ERAVANT
FORMERLY SAGE MILLIMETER

VNA FREQUENCY EXTENDERS

COMPATIBILITY SUPPLEMENT: KEYSIGHT PNA-X

COMPATIBILITY SUPPLEMENT

CONTENTS

1. INTRODUCTION

Eravant's STO series of frequency extenders for Vector Network Analyzers (VNAs) are compatible with many possible configurations of Keysight PNA and PNA-X instruments. This setup guide is applicable to PNA and PNA-X models that include a four-port test set. Instructions for two-port PNA and PNA-X instruments may be obtained by contacting Support@Eravant.com.

Available frequency extender models cover full waveguide bands from 50 to 330 GHz. A pair of Transmit/Receive (TX/RX) extenders provide full two-port, two-path measurement capability. A single TX/RX extender can only measure S11.

Each TX/RX frequency extender provides one waveguide test port (Fig. 1.1). A frequency multiplier in the extender converts the Radio Frequency (RF) stimulus signal provided by the VNA to a higher frequency. A directional coupler samples the incident signal applied to the Device Under Test (DUT). Another directional coupler samples the reflected signal. The sampled signals are fed to a pair of internal mixers that convert the Reference and Measured signals to the Intermediate Frequency (IF) of the VNA. A Local Oscillator (LO) signal from the VNA is also multiplied by the frequency extender and applied to the down-converting mixers.

An optional level-setting attenuator controls the test signal power level. An optional amplifier increases the maximum test signal power. Both options are recommended, as they provide maximum dynamic range and maximum versatility for a wide range of measurement applications.

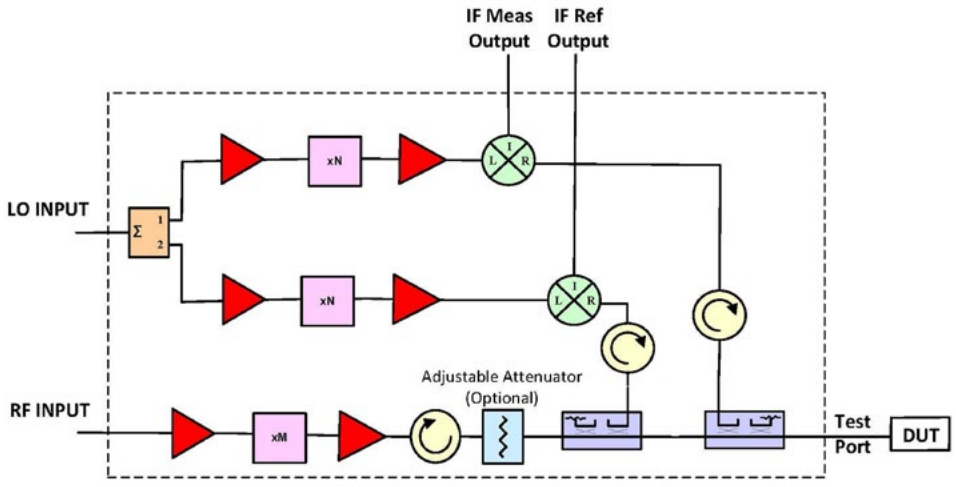

Fig. 1.1 – A single TX/RX frequency extender uses frequency multipliers to generate mm-wave test signals from lower frequency RF and LO signals provided by the VNA. Directional couplers sample the Reference and Measured signals. A pair of mixers down-convert the sampled signals to the IF of the VNA.

2. PNA AND PNA-X COMPATIBILITY

The STO series of frequency extenders are compatible with Keysight PNA and PNA-X series VNAs that include dual signal sources (Fig. 2.1). Software option S93080, Frequency Offset Mode, must be installed. Any of options S93082/83/87/89/90 may be substituted for S93080. Additionally, the Keysight Direct Connect Millimeter-Wave macro must be installed.

The Millimeter-Wave macro enables the user to set up the PNA for frequency extenders without a separate controller or signal source. The macro installation program may be downloaded from Keysight:

https://www.keysight.com/us/en/lib/software-detail/computer-software/pna-service-applications.html

The macro installation program, mmwave_setup.msi, can be executed from a USB thumb drive.

Full two-port millimeter-wave measurements require a four-port PNA, or a two-port PNA with an external LO signal generator that is SCPI command compatible, or a two-port PNA combined with a Keysight N5292A Millimeter-wave Test Set Controller. Setup instructions for 2-port PNA and PNA-X instruments are not included in this document.

Additional information about banded waveguide configuration options is available from Keysight:

https://www.keysight.com/us/en/assets/7018-05658/technical-overviews/5992-2177.pdf

Fig. 2.1 – The STO series of VNA frequency extenders are compatible with Keysight PNA and PNA-X series VNAs. Four VNA test ports allow direction connections between the VNA and two frequency extenders. No additional equipment is required.

