ERAVANT
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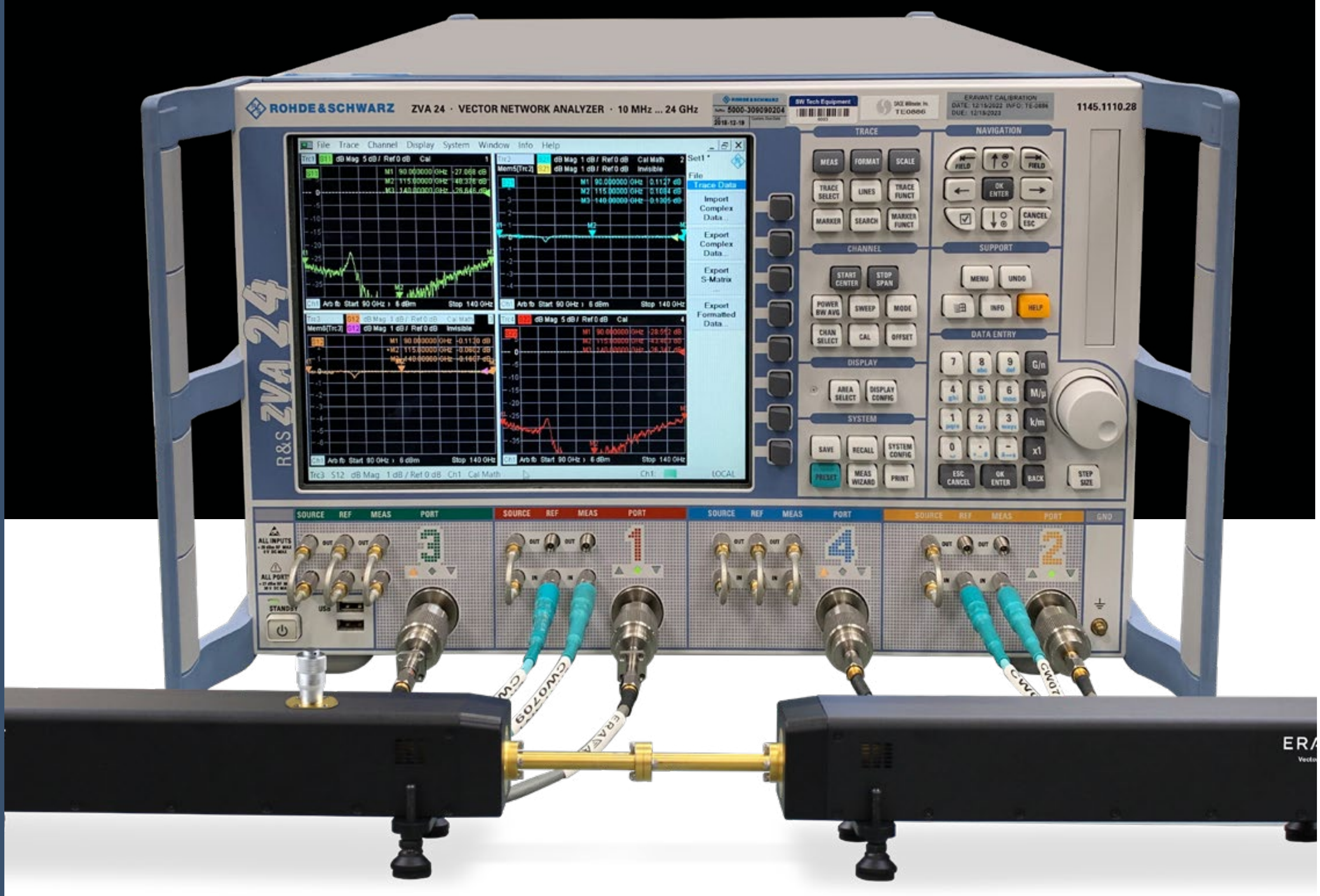
VNA FREQUENCY EXTENDERS

COMPATIBILITY SUPPLEMENT: ROHDE & SCHWARZ ZVA SERIES



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.

