 8 GHz @ +20 dBm min. and a RF frequency range of 10 GHz to 20 GHz @ +20 dBm min. It contains power supplies suitable only for the Keysight x85104A modules. It cannot be used with OML MMW modules because its LO frequency is to low too support the OML LO frequency plan. The Keysight 85105A is supplied with coax cables for connecting the millimeter wave module(s) IF outputs to the Keysight 85105A. No other cables are supplied. There are Options 04 and 54 available with the Keysight 85105A which move all of the front panel interfaces to the rear panel. This option is specifically for rack mounted systems. The interface between an Keysight 85105A Option 04 or 54 to OML MMW modules has not yet been developed. *Contact OML for details.*

Keysight 85105A Option K10

The **Keysight 85105A Option K10** was designed by Keysight specifically for use with the OML modules. The LO and RF output levels are correct for OML MMW modules and no internal LO and RF drive level optimization of the modules is required. It also has an IF input frequency of 20 MHz, however it does not have any internal gain. The IF gains of OML modules ordered for use with the Keysight 85105A-K10 are internally optimized. The RF frequency range is extended to 50 GHz (requires a 50 GHz synthesizer). This extended frequency coverage permits OML 90 to 325 GHz modules to be used without the "x2" Option. The K10 front panel is set up for interface to the OML MMW modules without any adapters. The Keysight 85105A-K10 is complete with the same IF cables as are provided with the Keysight 85105A and power cables that are compatible with OML modules. Keysight has available a RF and LO cabling kit for use with the OML modules or the user can supply his own cables. OML recommends Micro-Coax Model # UFA210B-1-0480-000000 UTIFLEX cables. The Keysight 85105A-K10 contains power supplies suitable only for the OML modules and thus cannot be used with Keysight modules. The Keysight 85105A-K10 can not be used with the OML "x2" Option. Contact OML for details. (See figure 1)

