

Quick Start Guide



Opto-electronic Network Analyzer Systems

ME7848A-0240, 40 GHz 850 nm System

ME7848A-0270, 70 GHz 1550 nm System

ME7848A-0271, 70 GHz 1310 nm System

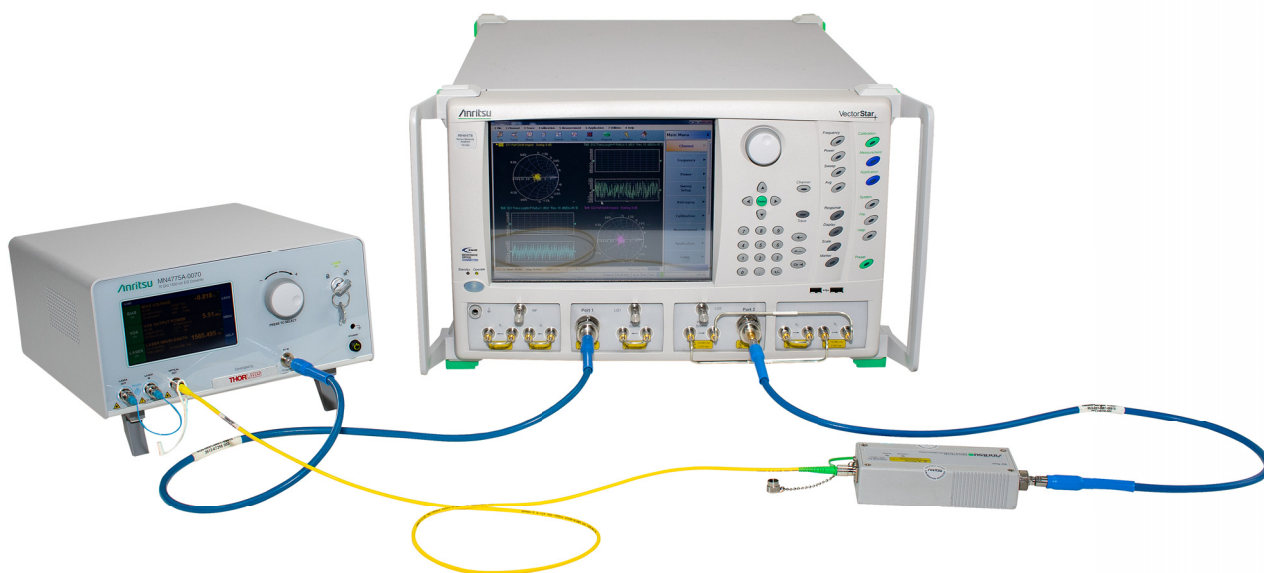
ME7848A-0272, 70 GHz 1310/1550 nm System

ME7848A-0140 40 GHz, 850 nm System (VNA and O/E module only)

ME7848A-0170 70 GHz, 1550 nm System (VNA and O/E module only)

ME7848A-0171 70 GHz, 1310 nm System (VNA and O/E module only)

ME7848A-0172 70 GHz, 1310/1550 nm System (VNA and O/E module only)



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Opto-electronic Network Analyzer System

The ME7848A opto-electronic network analyzer (ONA) system comprises a VNA, a calibration O/E module, and a laser/modulator converter assembly. Together, they allow calibrated RF response measurements of E/O, O/E, and certain O/O devices. This document describes the system components, basic connection and operation information, and some simple test steps to assure that the system is operating normally. Additional measurement information is contained in the *VectorStar® Calibration and Measurement Guide – 10410-00318*.

This document and all other documentation that supports the ME7848A is available on the Anritsu web site: <http://www.anritsu.com/>

1. Minimum Configurations

The following are the configurations for the -02xx opto-electronic network analyzer systems. The -01xx systems differ in that they do not include the E/O converter and do not undergo system parameter test (although individual elements are all fully tested and system specifications are expected to be met based on those element tests). The -01xx systems do include the accessory kit described below.

The VNA may be equipped with other loop-enable options (-061 or -062) in lieu of option -051. Other VNA options may also be added and none are excluded. Other O/E and E/O modules may be used with elements of the system but the technical data sheet values do not apply.