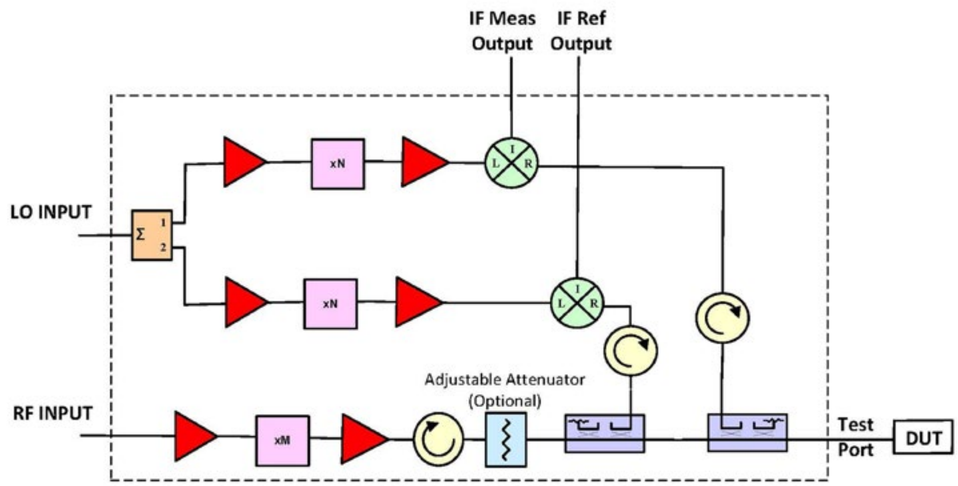


Fig. 1.1 – A single TX/RX frequency extender uses frequency multipliers to generate mm-wave test signals from lower frequency RF and LO signals provided by the VNA. Directional couplers sample the Reference and Measured signals. A pair of mixers down-convert the sampled signals to the IF of the VNA.

2. ZVA NETWORK ANALYZER COMPATIBILITY

Rohde & Schwarz ZVA series network analyzers must include two or more independent signal sources. The following setup instructions are applicable to four-port ZVA models that have four independent signal sources.

It may be possible to operate a single TX/RX extender using a two-port ZVA without requiring additional equipment. It may be possible to operate two TX/RX modules using a two-port ZVA by adding additional equipment. This document does not include setup instructions for two-port ZVA models.

Software option ZVA-K8, Control of frequency converters, is required. Hardware option ZVAxx-B16 is also required for direct access to Reference and Measured receiver channels.

The following hardware options are recommended for optimum system performance:

ZVAB-B4	Oven-stabilized quartz reference oscillator
ZVAxx-B21/B22/B23/B24	Generator step attenuators for Ports 1/2/3/4
ZVAxx-B31/B32/B33/B34	Receiver step attenuators for Ports 1/2/3/4

Fig. 2.1 – The STO series of VNA frequency extenders are compatible with Rohde & Schwarz ZVA series VNAs. Four test ports allow direct connections between the VNA and two frequency extenders.

3. ELECTRICAL CONNECTIONS

Eight phase-stable coaxial cables are necessary to connect two TX/RX frequency extenders to a ZVA network analyzer (Fig. 3.1).