8510B/C WITH 85105A OPTION K-10 INTERCONNECTIONS



NOTES

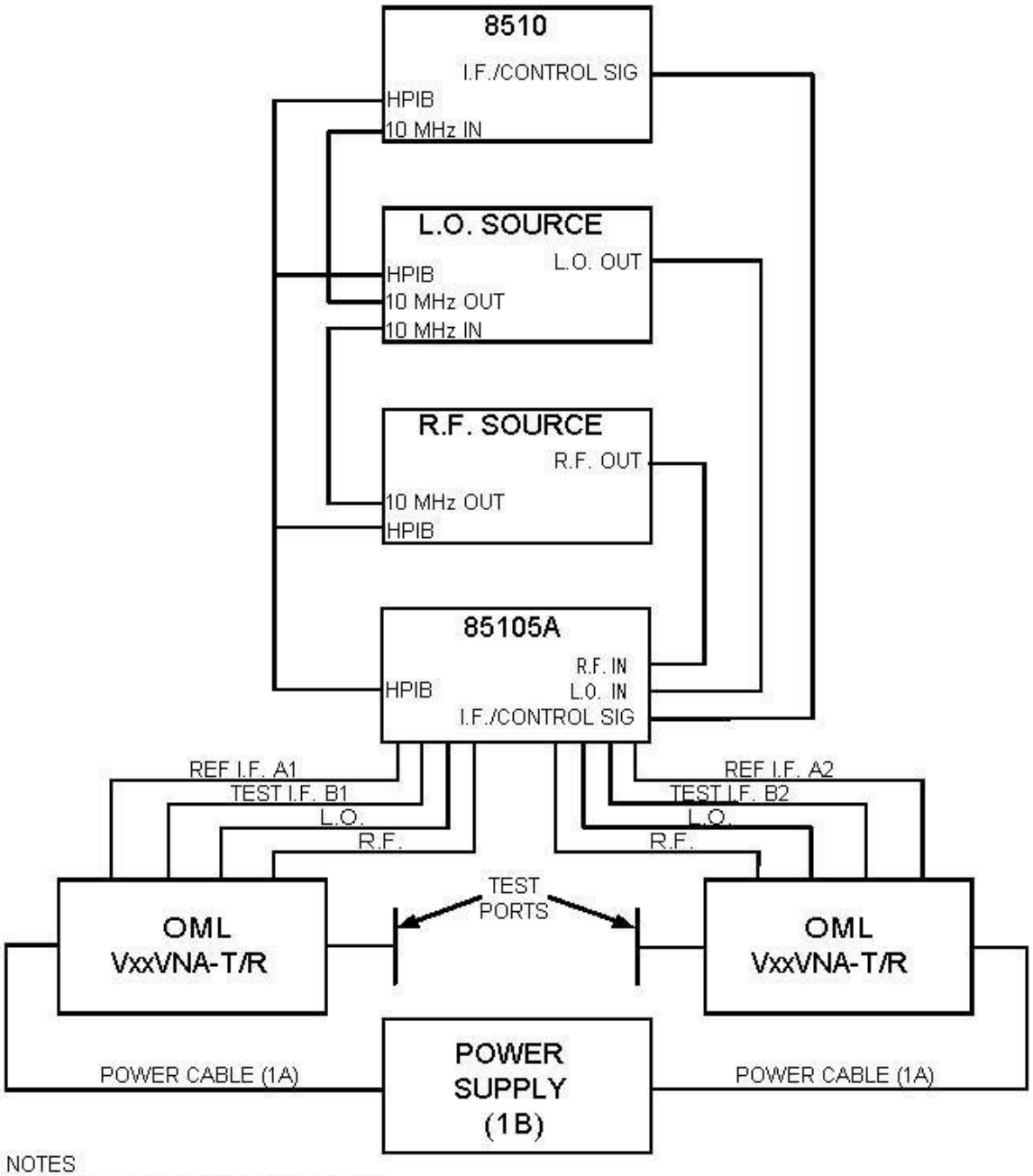
1) THIS CABLE SUPPLIED BY OML. CUSTOMER MUST SPECIFY 'K-10'.
2) ALL FOUR I.F. CABLES SUPPLIED B YKEYSIGHTWITH 85105A K-10
3) L.O. & R.F. CABLES AVAILABLE AS AN OPTION FROMKEYSIGHTOR CUSTOMER CAN PROVIDE HIS OWN GOOD QUALITY, FLEXIBLE MICROWAVE CABLE TERMINATED WITH 26 GHz 3.5 mm COMPATIVLE CONNECTORS (20GHz CONNECTORS IF "X2" OPTION INSTALLED). OML RECOMMENDED: MICRO-COAX MODEL # UFA210B-1-0480-000000 UTIFLEX CABLE."

Figure 1 – Setup Diagram for the 85105A-K10

Keysight 85105A Option H01

The new **Keysight 85105A Option H01** is a revised 85105A that can be used with either Keysight or OML millimeter wave modules and is less expensive than the Keysight 85105A-K10. It has the same IF input frequency of 20 MHz with 30 dB internal gain. The IF gains of OML modules ordered for use with the Keysight 85105A-H01 are internally optimized. The Keysight 85105A-H01 LO outputs have been modified to cover 2 GHz to 20 GHz @ +20 dBm minimum and its RF outputs are still 10 GHz to 20 GHz @ +20 dBm minimum. These LO and RF output levels are higher than required for OML MMW modules.. The Keysight 85105A-H01 is complete with the required two front panel adapters (85105A Interface Adapter, P/N 85105A-60015, see discussion in the OML Application Note 41-010511 *"Modifying the Keysight (Agilent/HP) 85105A for use with OML Millimeter Wave VNA Modules"*). Also included with the H01 are four double shielded coax cables for the IF interface complete with the required BNC to SMA adapters. Again OML recommends the use of Micro-Coax Model # UFA210B-1-0480-000000 UTIFLEX cables for RF and LO interconnection cables, four of which are required. These cables have been proven to be very high quality and are phase stable which is of special importance for the LO cables. The Keysight 85105A-H01 internal power supplies are suitable only for the Keysight x85104A modules. An external +12 VDC 4 Amp minimum power supply is required to power the OML modules. The OML millimeter wave modules are supplied with power cables set up for use with an external power supply. The interface between an 85105A-H01 Option 04 or 54 (rear panel interface) to OML MMW modules has not yet been developed. *Contact OML or Keysight for detail.* (See figure 2)]

8510B/C WITH 85105A-H01 OR USER MODIFIED 85105A AND KEYSIGHT ADAPTERS P/N 85105-60015



NOTES

1A) THIS CABLE SUPPLIED BY OML.