Table 1. ME7848A ONA System Configuration Options (1 of 2)

ME7848A ONA System	Configuration and Included Items
ME7848A-0240 40 GHz 850 nm System	MS4644B 40 GHz VectorStar VNA with Option 051, 061, or 062 MN4765B-0040 40 GHz 850 nm O/E Calibration Module (with characterization files) MN4775A-0040 40 GHz 850 nm E/O Converter 2000-1957-R Accessory Kit which includes: • 2 one meter F-M K RF cables • 1 one meter FC/PC-FC/APC fiber patch cord • 2 semi-rigid K cables to allow VNA coupler reversal for increasing forward dynamic range • 1 F-F K adapter • Optical connector cleaning accessories (for both fiber ends and ferrule-based connectors)
ME7848A-0270 70 GHz 1550 nm System	MS4747B 70 GHz VectorStar VNA with Option 051, 061, or 062 MN4765B-0070 70 GHz 1550 Calibration Module (with characterization files) MN4775A-0070 70 GHz 1550 nm E/O Converter 2000-1958-R Accessory Kit which includes: • 2 one meter F-M V RF cables • 1 one meter FC/PC-FC/APC fiber patch cord • 2 semi-rigid V cables to allow VNA coupler reversal for increasing forward dynamic range • 1 F-F V adapter • Optical connector cleaning accessories (for both fiber ends and ferrule-based connectors)



1. Minimum Configurations

Table 1. ME7848A ONA System Configuration Options (2 of 2)

ME7848A-0271 70 GHz 1310 nm System	MS4747B 70 GHz VectorStar VNA with Option 051, 061, or 062 MN4765B-0071 70 GHz 1310 Calibration Module (with characterization files) MN4775A-0071 70 GHz 1310 nm E/O Converter 2000-1958-R Accessory Kit which includes: • 2 one meter F-M V RF cables • 1 one meter FC/PC-FC/APC fiber patch cord • 2 semi-rigid V cables to allow VNA coupler reversal for increasing forward dynamic range • 1 F-F V adapter • Optical connector cleaning accessories (for both fiber ends and ferrule-based connectors)
ME7848A-0272 70 GHz 1310/1550 nm System	MS4747B 70 GHz VectorStar VNA with Option 051, 061, or 062 MN4765B-0072 70 GHz 1310 nm & 1550 nm Calibration Module (with characterization files) MN4775A-0072 70 GHz 1310 nm & 1550 nm E/O Converter 2000-1958-R Accessory Kit which includes: • 2 one meter F-M V RF cables • 1 one meter FC/PC-FC/APC fiber patch cord • 2 semi-rigid V cables to allow VNA coupler reversal for increasing forward dynamic range • 1 F-F V adapter • Optical connector cleaning accessories (for both fiber ends and ferrule-based connectors)



2. System Connections

The basic system connections are illustrated in [Figure 1](#). **Port 1** of the VNA is connected to the E/O modulator (the MN4775A in the -02xx systems) and **Port 2** of the VNA is connected to the MN4765B O/E calibration module. The ports can, of course, be swapped and the optical de-embedding software will support such a swap, but the configuration shown in [Figure 1](#) is the most common and will be assumed in the rest of this document. $|S_{12}|$ will be in the noise floor of the VNA in this common configuration. All RF cables (K(2.92 mm) or V(1.85 mm)) should be torqued to the usual 8 in-lbs.

This section discusses connections for the -02xx systems. Many of the steps are similar for -01xx systems, but those configurations may have different E/O converters, so details related to that part of the system will vary.

