

# Downconverter Insertion Gain/Loss

## For High Frequency RF Downconverters

### MS462XB/D

#### Scorpion™

### Introduction

A common test for frequency downconverters or downconverting mixers is insertion gain or loss. Conceptually, this is not a difficult test. A known power level is applied to the RF port of the device, and the output power is measured at the IF port. The difference between the IF and the RF is the insertion gain or loss. What can make this measurement time consuming is when the insertion loss must be known across a wide frequency span with many data points. This application note discusses how to use the MS462XB/D to perform the Insertion Gain/Loss test with a significant time savings over traditional methods. Also, this method allows the user to test downconverters with RF frequencies much higher than the 9 GHz capability of the MS462XB/D.

### Measurement Requirements

In order to use the MS462XB/D to perform Frequency Translated Power Compression Measurements, there are a few requirements:

- 1) External access for the DUT LO is required. In order to maintain phase coherency between the RF signal, the LO signal, and the IF receiver (see Figure 1).
- 2) Additional external components needed:
  - a. An ML2436/7A Power Meter to level the source power
  - b. An MG3690B series frequency synthesizer will be needed in order to provide the RF signal to the DUT.
  - c. A signal source with 10 MHz reference clock access to provide the LO signal to the DUT.

### Test Set-up

The test set up for the Insertion Loss/Gain Test will look like the diagram in Figure 1.

The test consists of a MS462XB/D, 2 - MG3690B Frequency Synthesizers, and an ML243XA Power Meter. Source 4 10 MHz Reference Out will need to be connected to the Source 3 10 MHz Reference In, and the Source 3 10 MHz Out will need to be connected to the MS462XB/D 10 MHz In. The Dedicated GPIB port on the back of the MS462XB/D will need to be connected to the GPIB connector on the ML243XA power meter and the MG3690B source 3 (and source 4 if the LO source is to be controlled remotely). The instruments GPIB addresses need to be set per Table 1 below.

Instrument	Purpose	GPIB Address
ML243XA Power Meter	Source Leveling	13
MG369XB Synthesizer	RF Source (Source 3)	9
MG369XB Synthesizer	LO Source (Source 4)	10

Table 1: GPIB Addresses

The MS462XB/D does not have a 10 MHz auto-sense, so the external reference mode will have to be set manually. In order to set the external reference, press the Utility front panel key and the following menu soft keys:

```

REAR PANEL
REFERENCE FREQUENCY
EXTERNAL
  
```

When using a Vector Network Analyzer for traditional S-parameter measurements, the signal input to the DUT would come from the internal source at port 1, and the output from the DUT would be connected to the receiver at port 2. The port 1 source frequency would be tuned to the same frequency as the receiver at port 2. For this measurement we are using the MS462XB/D strictly as a receiver. The external source 3 will provide the RF signal to the DUT and will be under the control of the MS462XB/D. The external source 4 will provide the LO signal. This can be set up to be controlled by the MS462XB/D, but this is not necessary unless the LO source will be swept. For this reason, it is possible to use a non-Anritsu source, or a LO signal internal to the DUT.

This architecture takes advantage of the external RF source in that the user is not restricted to the 9 GHz frequency range of the MS462XB/D. As long as the IF frequency falls into the MS462XB/D frequency range, the RF frequency can be as high as the MG3690B can provide, up to 67 GHz.