1B) CUSTOMER PROVIDED. OML RECOMMENDS A LAB GRADE POWER SUPPLY +12 VDC @ 4 AMPS.

2) I.F./L.O./R.F. CABLES AVAILABLE AS AN OPTION FROM KEYSIGHT OR CUSTOMER CAN PROVIDE HIS OWN GOOD QUALITY, FLEXIBLE MICROWAVE CABLE TERMINATED WITH 26 GHz 3.5 mm COMPATIVLE CONNECTORS (20GHz CONNECTORS IF "X2" OPTION INSTALLED). OML RECOMMENDED: MICRO-COAX MODEL # UFA210B-1-0480-000000 UTIFLEX CABLE."

3) CUSTOMER MUST MODIFY 85105A. SEE WWW.OML-MMW.COM/VECTOR/85105A.HTM

4) KEYSIGHT ADAPTER P/N 85105-60015 AVAILABLE THROUGH KEYSIGHT SUPPORT PARTS @ 877-447-7278.

Figure 2 – Setup Diagram for the 85105A-H01 and the modified 85105A

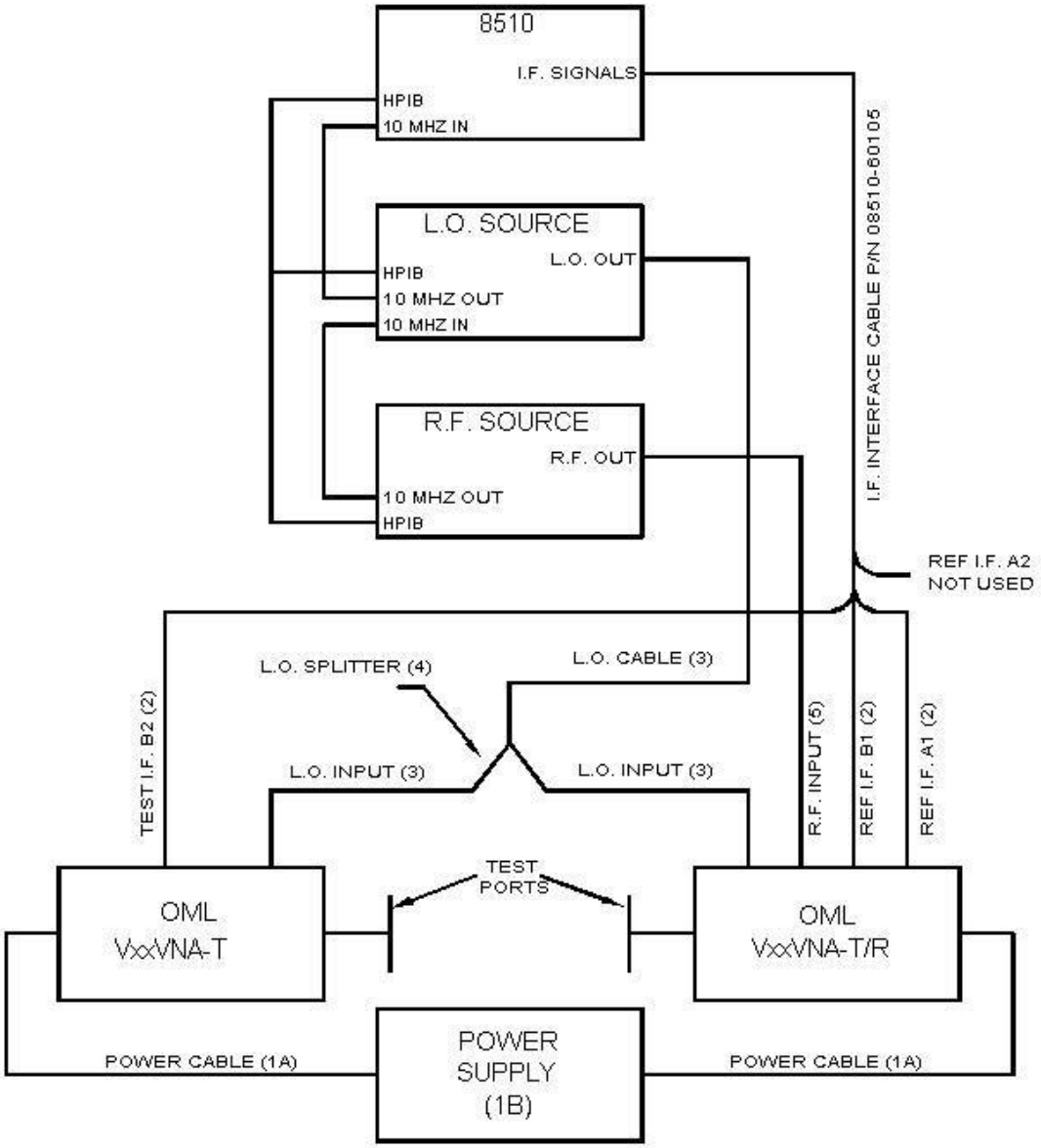
User modified Keysight 85105A

The **user modified Keysight 85105A** has an IF input frequency of 20 MHz with 30 dB internal gain. The IF gains of OML modules ordered for use with the modified Keysight 85105A are internally optimized. The LO frequency range is expanded to cover 2 GHz to 20 GHz @ +20 dBm minimum with the same RF frequency range of 10 GHz to 20 GHz @ +20 dBm minimum. It is suitable for driving OML 33 to 110 GHz and the OML 90 to 325 GHz modules that include the OML "x2" Option. LO and RF drive level optimization is accomplished internally in OML modules ordered for use with the modified Keysight 85105A. The Keysight 85105A is supplied with coax cables for connecting the millimeter wave module(s) IF outputs to the Keysight 85105A. The Keysight 85105A modifications necessary to achieve the expanded LO frequency range are simple and inexpensive. Details can be found in the OML Application Note41-010511 *Modifying the Keysight (Agilent/HP) 85105A for use with OML Millimeter Wave VNA Modules."