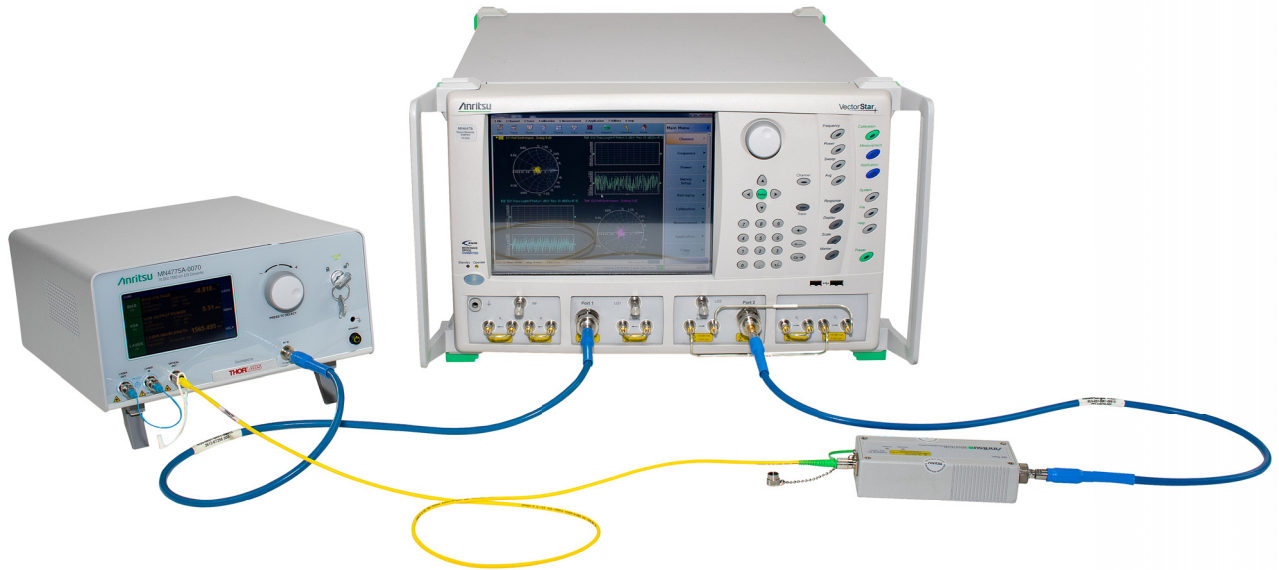


Figure 1. Typical ME7848A Measurement Setup

An optical patch cord is used to connect the E/O converter to the O/E module. The MN4765B is connectorized for FC/APC fiber (and those patch cord connections are often denoted by a green boot). The MN4775A (and many other modulators) is connectorized for FC/PC fiber (and those connections are often denoted by a white boot). The accessory kit includes a FC/PC-FC/APC adapting patch cord for this purpose... it is important to orient the cable appropriately (while some surface scratching or other damage of the fiber ends is unlikely, high insertion loss will be the outcome for reversing the patch cord). Example pictures of these different boots are shown in [Figure 2](#). If another patch cord is used, check with the vendor for color coding information.

The MN4775A-007x models have a loopback fiber between the laser output and modulator input, as shown in [Figure 1](#) (not present in the -0040 model), that must be connected (and is included with the MN4775A-007x). This fiber patch cord should be polarization-maintaining (usually denoted by a blue jacket cover) for stable operation of the modulator.

2. System Connections

The user's DUT (an E/O, O/E or O/O device) would substitute into one of the positions shown in the figure and the remaining system components calibrated or de-embedded out to reveal the DUT response. The MN4765B can also be connected to **VNA Port 1** (and E/O converter to **VNA Port 2**) if desired.

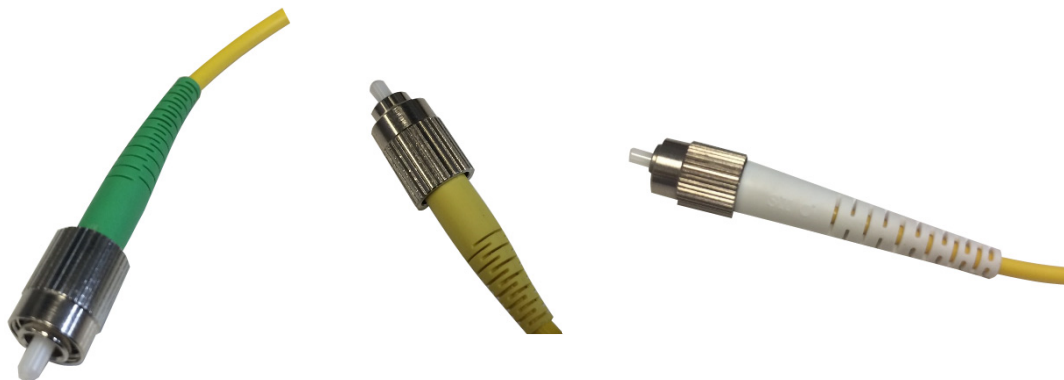


Figure 2. Common Color-coding of Patch Cord Ends (green often for FC/APC (angled) and yellow or white often for FC/PC (non-angled))

The cable on the left (green boot) of [Figure 2](#) is typically of an FC/APC connector which should be used with the MN4765B O/E module. The two other cables (yellow and white boots) are typical of FC/PC connectors; these ends should be used with the MN4775A E/O converter. Other lasers and modulators/converters may be connectorized differently.

The MN4775A (and equivalent units) contain a laser and are accompanied by a warning label like that shown in [Figure 3](#). The MN4775A-007x are class 1M and the MN4775A-0040 is class 3B (due to the shorter wavelength).