3. ELECTRICAL CONNECTIONS

Eight phase-stable coaxial cables are necessary to connect two TX/RX frequency extenders to a PNA or PNA-X instrument (Fig. 3.1).

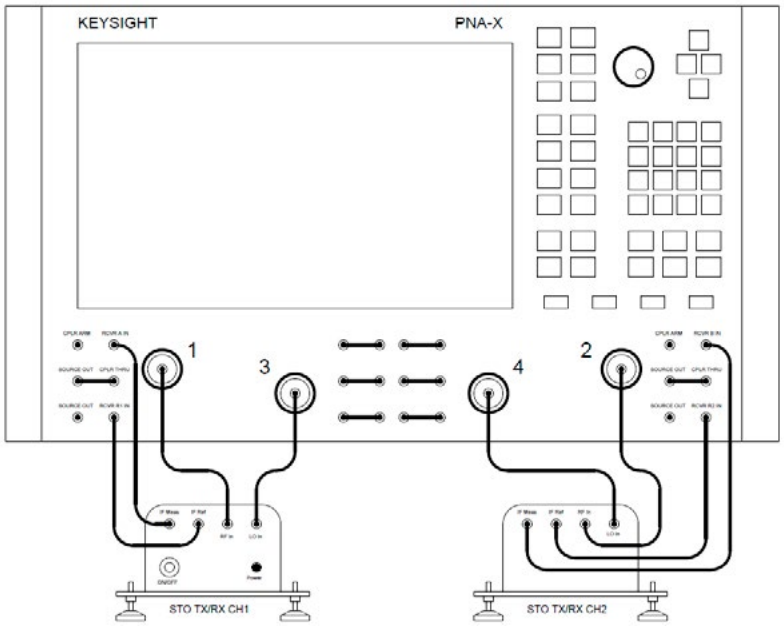

Fig. 3.1 – Each TX/RX frequency extender requires four instrumentation-grade coaxial cables to carry RF and LO signals to the extender and two IF signals back to the VNA. Ports 3 and 4 supply the LO signals.

If a single TX/RX frequency extender is used, connections for Channel 1 are unchanged (Fig. 3.2).

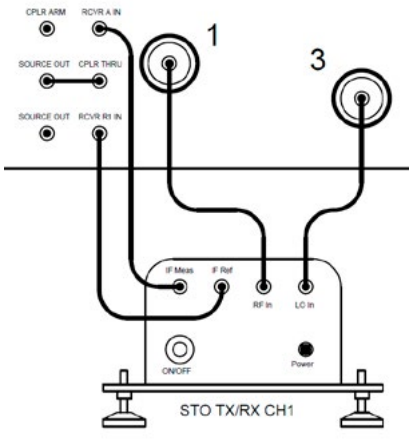

Fig. 3.2 – A single TX/RX frequency extender obtains its LO signal from Port 3 of the PNA.

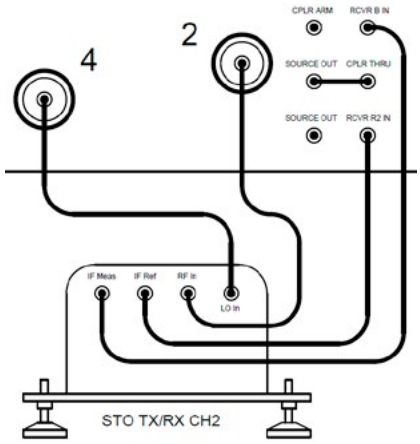

Fig. 3.3 – A second TX/RX extender obtains its LO signal from Port 4 of the PNA.

4. INSTRUMENT SETUP

The following instrument screens were obtained from a model N5242B PNA-X Microwave Network Analyzer with firmware version A.16.20.02. Installed options included the following:

OPTION	PURPOSE
N5242B-425	Includes a 4-Port configurable test set, a second signal source, and source attenuators
N5242B-020	Adds IF Input connectors
S93084B	Provides embedded LO capability and includes Frequency Offset Mode

PNA Configuration

From the menu bar at the top of the screen, select Instrument (Fig. 4.1). In the menu tree, select Setup, External Hardware, and Millimeter Config. In the Select Configuration Table, highlight Standard PNA. Click the OK button to confirm (Fig. 4.2).