* Here again OML recommends the use of Micro-Coax Model # UFA210B-1-0480-000000 UTIFLEX cables for RF and LO interconnection cables, four are required. These cables have been proven to be very high quality and are phase stable which is of special importance for the LO cables. As the internal power supplies are suitable for only the Keysight x85104A modules, an external +12 VDC 4 Amp power supply is required to operate the OML modules. The OML millimeter wave modules are supplied with power cables set up for use with an external power supply. Properly modified, the 85105A can be used to drive either Keysight or OML MMW modules. All three Keysight 85105A versions share the same outline. The interface between an 85105A Option 04 or 54 (rear panel interface) to OML MMW modules has not yet been developed. *Contact Keysight or OML for details.* (See figure 2)

08510-60105 IF Interface Cable

Keysight developed the **08510-60105 IF Interface Cable** for use in the old 85104A millimeter wave system which some customers are still using. This Cable is still available and when used in place of the 85105 it represents an inexpensive one path two port approach to millimeter wave vector analysis using OML T/R and T modules. The IF is 20 MHz and all necessary IF gain is provided in the OML modules. The LO frequency range required is 8 GHz to 20 GHz @ +10 dBm and the RF frequency range is 10 GHz to 20 GHz @ +10 dBm. The LO and RF levels given are those provided by the least expensive 8360 synthesizers. A +12 VDC 4 Amp minimum power supply is required for the OML modules. The OML millimeter wave modules are supplied with power cables set up for use with an external power supply. (See figure 3)

8510 B/C WITH KEYSIGHT I.F. INTERFACE CABLE P/N 08510-60105 INTERCONNECTIONS



NOTES:

1A) THIS CABLE SUPPLIED BY OML.

1B) CUSTOMER PROVIDED. OML RECOMMENDS A LAB GRADE POWER SUPPLY +12 VDC @ 4AMPS.