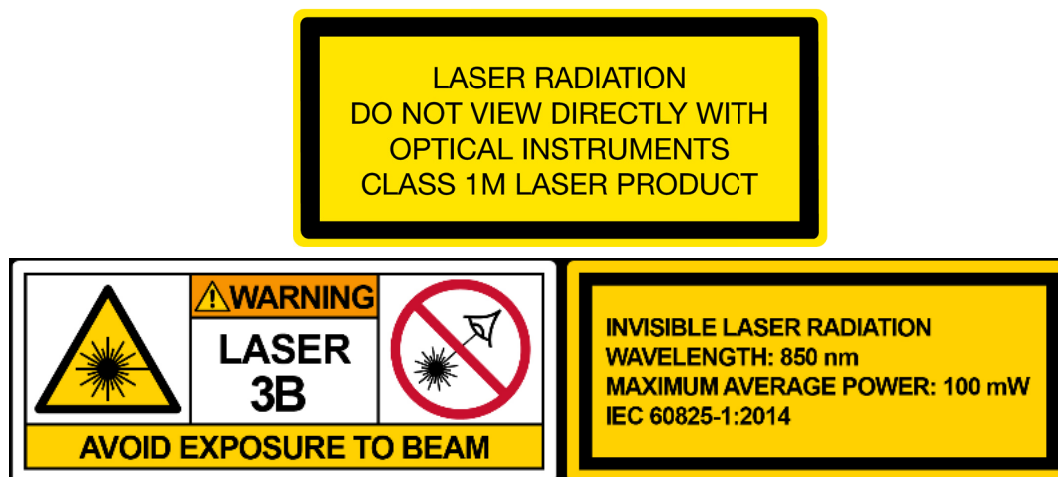


Figure 3. Laser Warning Labels Examples

In addition to the above basic setup, it is possible to improve dynamic range of the measurement in certain frequency ranges but altering some basic connections to effectively 'reverse' the port 2 test couplers in the VNA (connections shown in [Figure 4](#) and [Figure 5](#)). On the rear panel, existing loops are simply rotated 90 degrees and reconnected. For the front panel, semi-rigid cables are included in the accessory kit to help accomplish this task that make use of the loop access points provided by options 51/61/62 in the VNA. In the common configuration, we are much more interested in S₂₁ than S₁₂, so by reversing the port 2 coupler we improve the noise floor for S₂₁ at the expense of drive power for S₁₂.

Consult the *ME7848A Technical Data Sheet* – 11410-01145 for more information on the amount of dynamic range/noise floor improvement possible with the ‘reversed’ vs. the ‘normal’ coupler arrangement, but it is generally on the order of 10 dB at low frequencies, decreasing to 0 dB slightly above 40 GHz.



Figure 4. Rear Panel: ‘Normal’ (left) and ‘Reversed’ (right) Configurations



Figure 5. Front Panel: ‘Normal’ (left) and ‘Reversed’ (right) Configurations

3. System Check

Initial Settings

1. Begin with the VNA in a Preset state and then set up for the measurement:
 - a. Set test port power to +5 dBm (POWER Menu) for -0240 systems and -10 dBm for the -027x systems.
 - b. Set IFBW to 100 Hz (AVERAGING menu).
 - c. Set the frequency range from 70 kHz to 40/70 GHz (for -0240 or -027x systems, respectively) with 201 points.
 - d. Set up one trace to display S21 in log mag form.
2. Connect the RF cables from the accessory kit to the VNA ports (uses the FF adapter on port 2).
3. Perform a full 2-port SOLT calibration of the VNA at the cable ends (see the *VectorStar Calibration and Measurement Guide* if more information is needed on this).
4. Make all connections to form the opto-electronic system as outlined in the previous section (port 1 cable to the E/O converter, port 2 cable to the O/E module, fiber patch cord between the E/O and O/E devices). The O/E module should be powered up and warmed up. The E/O converter should be powered up but the laser still off.

3. System Check

5. For the ME7848A-0240:
 - a. Configure the MN4775A-0040 E/O Converter:
 - i. Turn the laser on.
 - ii. Set modulator bias to quadrature and dither.
 - A. Initiate a bias calibration.
 - iii. Set VOA (variable optical amplifier) to constant power output and -3 dBm.
6. For the ME7848A-0270:
 - a. Configure the MN4775A-0070 E/O Converter:
 - i. Turn the laser on.
 - A. Adjust the wavelength to 1550 nm.
 - ii. Set the modulator bias to quadrature and dither.
 - A. Initiate a bias calibration.
 - iii. Set the VOA (variable optical amplifier) to constant power output and +5 dBm.
7. For the ME7848A-0271:
 - a. Configure the MN4775A-0071 E/O Converter:
 - i. Turn the laser on.
 - ii. Set the modulator bias to quadrature and dither.
 - A. Initiate a bias calibration.
 - iii. Set the VOA (variable optical amplifier) to constant power output and +2 dBm.
8. For the ME7848A-0272:
 - a. Configure the MN4775A-0072 E/O Converter for 1550 nm operation:
 - i. Turn the laser on.
 - A. Set the wavelength to 1550 nm.
 - ii. Set the modulator bias to quadrature and dither.
 - A. Initiate a bias calibration.
 - iii. Set the VOA (variable optical amplifier) to constant power output and +4 dBm.
 - iv. Observe the response described in Step 9.
 - b. Configure the MN4775A-0072 E/O converter for 1310 nm operation:
 - i. Turn the laser on.
 - A. Set the wavelength to 1310 nm.
 - ii. Set the modulator bias to quadrature and dither.
 - A. Initiate a bias calibration
 - iii. Set the VOA (variable optical amplifier) to constant power output and +2 dBm.
 - iv. Perform the observation described in Step 9 below.
9. Observe |S21| on the trace set up in step 1.d. The low frequency response will range from -30 dB to -50 dB for the various models and there should be a roughly monotonic decrease with frequency (about 10 dB of roll-off to 70 GHz for the -027x systems or 12 dB of roll-off to 40 GHz with the -0240 systems).