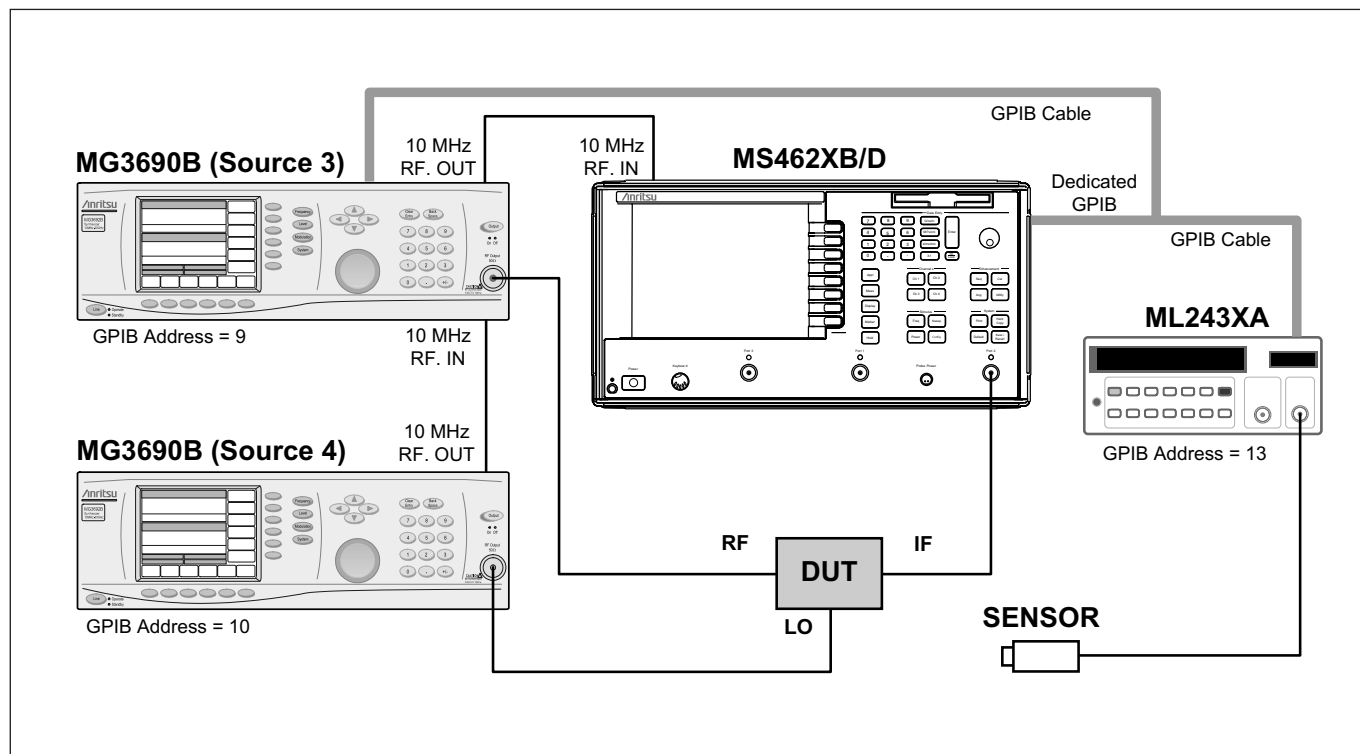


Figure 1. Test set-up

## Calibration

The calibration will be performed in several steps. First, the RF signal from source 3 will need to be leveled using the power meter. Second, the internal source on the MS462XB/D will be leveled to the same power level as the RF source 3. The internal source will be used to calibrate the receiver at port 2 of the MS462XB/D.

### RF source leveling

The first step is to set the correct power level for the RF input to the DUT, and perform a source level calibration. The source should be set up such that the frequency range equals the IF frequency range plus the LO frequency. Also the number of data points should match between the MS462XB/D and the MG3690B (source 3). Make sure to include any cabling that will be in front of the DUT during the measurement.

The following are the steps to set up and calibrate the MG3690B (source 3)

- Step 1. Zero and Calibrate the ML243XA Power Meter
- Step 2. Connect the power sensor to the output of the MG3690B (Source 3) as shown in Figure 2. Make sure to use the cable that will be used during the measurement.
- Step 3. Set the DUT input power on the synthesizer by pressing the Level front panel key and entering the power level.

Step 4. Set up the user level calibration by selecting the following menu soft keys:

User Lvl Cal

User1

Edit Start (enter RF start frequency)

Edit Stop (enter RF stop frequency)

Edit Points (enter desired number of frequency points) –  
this should match the number of points to be selected on VNA

Start Calibration

On

Step 5. Disconnect sensor from the MG3690B.