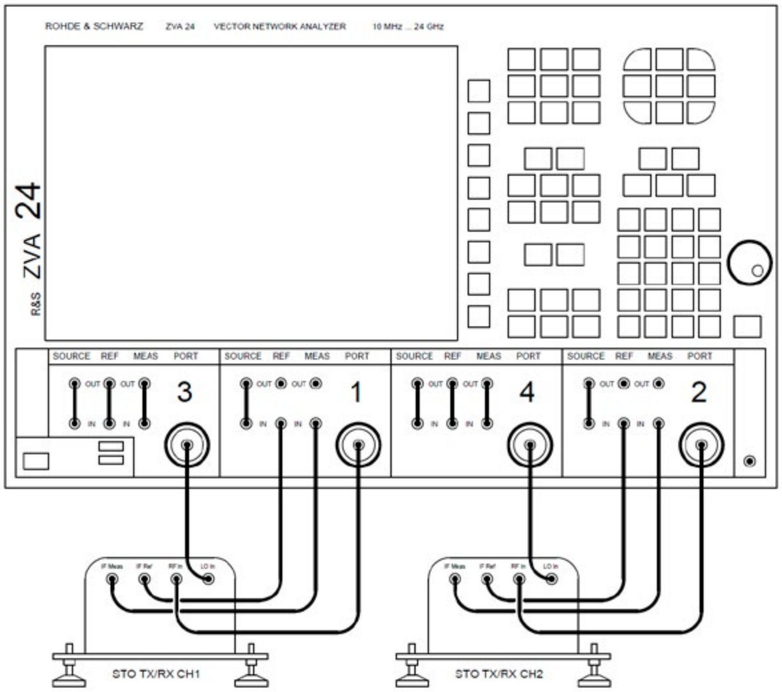
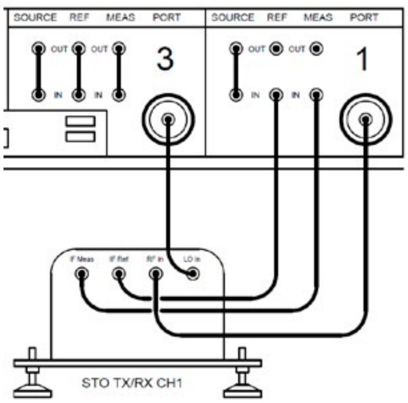


Fig. 3.1 – Each TX/RX frequency extender requires instrumentation-grade coaxial cables to carry RF and LO signals to the extender, and two IF signals back to the VNA.

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



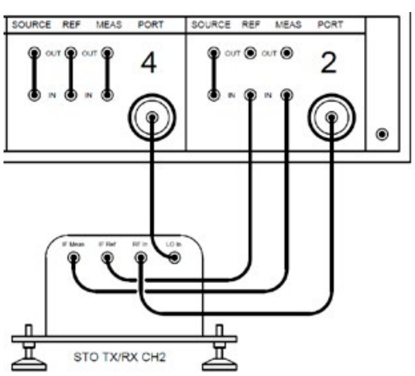


Fig. 3.2 – A single TX/RX frequency extender obtains its LO signal from Port 3 of the ZVA.

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

4. INSTRUMENT SETUP

The following instructions were developed using a Rohde & Schwarz Model ZVA four-port network analyzer with firmware version 4.11. Different models or firmware versions may have slightly different procedures or displays.

Some Rohde & Schwarz ZVA network analyzers are pre-loaded by the manufacturer with configurations for various types of frequency extenders. The following instructions are applicable to when the Type field in the Frequency Converter section of the System Configuration menu is set to <NONE>.

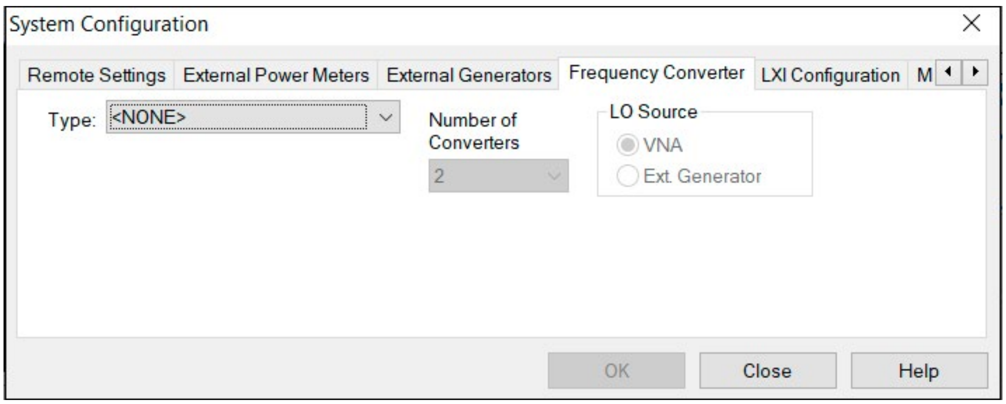


Fig. 4.1 – The following instructions apply when the Frequency Converter Type selection is <NONE>

4.1 Stimulus Configuration

Use the Menu bar at the top of the screen to select Channel and open the Stimulus dialog. Enter the start and stop frequencies of the frequency extender, as well as a base power level for the RF and LO signals generated by the ZVA test ports (Fig. 4.2).