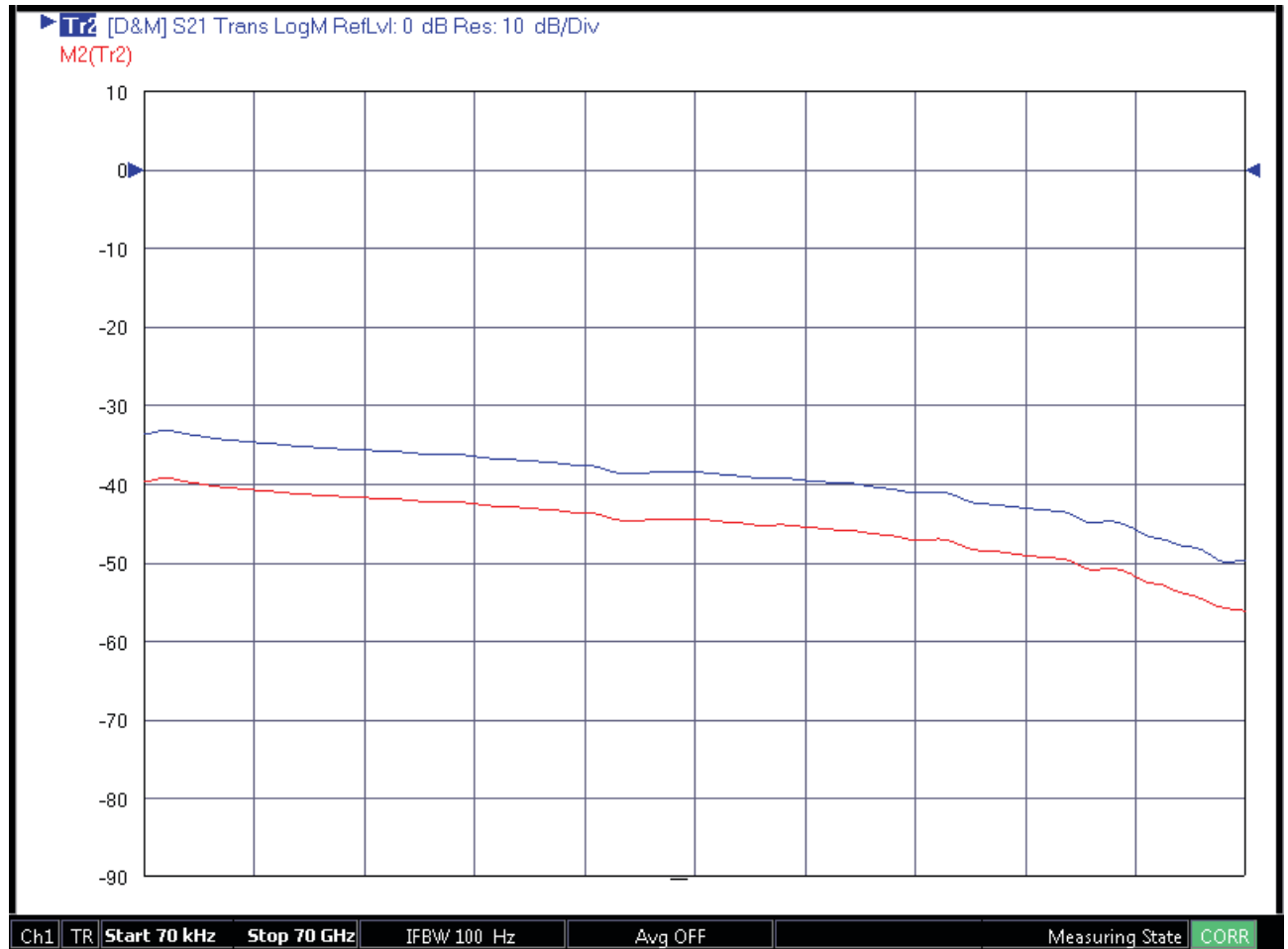


Figure 2. Example Plot of $|S_{21}|$ for the System Check on a ME7848A-0270 System at +5 and +2 dBm Optical Power Levels. The absolute values and approximate shape are of interest.