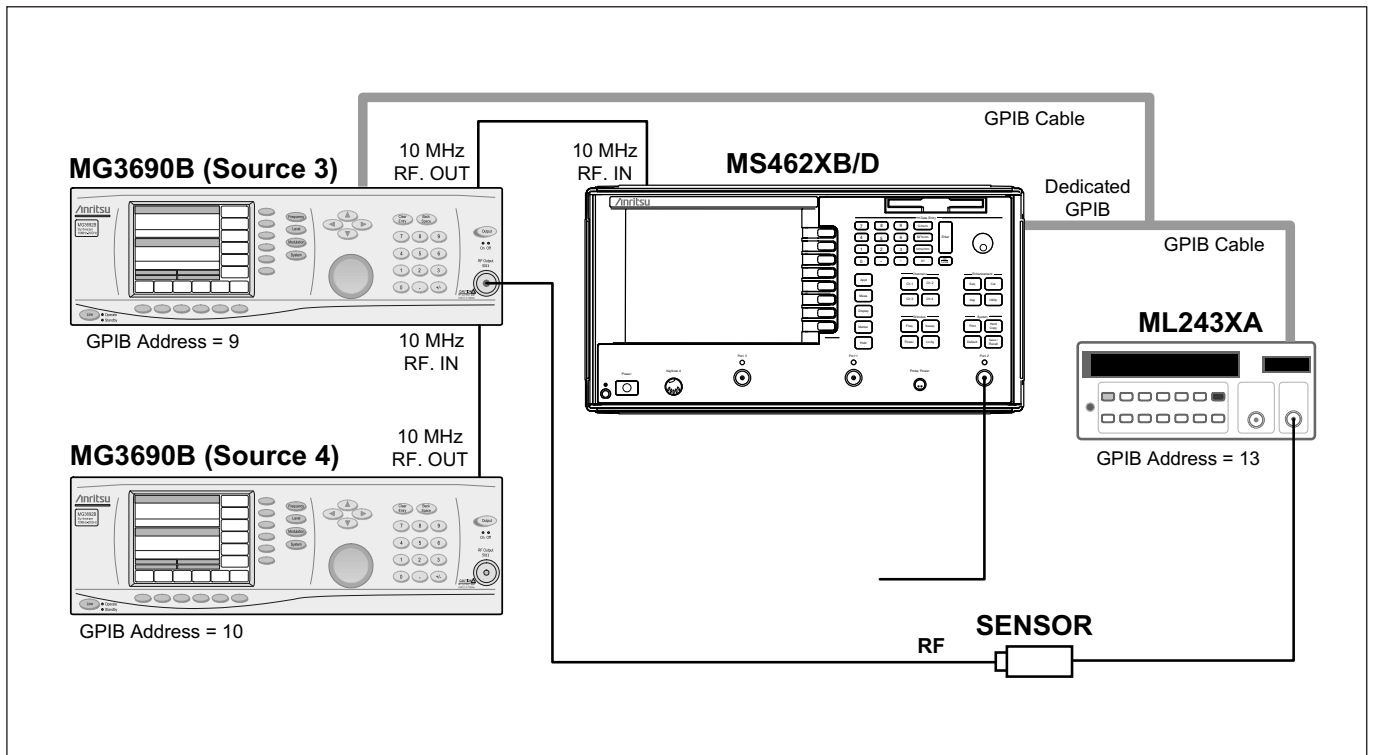


Figure 2. RF Source Leveling Connections

### Port 2 Receiver IF calibration

In order to calibrate the Port 2 Receiver, there must be a leveled source available. This procedure takes advantage of the Source Level calibration feature. The internal source in the MS462XB/D will be leveled to a specified power level, and that leveled power will be used to calibrate the receiver at VNA Port 2. The following are the steps to calibrate the Receiver VNA Port 2:

Step 1. Set up the display by pressing the Display front panel key and select the following menu soft keys:

DISPLAY MODE

SINGLE CHANNEL

Step 2. Set up the graph type by pressing the Display front panel key and select the following menu soft keys:

GRAPH TYPE

LOG MAG

- Step 3. Change the measurement ratio by pressing the Meas front panel key and select the following menu soft keys:
- USER DEFINED
  - USER 2
  - CHANGE RATIO
  - MORE
  - B2 (Tb) – this is the numerator value
  - 1 (UNITY) – this is the denominator value
  - RETURN
- Step 4. Set the number of data points by pressing the Config front panel key and select the following menu soft keys:
- DATA POINTS – Enter the number of required data points for the sweep.  
The number of data points needs to be the same as the MG3690B
- Step 5. Set the sweep for the RF, IF and LO (optional) frequencies by pressing the Config front panel button and select the following menu soft keys:
- MULTIPLE SOURCE
  - DEFINE BANDS
  - BAND START FREQ – Enter the start frequency
  - BAND STOP FREQ – Enter the stop frequency
  - EDIT SYSTEM EQUATIONS
  - SOURCE 3
  - OFFSET FREQ – Enter the LO Frequency
  - RETURN
  - SOURCE 4 (optional, if using the MS462XB/D to control the LO Source)
  - CW (optional, if using the MS462XB/D to control the LO Source)
  - OFFSET FREQ – Enter the LO Frequency (optional, if using the MS462XB/D to control the LO Source)
  - RETURN (optional, if using the MS462XB/D to control the LO Source)
  - RETURN
  - STORE BAND 1
  - RETURN
  - OFF
- Step 6. Press the Power front panel key.
- Step 7. Select which source (source 1 or source 2) to perform the calibration.
- SOURCE 1 SETUP
- Step 8. Set the selected source to the desired power level.
- SOURCE 1 POWER = (enter operating input power for the DUT) – Use the attenuator to achieve lower power levels if necessary.
- Step 9. Select the flat test port power calibration.
- FLAT TEST PORT POWER CAL
- Step 10. Ensure that the power meter is still calibrated and zeroed.
- Step 11. Connect the power sensor to the test port 1 as shown in Figure 3