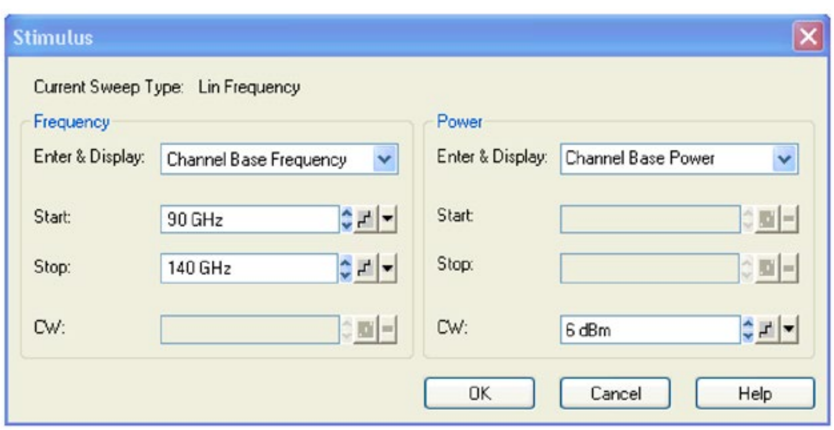


Fig. 4.2 – The Stimulus dialog sets the Base start and stop frequencies and the Base power level.

4.2 Port Configuration

The Port Configuration dialog defines the Measurement ports (Ports 1 and 2), as well as the RF and LO Generator ports (Fig. 4.3)

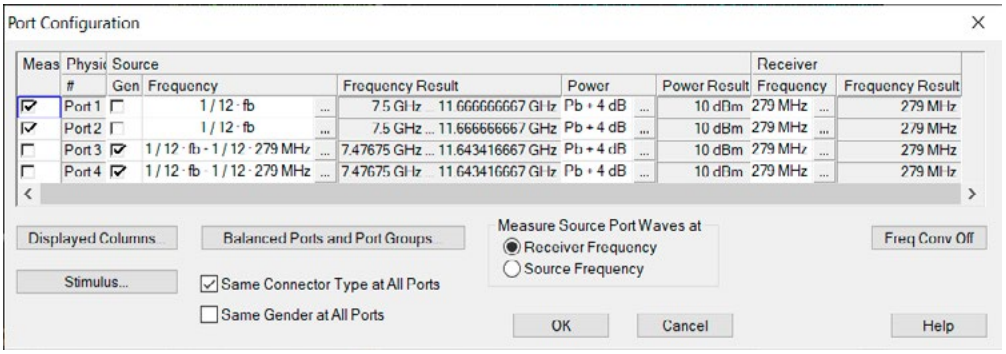


Fig. 4.3 – The Port Configuration dialog defines the ZVA test port frequencies and power levels.

From the menu bar at the top of the display, select Channel, Mode, Port Config. In the Port Configuration dialog, the variable fb refers to the base measurement frequency. The variable Pb refers to the base signal power level. Mathematical expressions determine the frequencies and signal powers generated at each test port as functions of fb and Pb.

4.2.1 – Port 1 Setup

In the Port Configuration dialog, check the box to the left of the Port 1 label to configure it as a Measurement port. Click on the "..." button next to the mathematical expression for Frequency to open the Port 1 Source Frequency dialog (Fig. 4.4). The divisor applied to fb is the RF multiplication factor used by the frequency extender. Enter 0 Hz for the offset value. The resulting range of Port 1 frequencies is displayed.