In [Figure 2](#), the blue curve is at 5 dBm optical power out of the modulator which is the test condition mentioned above. The red curve is at +2 dBm optical power for information. ME7848A-0271 systems will have a similar curve shape but shifted lower in values than the red curve (due to lower O/E responsivity). ME7848A-0240 systems will roll-off faster and have a shift down in values relative to the red curve (due to lower O/E responsivity).

Functional Test

1. Measurement setup

- a. Set the VNA to sweep from 70 kHz to the 40/70 GHz (depending on the system), 201 points, 100 Hz IFBW, +5 dBm for -0240 systems and -10 dBm for the -027x systems.
- b. Set the display parameter to be user-defined b2/1 | P1.
- c. Connect an RF thru line (ends of RF cables connected together).
- d. Perform a port 2 test receiver calibration (under the power menu). The plot after the cal should be a flat line at -10 dB.

2. Connect the port 1 RF cable to the modulator input and the port 2 RF cable to the O/E calibration module as before. Also ensure the optical patch cord is in place. Activate the laser and set the modulator as discussed in the previous section.

4. Making Opto-electronic Component Measurements

3. The response is the absolute detected power and will have a similar shape to the $|S_{21}|$ plots in the previous section but the numerical levels will be different.

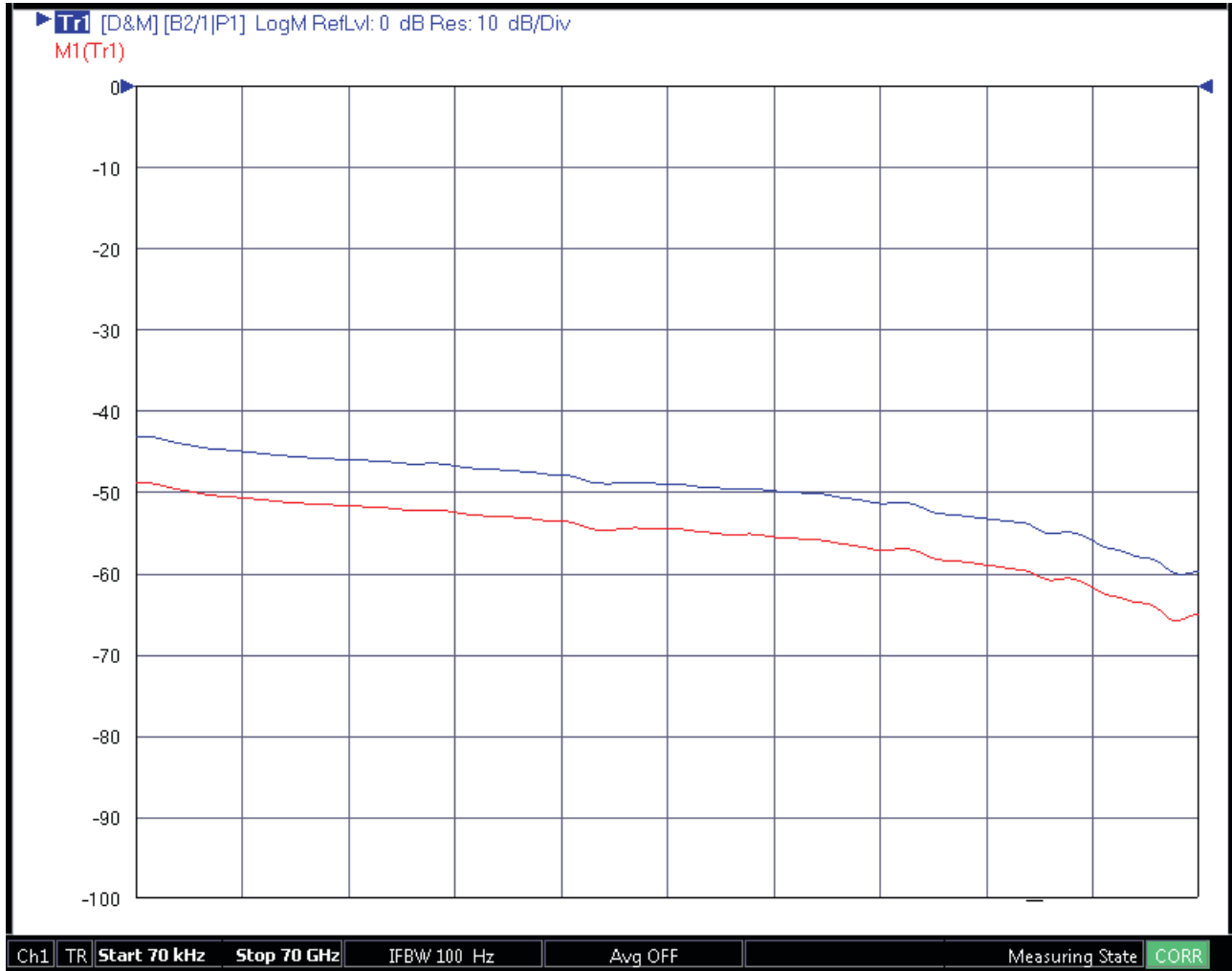


Figure 3. Example Plot of the Functional Test at +5 and +2 dBm Optical Power Levels