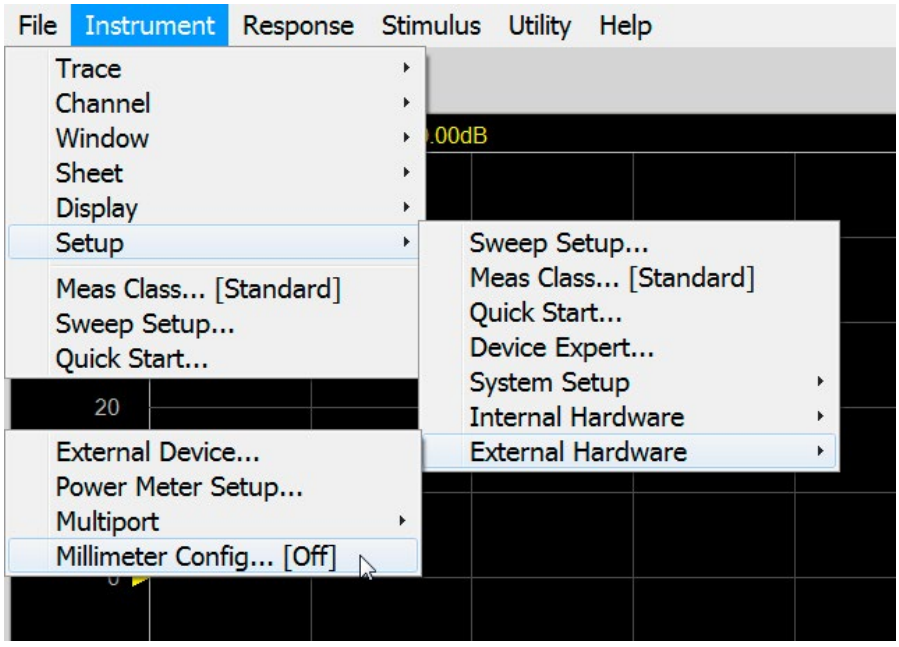

Fig. 4.1 – Navigate to reach Millimeter Config...

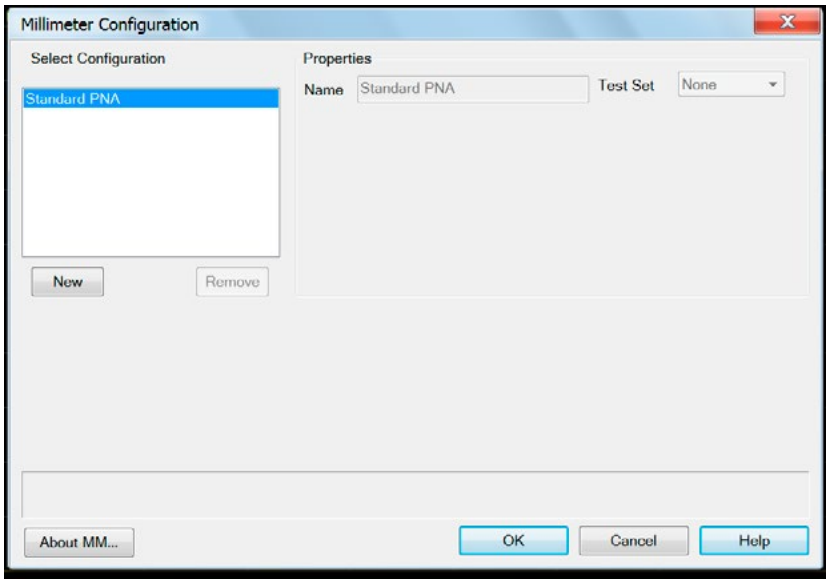

Fig. 4.2 – Select Standard PNA and click OK

Calibration Preference

From the menu bar at the top of the screen, select Utility (Fig. 4.3). In the Utility menu tree, navigate to System, System Setup, and Preferences. In the Preferences table, check the box next to Cal: For Frequency Offset, use Primary frequencies (Fig. 4.4). Click the OK button to save preferences.