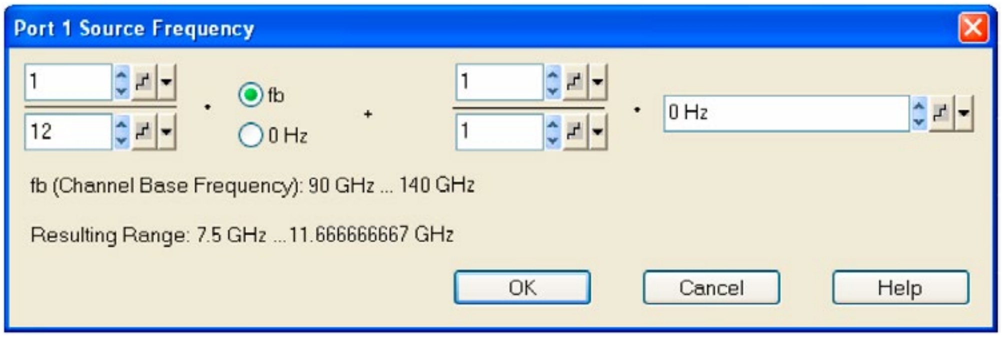


Fig. 4.4 – The Port 1 Source Frequency is a linear function of the base test frequency, fb.

In the Port Configuration dialog, click on the "..." button next to the mathematical expression for Power to open the Port 1 Power dialog (Fig. 4.5). Select either the base power level (Pb) or 0 dB as a reference level. Enter the Port Power Offset to obtain the RF power level required by the frequency extender.

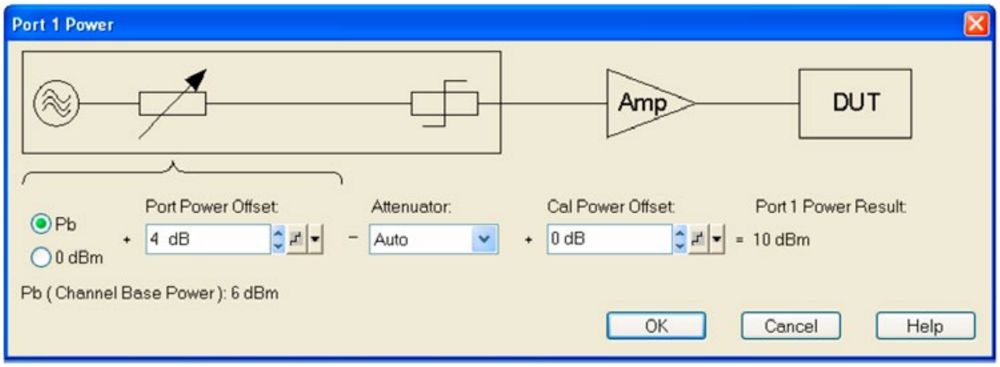


Fig. 4.5 – The Port 1 Power dialog controls the RF power level supplied to the frequency extender.

The ZVA series of VNA uses a fixed IF frequency of 279 MHz for frequency extenders. In the Port Configuration dialog, click on the "..." button next to the mathematical expression for Receiver Frequency to open the Port 1 Receiver Frequency dialog (Fig. 4.6). Select 0 Hz as the reference frequency and enter 279 MHz for the offset. The resulting Port 1 Receiver frequency is displayed.

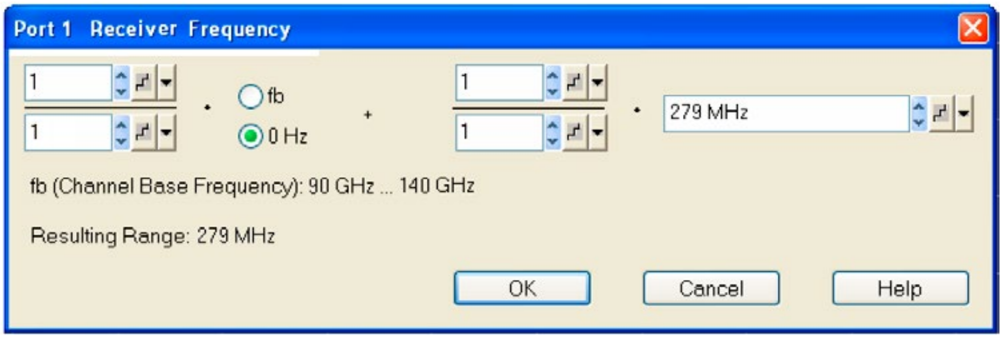


Fig. 4.6 – The Port 1 Receiver Frequency dialog controls the receiver frequency.