2) THE I.F. INTERFACE CABLE ATTACHES TO J1 "TEST SET INTERCONNECTION" ON THE REAR OF THE HP8510, AND IS AVAILABLE THOUGH AGILENT SUPPORT PARTS @ 877-447-7278. BNC (F) TO SMA (M) ADAPTERS REQUIRED FOR THE CONNECTION OF THE I.F. INTERFACE CABLE BNC CONNECTORS TO THE OML MODULE

3) OML RECOMMENDS THE MICRO-COAX MODEL # UFA210B-1-0480-000000 UTIFLEX CABLE, AN ATTRACTIVELY PRICED "PHASE STABLE" CABLE FOR THE L.O.

4) THE NARDA #4456-2 POWER SPLITTER IS WELL SUITED TO THIS APPLICATION. OML RECOMMENDS THAT THE POWER SPLITTER INPUT BE MOUNTED DIRECTLY TO THE SYNTHESIZER OUTPUT CONNECTOR.

5) A GOOD QUALITY FLEXIBLE MICROWAVE CABLE, TERMINATED WITH 26 GHZ 3.5 mm * COMPATIBLE CONNECTORS, IS REQUIRED FOR THIS APPLICATION. OML RECOMMENDS THE MICRO-COAX MODEL # UFA210B-1-0480-000000 UTIFLEX CABLE. * 20 GHZ CONNECTORS IF "X2" OPTION INSTALLED IN MODULE.

Figure 3 - Setup Diagram for using the 08510-60105 I.F. Interface Cable

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-22	WR-22	WR-22	WR-22	WR-22
WR-19 (N/A)	WR-19	WR-19	WR-19	WR-19
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:				
Hard Copy User Entered	Disk/Tape	Disk/Tape	Disk	User Derived

The routines built into the Keysight 8510 will allow the user to characterize his own set of components as standards. A Keysight 9122C disk drive (or appropriate Keysight hard drive) is required to use disk media with a Keysight 8510B.

Necessary OML Millimeter Test Sets

OML has available the following millimeter wave Frequency Extension Modules: Q Band / WR-22, 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 (Y Band / WR-04 is under development). Expanded bands are possible subject to waveguide frequency limits. The OML millimeter wave Modules can be used with the Keysight

8510 without any other intermediate test set or millimeter wave controller (see "Third, ...controller, above). This feature offers more dynamic range than does the Keysight millimeter wave solution, and is significantly less expensive. There are two types of OML Modules that can be used to construct a millimeter wave test system. A "T/R" Module contains an R.F. 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 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 R.F. 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 Keysight 8510. 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. An Keysight 85105A Option H01 or Option K10 or a modified 85105A will support the bi-directional test system. The Keysight I.F. Interface Cable will also support this type of system. However, the bi-directional system using the I.F. Interface cable is complicated by the fact that there is no automatic method easily available for switching the R.F. signal from T/R Module #1 to T/R Module #2.

A block diagram of the two types of Modules used in the OML Millimeter Wave VNA Test Set Modules is shown below. (See figure 4)