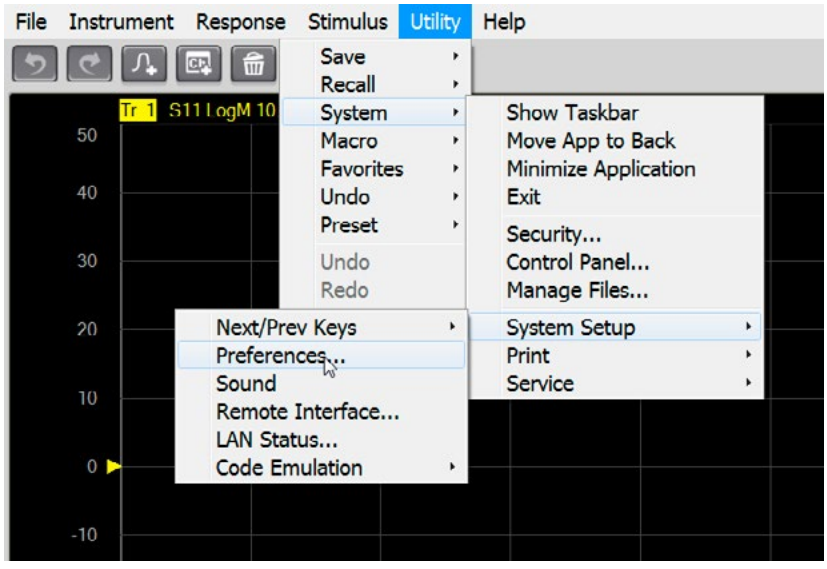

Fig. 4.3 – Navigate to System, System Setup, and Preferences

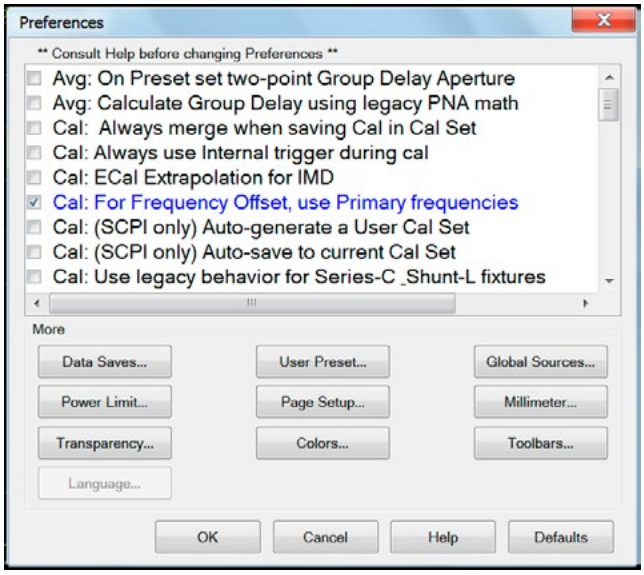

Fig. 4.4 – Check the box next to Cal: For Frequency Offset, use Primary frequencies and click the OK button.

RF Path Configuration

From the menu bar at the top of the screen, select Instrument (Fig. 4.5). In the Instrument menu tree, navigate to Setup, Internal Hardware, and RF Path Configuration. Confirm that the RF path setup uses the Default instrument configuration (Fig. 4.6).

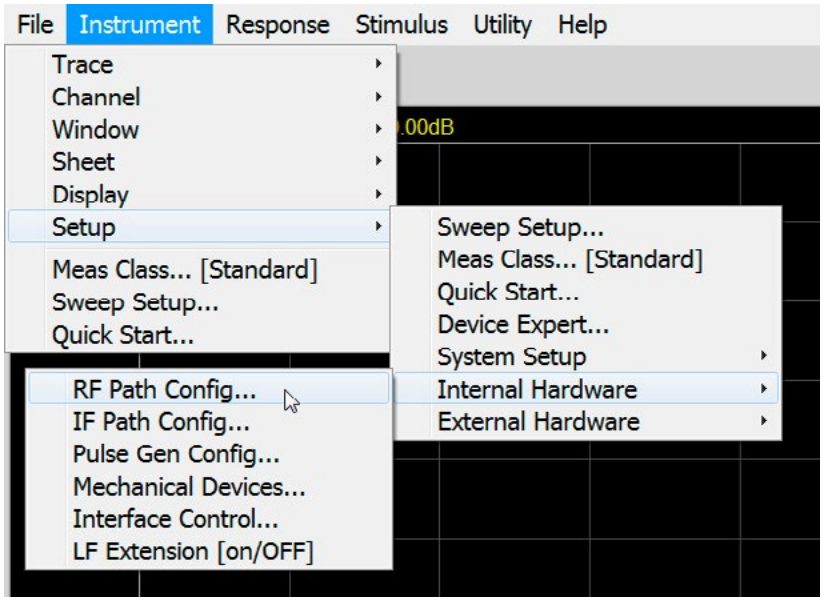

Fig. 4.5 – Navigate to RF Path Config...