4.2.2 – Port 2 Setup

If a TX/RX extender is connected to Port 2, follow the same steps as those used to set up Port 1.

4.2.3 – Port 3 Setup

Port 3 provides a the LO signal for the frequency extender associated with Port 1. The LO frequency is always below the RF frequency, with an offset equal to the Port 1 receiver frequency.

In the Port Configuration dialog, check the box to the right of the Port3 label to configure it as a Signal Generator. Click on the "..." button next to the mathematical expression for Frequency to open the Port 3 Source Frequency dialog (Fig. 4.7). For the divisor applied to fb, enter the LO multiplication factor used by the frequency extender. Enter-279 MHz for the offset value. For the divisor applied to the offset value, enter the LO multiplication factor used by the frequency extender. The resulting range of Port 3 frequencies is displayed.

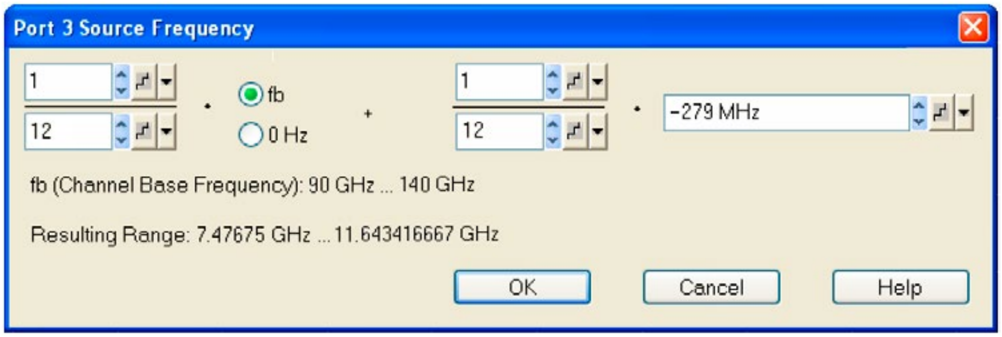


Fig. 4.7 – The LO frequency generated at Port 3 is a function of fb and the receiver frequency.

In the Port Configuration dialog, click on the "..." button next to the mathematical expression for Power to open the Port 3 Power dialog. Select either the base power level (Pb) or 0 dB as a reference level. Enter the Port Power Offset to obtain the LO power level required by the frequency extender.

4.2.4 – Port 4 Setup

If a TX/RX extender is connected to Port 4, follow the same steps as those used to configure Port 3.

4.3 Additional Settings

Low Phase Noise (Enabled)

Low Phase Noise should be enabled for optimum performance. Low Phase Noise reduces the phase noise of the RF and LO signals applied to the frequency extender. This setting is available for older synthesizer generations with coupled test ports. Later synthesizer generations, including ZVA67 and ZVA24/40 models with 4 ports and 4 sources, do not offer this setting. From the menu bar at the top of the display, select Channel, Mode, Low Phase Noise.

Automatic Level Control (Disabled)

Automatic Level Control (ALC) keeps the source power level at a constant value, independent of the DUT's input impedance. ALC should be disabled when using frequency extenders. From the menu bar at the top of the display, select Channel, Power Bandwidth Average, ALC Config... to disable ALC.

5. 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 ZVA.

System Power

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

Uncalibrated S11 or S22 Traces

Configure the ZVA 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. Combine the saved trace with 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 ZVA 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.

6. WORKING WITH TWO TX/RX FREQUENCY EXTENDERS

AA pair of TX/RX frequency extenders provides full two-port measurement capability. After both TX/RX frequency extenders have been installed and tested, ZVA 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 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 ZVA. 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 may 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 the DUT's 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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