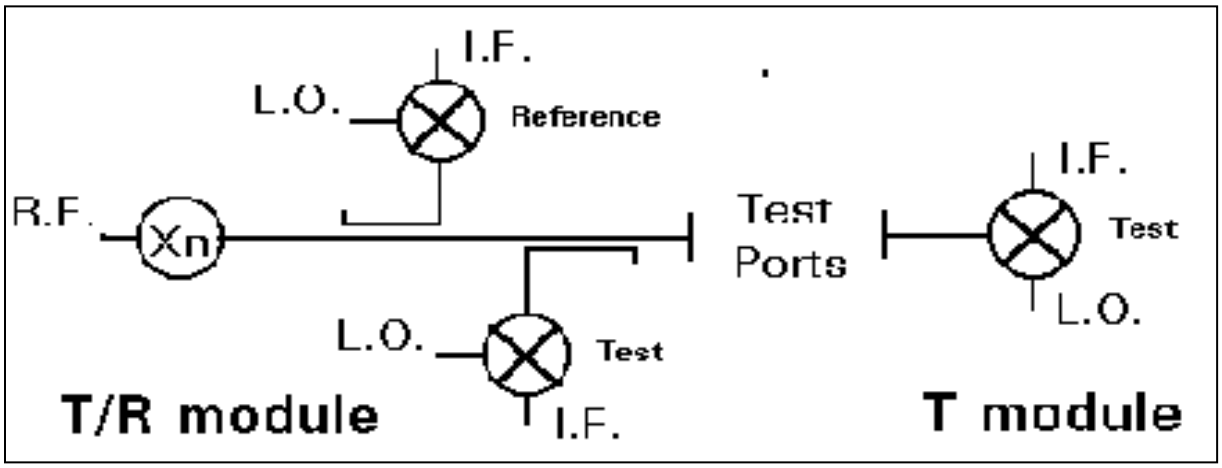


Figure 4 – Block diagram of the two types of OML modules

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 L.O. frequencies than do competing designs. The use of higher L.O. frequencies allows the harmonic mixers in the downconverters to function at a correspondingly lower L.O. multiple which significantly improves conversion loss and reduces the number of spurious responses. These mixers are multiple diode balanced mixers and receive L.O. power, set to the optimum level, from a built-in L.O. 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 subharmonic 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 operate from a customer supplied +12 or +15 VDC power source and are engineered to run continuously in a typical laboratory environment (+20 to +30 deg. C.). OML has delivered over 350 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.

The following documents will aid the user in operating the Keysight 8510 in a millimeter wave test configuration:

1) Keysight Product Note 8510-5A, Network Analysis, "Specifying calibration standards for the Keysight 8510 network analyzer", 2) Keysight Product Note 8510-8A, Network Analysis, "Applying the Keysight 8510 TRL calibration for non-coaxial measurements", 3) Keysight Product Note 8510-12. Millimeter-Wave Measurements, "Using the Keysight 8510 Network Analyzer", 4) "Keysight 85105A K10 Sub-millimeter Controller" hardware reference manual part number 85105-90020, is included with the Keysight 85105A K10 when purchased

Notes:

1) Source Notes: The swept sources usable with the various Keysight 8510's are listed as found in Keysight literature. Apparently upgraded firmware or software will allow any of the listed sources to be used with any Keysight 8510B.

	HP 8510A	HP 8510B	HP 8510C
8350B with appropriate plug-in (see below)	X	X	X
8340A/B 8341A/B	X	X	X

8360 series	1990 or newer			X	X

Keysight no longer recommends or supports the use of a synthesizer/sweeper combination. The 8350 product line is no longer available from Keysight. The following data is based on published Keysight product notes and specifications and is included for history's sake. OML's comments are added (x).

Model #	Frequency Range	Source Type	Millimeter L.O. (a)	Accessories Needed (b)	Recommended by OML
83550A	8-20 GHz	fundamental	to WR-10	none	yes
83595C	to 26.5 GHz	multiplier/good filter	to WR-08 (a)	amp ?	yes (?)
83592C	to 20 GHz	multiplier/good filter	to WR-10	amp	yes (?)
83592B	to 20 GHz	multiplier/good filter	to WR-10	amp	yes (?)
83599A	to 50 GHz	multiplier/some filter	to WR-05	amp	not verified (c)
83598A	to 50 GHz	multiplier/some filter	to WR-05	amp	not verified (c)
83597A/B	to 40 GHz	multiplier/some filter	to WR-05	amp	not verified (c)
83596A/B	to 40 GHz	multiplier/some filter	to WR-05	amp	not verified (c)
83594A	to 26.5 GHz	multiplier/poor filter	to WR-08 (a)	amp	not verified (c)
83595A	to 26.5 GHz	multiplier/poor filter	to WR-08 (a)	amp	not verified (c)
83592A	to 20 GHz	multiplier/poor filter	to WR-10	amp	not verified (c)
83590A	to 20 GHz	multiplier/poor filter	to WR-10	amp	not verified (c)

(a) System performance will be adversely affected by phase noise degradation above 110 GHz.

(b) Observations based on OML's examination of the data.

(c) Keysight specifications are unclear as to harmonic & spurious levels and these plug-ins are not mentioned in HP Millimeter Wave VNA Application Notes.