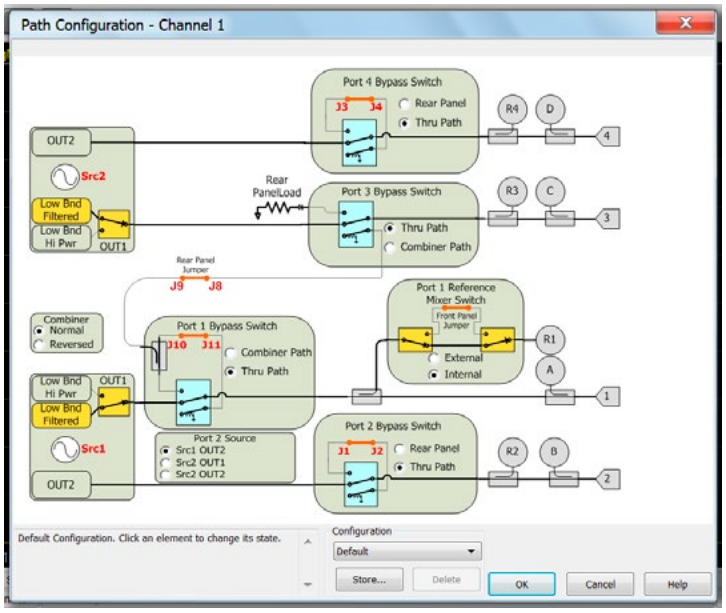

Fig. 4.6 – The default RF path configuration should be enabled

5. MILLIMETER-WAVE MACRO INSTALLATION AND SETUP

Use the download link provided in Section 2 of this document, PNA and PNA-X Compatibility, to obtain the macro installation program from Keysight. The install program, mmwave_setup.msi, may be saved to a USB thumb drive that is later plugged into the instrument. The install program can be executed from the thumb drive.

Double-click on the install program and follow the instructions. The install program creates an executable macro, mmWave.exe, and places it in the following location:

C:\Program Files (x86)\Agilent\Network Analyzer\Applications\mmWave\mmWave.exe

After the macro is installed, it must be set up in the PNA software.

From the menu bar at the top of the screen, select Utility (Fig. 5.1). In the menu tree, navigate to Macro and Macro Setup... In the Macro Setup dialog box, highlight the next available macro definition, indicated by empty brackets (Fig. 5.2). Click on the Edit button.

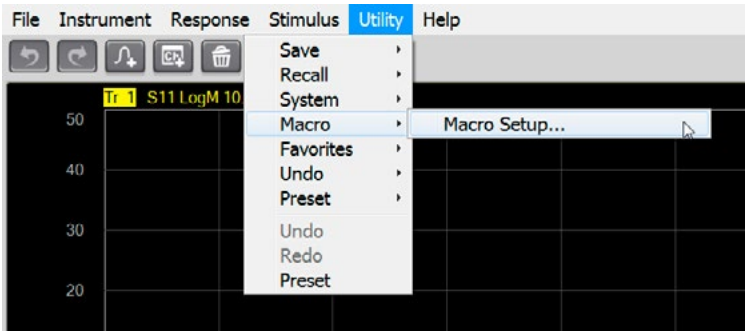

Fig. 5.1 – Navigate to the Macro Setup dialog box

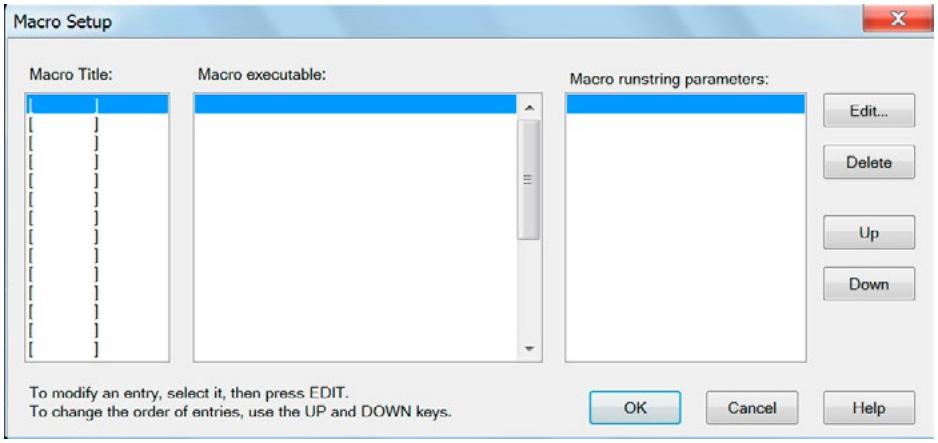

Fig. 5.2 – Select the next available empty position and click on the Edit button

In the Edit Macro Setup dialog box, enter “mmWave” in the Macro Title data field and click on the Browse button to locate the Macro Executable file (Fig. 5.3). Navigate to the directory where the Macro Executable is located (Fig. 5.4). Highlight the executable file and click Open.