An example plot of the functional test is shown in [Figure 3](#) for the ME7848A-0270 system at +5 dBm optical power (blue curve) and +2 dBm optical power (for reference, red curve). The -0271/0272 and -0240 systems will have values somewhat lower than the red curve (2-5 dB for the -0271/0272 and 5-10 dB lower for the -0240).

4. Making Opto-electronic Component Measurements

The typical measurement scenario with the ME7848A opto-electronic network analyzer system is to analyze the conversion behavior of E/O or O/E devices or to study the RF envelope behavior for signals passing through O/O components. All of these measurements are done from an RF perspective by the VNA with the optical carrier (provided by the laser) acting as a parameter. Much more measurement information is available in the *VectorStar Calibration and Measurement Guide*, 10410-00318, (with an entire chapter devoted to this particular measurement class) but some salient points will be summarized here.

- The VNA calibration establishes reference planes (for insertion loss and phase, group delay, and reflection) at the ends of the RF cables (or wherever the calibration was performed). Thus a measurement of, for example insertion loss, the structure in [Figure 2](#) will represent the combined conversion loss of the E/O and O/E modules and the optical interconnect.

- To study individual components (i.e., an E/O converter of interest is to be inserted into the path), the other components need to be de-embedded. There are many ways to start this process, but for reasons of maximum accuracy and traceability, the MN4765B O/E module is delivered with a characterization file describing its behavior). After the non-DUT components have been de-embedded, the residual response is that of the device of interest.
- Most transmission measurements in this class are relative (e.g., to get at 3 dB or 10 dB bandwidth) but absolute responsivities can be extracted using the known optical power and the known absolute responsivities of the system components.
- Measurements on 2- and 4-port VectorStar VNAs are possible that allow the coverage of differential and dual devices. These measurements are not covered in detail here since the ME7848A system definitions are 2-port-based, but upgrades are possible and more information is available in the *VectorStar Calibration and Measurement Guide*, 10410-00318.

E/O Measurements

This is the simplest class where the E/O DUT is connected to the MN4765B calibration module (and patch cord losses are usually neglected) and the MN4765B is de-embedded. In the VNA software is a dialog like that shown below where the configuration is entered and the .s2p file describing the MN4765B is loaded. When this dialog is exited, the calibration coefficients will be modified by the de-embedding file so the resulting measurement represents the response of the DUT. If input match of the E/O device is of interest, a direct S11 measurement (assuming the configuration of [Figure 3](#); no de-embedding needed) will accomplish the task.

A screenshot of an E/O measurement dialog on VectorStar is shown in [Figure 4](#). The measurement is configured and the characterization data for the O/E device are loaded and, upon hitting 'Done', the calibration coefficients are updated on the instrument to de-embed the O/E characteristics.