The above data was derived from an examination of the data contained in Keysight

(d) Publication # 5091-2509E, Keysight 8350B Sweeper 10 MHz to 50 GHz "A Powerful General Purpose Source for your Microwave Measurements", 8/92.

2) When an Keysight 8350B is used as a L.O. source in combination with a synthesizer as an R.F. source, the Keysight 8350B is phase locked so that the final L.O. signal (as multiplied in the harmonic mixer) will faithfully track the final R.F. signal (as multiplied in the R.F. multiplier chain). The phase locking error signal is generated by the Keysight 8510 (the Keysight 8517A/B Option H06 may have this capability, consult Keysight). In the process of harmonic mixing and signal multiplying various spurious responses are generated. These spurious responses can cross through the Keysight 8510 I.F. bandwidth causing loss of the desired phase lock. At that point of spurious signal crossing through the I.F. response, the Keysight 8510 sweep may momentarily be interrupted until the Keysight 8510 logic circuitry resumes swept with the proper phase lock. A small disruption may be noted in the data presented at that point. This is an infrequent normal occurrence that may or may not take place depending on the frequency band being sweep and the number of data points selected. This phenomenon can occur when using a totally Keysight millimeter wave VNA system or when using an OML/Keysight millimeter wave system. The user should watch for such possible "glitches" in his data. These "glitches" do not invalidate all of the data taken, only the one data point taken where the spurious crossover occurs.

3) In the earlier Keysight millimeter wave systems, Keysight always used the Keysight 8350B source as the L.O. source. OML's experience indicates that it might be advantageous to consider doing otherwise. When operating with a combination of different model Keysight sources (synthesizers/sweepers), the source with the best spurious and subharmonic specifications should be used as the L.O. source if frequency coverage of that source so allows. Spurious and subharmonic signals entering the down conversion harmonic mixers through the L.O. port can create undesirable spurious responses in the test data. The OML comments about the Keysight 8350B found under "Source Type" [1], are an indicator of the potential problems that can be experienced with sweeper plug-ins with marginal filtering. For example: in a combination of an Keysight 8340 A/B synthesizer (26 GHz, -25 dBc subharmonics) and Keysight 8350B sweeper, if the plug-in is an Keysight 83598A (50 GHz, -45 dBc subharmonics) then Keysight 8350B/83598A should be used as the L.O. source. All Keysight 8340 series synthesizers are specified at -25 dBc for subharmonics. All 8360 series synthesizers are specified at -50 dBc for subharmonics.

4) Keysight has featured the use of the OML millimeter wave Frequency Extension Modules with the Keysight 8510 in the October 1998 issue of the "Keysight 8510/8720 News".

5) The current least expensive, Keysight recommended, millimeter wave system capable of supporting the OML Modules includes the following: (based on the 9-01 Keysight U.S. prices).

Keysight 8510C Vector Network Analyzer
Keysight 85105A-K10 Test Set
Keysight 83621B 20 GHz Synthesizer (LO)
Keygsight 83621B 20 GHz Synthesizer (RF), requires OML "x2" Option for coverage above 110 GHz.
Misc. accessories (power supplies, cables, etc.)

6) The following points contain some suggestions and cover some of the limitations faced by the user who currently has an older Keysight 8510 system components:

A) Use of an Keysight 8350B sweeper as the in conjunction with a synthesizer is not recommended nor currently supported by Keysight. The Keysight 8350 product line is no longer available from Keysight.

B) Recent information indicates that the Keysight 8510A can only be upgraded to a Keysight 8510C. The same information indicates that Keysight is currently offering to upgrade the Keysight 8510B to a Keysight 85105C. A Keysight 8510B must have software version 5.14 or later to be useable for millimeter wave.

C) The Keysight 8340 series synthesizers do not go high enough in frequency to be used as a R.F. source operation above 140 GHz. This product is no longer available from Keysight. Keysight indicates that the Keysight 8340 series synthesizers can not be used in conjunction with the Keysight 8360 series synthesizers because of non-compatible timing issues between the two models.