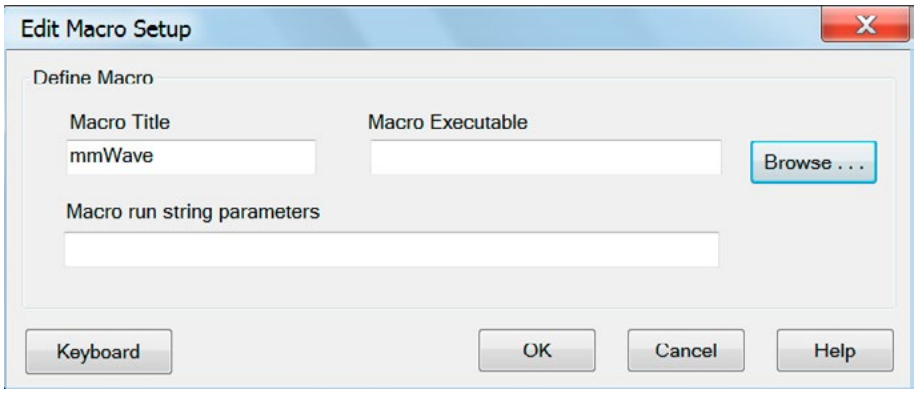

Fig. 5.3 – Enter the macro title and click on the Browse button

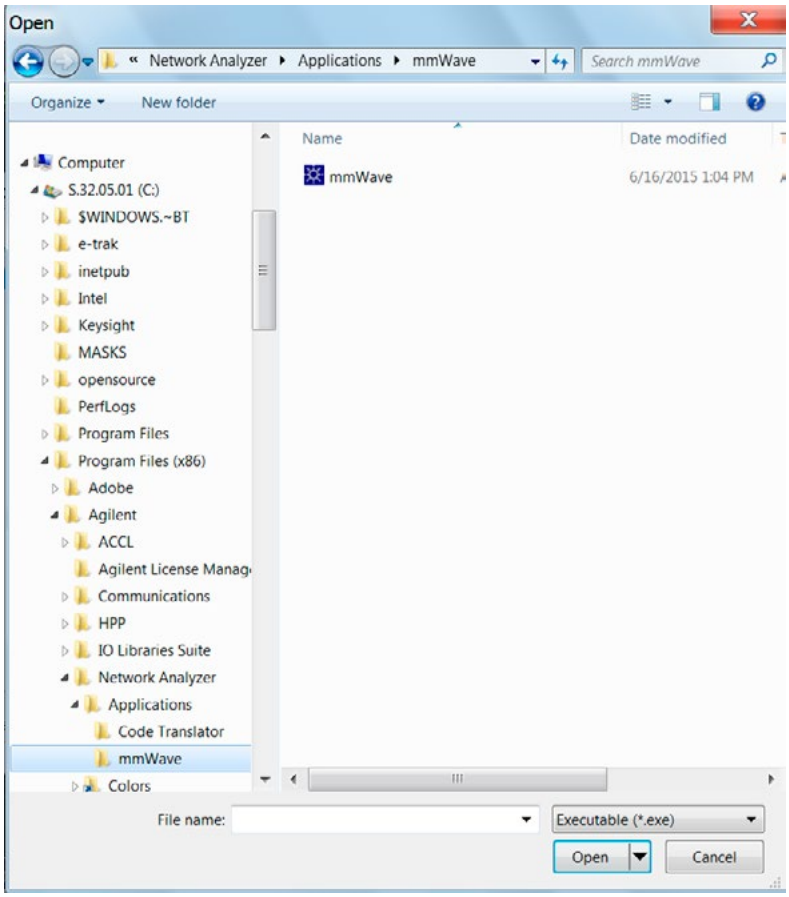

Fig. 5.4 – Highlight the macro executable and click on the Open button

Leave the Macro run string parameters field blank and click OK (Fig. 5.5). In the Macro Setup dialog box, click OK (Fig. 5.6).