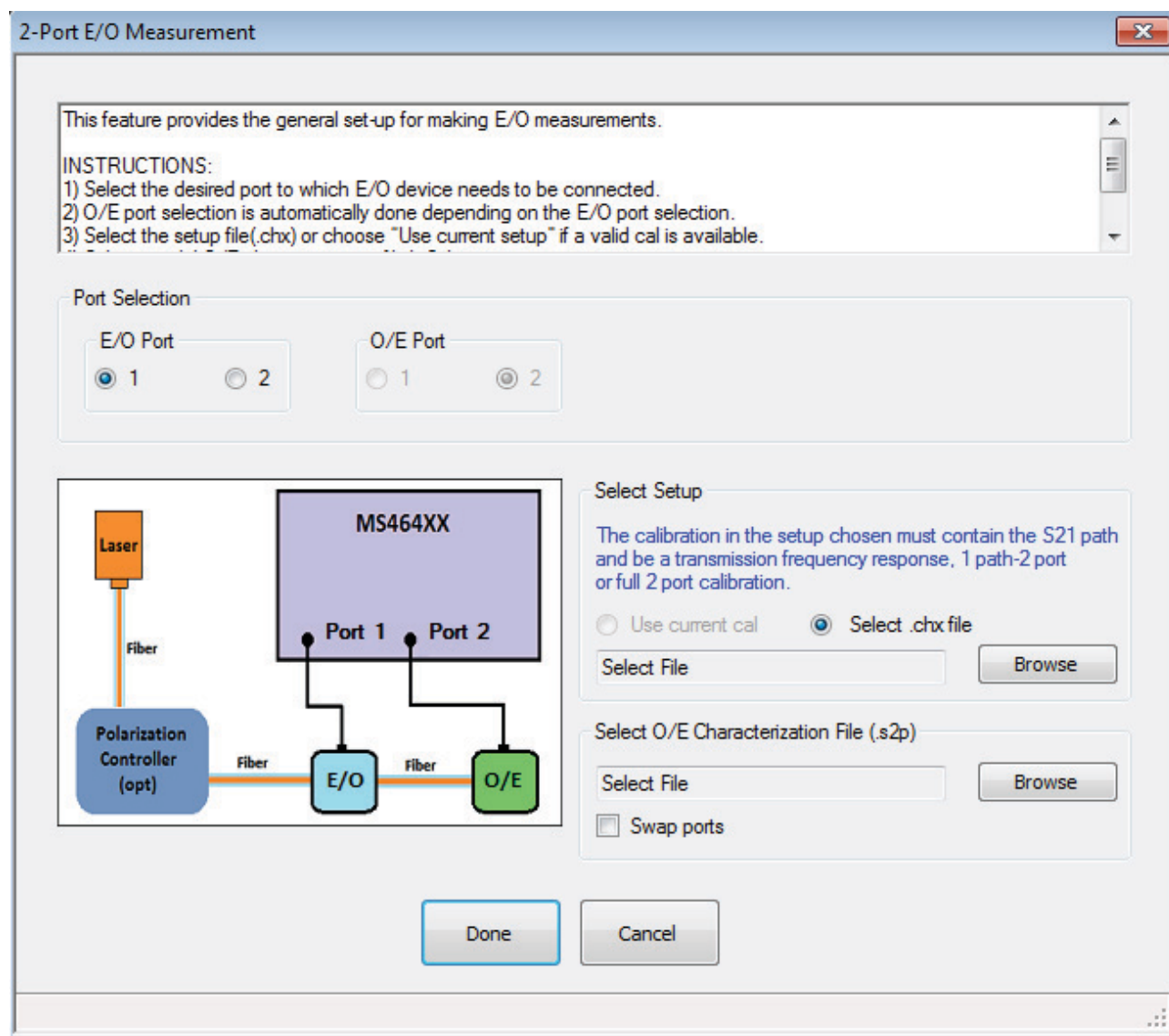


Figure 4. E/O Measurement Dialog

O/E Measurements

In this case, the E/O device must be de-embedded. Sometimes, the .s2p file of that device is available but, if not, a two-step process is used. The MN4765B is connected to the E/O device (the MN4775A usually) and the VNA tools are used to generate the .s2p file for the MN4775A by de-embedding the MN4765B. Now the DUT is connected in place of the MN4765B and the MN4775A response is de-embedded instead. The calibration coefficients are modified upon dialog exit and the resulting measurement response is that of the O/E device of interest. If O/E match is of interest, a simple S22 measurement (assuming the configuration of Figure 2) will suffice.

O/O Measurements

These measurements require de-embedding of both O/E and E/O devices and the pattern should be obvious from the previous subsections. The O/O measurements described here are slightly different from those one might conduct with optical power meters or optical spectrum analyzers in that the system monitors what happens to the RF envelope. Broadband insertion loss results will be similar unless the O/O device has some bandwidth-limiting properties that affect the envelope. Optical return loss is not corrected in this measurement so fiber end preparation/care can have more of an effect. In all of the measurements, absolute insertion phase has little meaning because of the (usually) very large electrical lengths represented by the optical components. Group delay (a frequency derivative of phase) or deviation from linear phase are more often the angular metrics of most interest.

In addition to the *VectorStar Calibration and Measurement Guide*, additional white papers (such as *Wideband Optical Modulator and Detector Characterization*, available on the Anritsu website) and application notes are available that discuss this measurement class.

5. Regulatory Compliance

European Union

- EMC 2014/30/EU, EN61326-1:2013
- CISPR-11/EN 55011 & IEC/EN 61000-4-2/3/4/5/6/8/11¹
- Low Voltage Directive 2014/35/EU
- Safety EN61010-1:2010
- RoHS Directive 2011/65/EU & 2015/683: applies to instruments with CE marking placed on the market after July 22, 2017.

Australia and New Zealand

- RCM AS/NZS 4417:2012

1. Under the influence of radiated RF signal frequencies of 421, 439, 441, 451, and 459 MHz, the system may exhibit minor performance degradation.







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