D) The Keysight 85105A millimeter wave system controller will not allow L.O. frequencies above 8 GHz. The OML Modules require L.O. frequencies up to 20 GHz. OML has published a modification to the Keysight 85105A which will overcome this limitation. Keysight has adopted this OML modification and made it available as the Keysight 85105A Option H01. For operation of OML Modules WR-08 and higher with the Keysight 85105A Option H01, the OML "x2" Option must be installed in the OML Modules. The Keysight 85105A Option H01does not include the power supplies for the OML Modules, external power supplies are required. Keysight has the Keysight 85105A Option K10 available which includes extended frequency coverage for use with OML Modules up to 325 GHz and power supplies for **only the OML Modules**. The Keysight 85105A K10 is not capable of operating with the Keysight 85104A millimeter wave

Modules. The standard Keysight 85105A is not upgradable to the Keysight 85105A-K10 version. However, as stated above, the user can modify an Keysight 85105A by following the procedure developed by OML. A complete cabling kit is available from Keysight or the user can consider cabling recommended by OML.

E) A common, older Keysight millimeter wave system will consist of the following pieces: Keysight 8510B VNA with Rev. 5.14, Keysight 8350B/83540A Sweeper, Keysight 8340A/B or 8341A/B Synthesizer, Keysight 85105A millimeter controller and a pair of lower millimeter wave heads (below 110 GHz). At a minimum an owner of such a system, trying to expand his frequency coverage above 110 GHz, will have to modify his Keysight 85105A and purchase a second Keysight 8340A/B or 8341A/B or switch to Keysight 8360 series synthesizer. The owner will probably choose to upgrade the Keysight 8510B to a Keysight 8510C.

F) The Keysight 8510B user, confined by budget constraints, can achieve good quality "S11" and "S21" millimeter wave measurement capability in the following manner. If the Keysight 8510B internal software revision is not Rev. B.05.13 or later, obtain from Keysight a free copy of Rev. B.05.14 and install it into the VNA. Obtain a Keysight 8510 I.F. Interface Cable (Keysight P/N 08510-60105) for use as an interface between the Keysight 8510B and the OML Modules. If this cable should become obsolete from Keysight, this approach will no longer be that inexpensive, so check on its availability first. If the user currently has a Keysight 8340/41 series synthesizer then consider procuring a second unit of that type from a reputable used equipment source. This would save or defer the expense of purchasing two Keysight 8360 series synthesizers. One good source of these units is Test Lab Company, Mountain View, CA. @ Tel. # 650 969 1142. Remember, the use of the Keysight 8340/41 combination is limited to waveguide bands no higher than WR-10 without the OML "x2" Option and will require the use of external filtering for subharmonic suppression. If the user already has one Keysight 8360 series synthesizer then the obvious choice is to procure a second one, observing the constraints listed in the previous "Source" discussion.

Keysight has indicated that the Keysight 8340/41 synthesizers can be used with the Keysight 85105A-H01 or K10. Interested parties can contact OML to discuss the above information and for suggestions/recommendations via telephone, FAX or email.

7) 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-42	18-26.5	14.08	WR-10	75-110	59.05
WR-28	26.5-40	21.07	WR-08	90-140	73.84
WR-22	33-50	26.34	WR-06	110-170	90.84

WR-19	40-60	31.41	WR-05	140-220	115.75
WR-15	50-75	39.86	WR-04	170-260	137.52
WR-12	60-90	48.35	WR-03	220-325	173.28

8) 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-42	K	68-001KM	0.875" sq.	595/U
WR-28	Ka	68-001AM	0.750" sq.	599/U
WR-22	Q	67B-006	1.125" rd.	383/U
WR-19	U	67B-007	1.125" rd.	383/U-M
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 primarily obtained through OML firsthand knowledge gained through use of and experimentation with the subject Keysight equipment. OML would appreciate any comments the user may have on this document. Also please do not hesitate to contact OML with any questions.

Attachments:

#1 Block Diagram OML Millimeter Wave "T" Module
#2 Block Diagram OML Millimeter Wave "T/R" Module
#3 Physical layout OML Millimeter Wave Typical "T" Module
#4 Physical layout OML Millimeter Wave Typical "T/R" Module