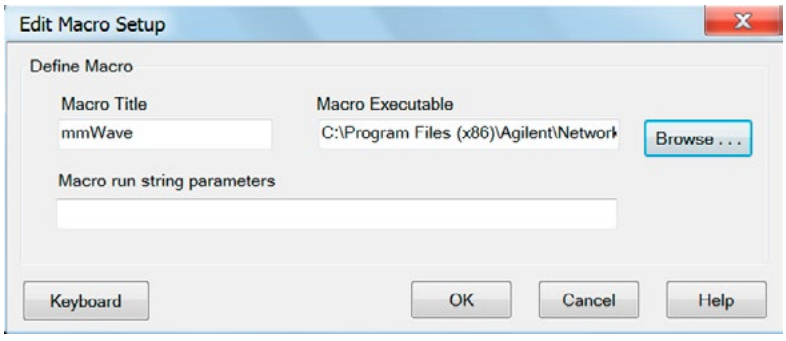

Fig. 5.5 – Click OK to accept the macro title and the executable file

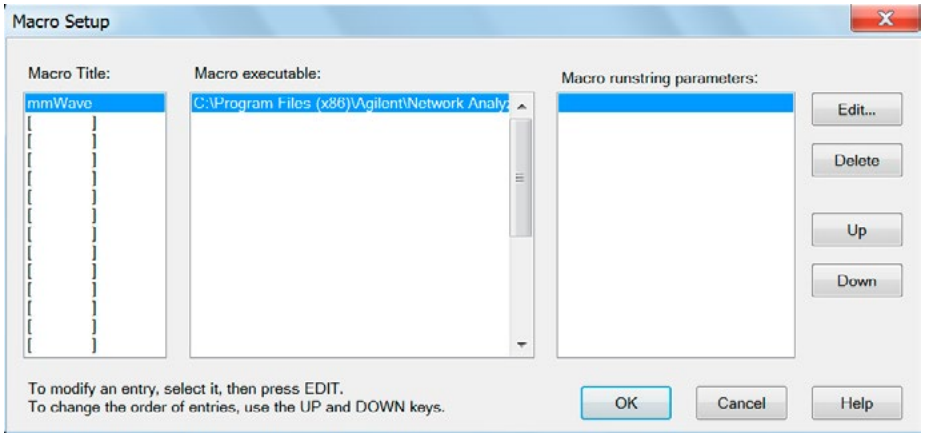

Fig. 5.6 – Click OK to complete the macro setup process

6. FREQUENCY EXTENDER PARAMETERS

Use the mmWave macro to enter operating parameters for the frequency extenders.

From the menu bar at the top of the screen, select Utility. In the menu tree, navigate to Macro and click on the mmWave macro (Fig. 6.1).

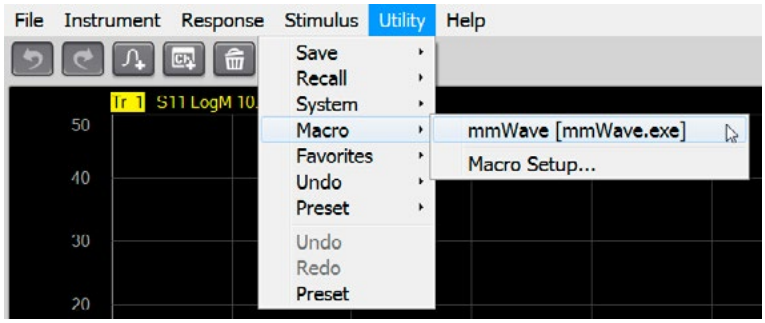

Fig. 6.1 – Click on the mmWave macro to enter frequency extender parameters.

Enter the extender's operating parameters in the dialog box (Fig. 6.2), noting the following:

If the RF/LO Multipliers and the mmWave Start and Stop frequencies are specified, the RF/LO Start and Stop frequencies will be populated when the Calculate button is clicked .

A default IF of 100 MHz is recommended.

The box next to mmWave LO < mmWave RF should be checked.

If the Port (RF) and LO power levels are different, uncheck the box next to Port Powers Coupled.

The Port and LO power levels should be set slightly above the levels specified for the frequency extenders to compensate for cable loss.

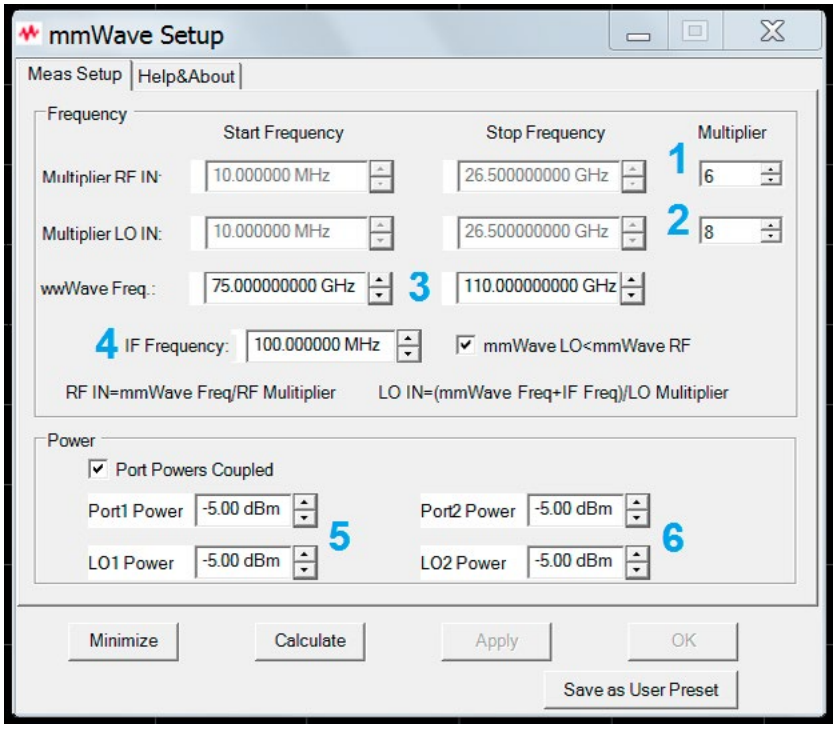

Fig. 6.2 – Enter the following parameters in the setup dialog box:

1) *RF Multiplier*
2) *LO Multiplier*
3) *mmWave Start & Stop Frequencies*
4) *IF Frequency*
5) *Port 1 and LO1 Powers*
6) *Port 2 and LO2 Powers*

Click on Calculate to populate any computed data fields. Click on Apply to accept the settings. Click on OK to finish the frequency extender setup process. Click on Save As User Preset to save the PNA setup.

7. SYSTEM TESTS

The following instructions are guidelines for testing a single TX/RX frequency extender. It is recommended to test each TX/RX extender individually before testing them together.

Short-Circuit Termination

Terminate the waveguide test port with a short-circuit flange. The Short termination reflects all of the test signal power and maximizes the Measured IF signal returned to the PNA.

System Power

Apply power to the PNA before powering the frequency extender. This ensures that the VNA has sufficient time to configure itself to operate correctly with the frequency extender. The user should verify that the VNA is correctly configured before applying power to the frequency extender.

Uncalibrated S11 or S22 Traces

Configure the PNA to display S11 (or S22) over the entire waveguide band. Display the uncalibrated S11 magnitude trace at 10 dB per division. The displayed trace should be continuous and not vary by more than ±10 dB across the waveguide band. Unusual features in the uncalibrated S11 trace may indicate loose connectors, damaged cables, or a configuration error.

Save the displayed trace to memory. Add the saved trace to the currently displayed (active) S11 trace. Flex the coaxial cables and observe any differences between the active and saved traces. Amplitude variations should be less than ±0.1 dB. If greater changes are observed, the coaxial cables may be damaged or they may be of insufficient quality.

Remove the short-circuit waveguide termination and replace it with a matched load. The active S11 trace should drop by at least 10 dB across the entire frequency band.

Remove the saved S11 trace from the display.

One-Port Calibration

Perform a one-port calibration, following the PNA user instructions. An Open-Short-Match (OSM) or Short-Open-Load (SOL) calibration is sufficient. When calibrating a waveguide VNA, the “Open” standard is usually a quarter-wave shim combined with a short-circuit flush termination.

After completing the one-port calibration, connect a short-circuit flush termination to the frequency extender test port. The displayed magnitude of S11 should be approximately 0 dB and the displayed phase should be approximately 180 degrees across the entire frequency band.

8. WORKING WITH TWO TX/RX FREQUENCY EXTENDERS

A pair of TX/RX frequency extenders provides full two-port measurement capability. After both TX/RX frequency extenders have been installed and tested, PNA operation is essentially the same as when no frequency extenders are installed. Exceptions may include the range of calibration methods that can be used. Some PNA measurement modes such as gain compression or intermodulation may not be possible or may require careful interpretation of the test results.

Eravant frequency extenders require a limited range of amplitudes for the RF and LO signals provided by the PNA. This is because the frequency multipliers exhibit good conversion efficiency over a limited range of input power levels. If the RF input amplitude is varied, the frequency extender output power does not change proportionally due to the nonlinear transfer function of the RF frequency multiplier. This effect may skew the results of measurements that involve varying the test signal power level.

With most passive components, the frequency response does not depend on the test signal power level. For other devices such as amplifiers, modulators, and some passive components, control of the test signal power may be essential. If return loss measurements are not required, the test signal power level may be reduced by placing an attenuator between the frequency extender and the DUT.

Alternatively, the frequency extender on the input side of the DUT may be equipped with a level-setting attenuator to control the test signal power level. The attenuator is positioned between the RF frequency multiplier and the directional couplers. The attenuator adjusts the test signal power level without affecting the ratio between the Reference and Measured signals, preserving the system's ability to accurately measure return loss.

The level-setting attenuator includes a micrometer head that enables precise and repeatable adjustments. Its numerical reading does not indicate the attenuation level. The attenuator is typically adjusted or calibrated using a waveguide power detector, or by monitoring signal levels at various points in the test system.

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