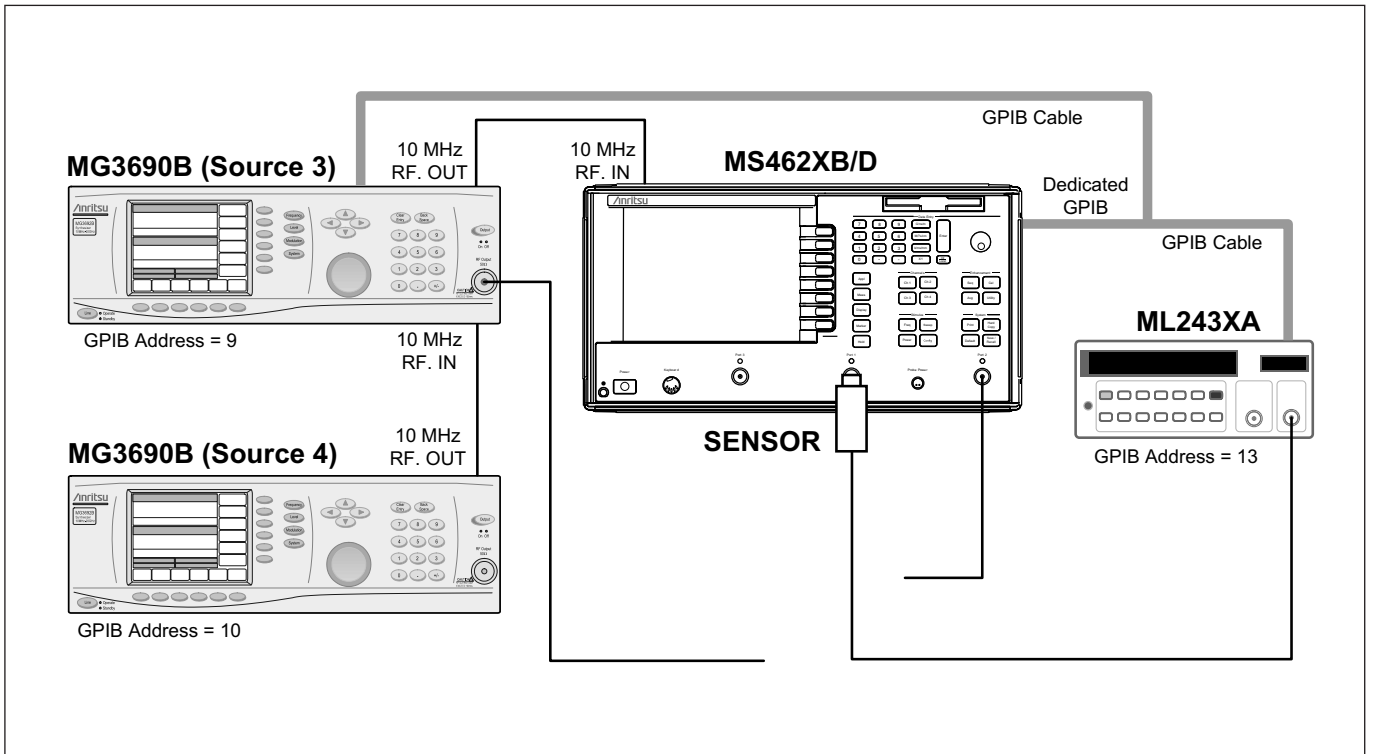


Figure 3. IF Source Leveling Connections

Step 12. Select the number of power points to be measured. For best results, one power point should be measured per sweep point, otherwise interpolation will occur and the accuracy will be reduced.

MEASURE 1 POWER POINT EVERY 1 POINT(S)

Step 13. Enter the target source power. For best results, the target source power should be equal to the source power set previously.

POWER TARGET = (enter operating input power for the DUT)

BEGIN CAL

Step 14. Wait until the process is complete. This measurement may take a few minutes.

Step 15. Save the calibration if desired.

Step 16. Connect a thru line between the Calibrated VNA Port 1 and VNA Port 2 as shown in Figure 4.

Step 17. Use trace math to zero the Receiver by pressing the Display front panel key and the following menu soft keys:

TRACE MEMORY

STORE DATA TO MEMORY

DATA (/) MEMORY

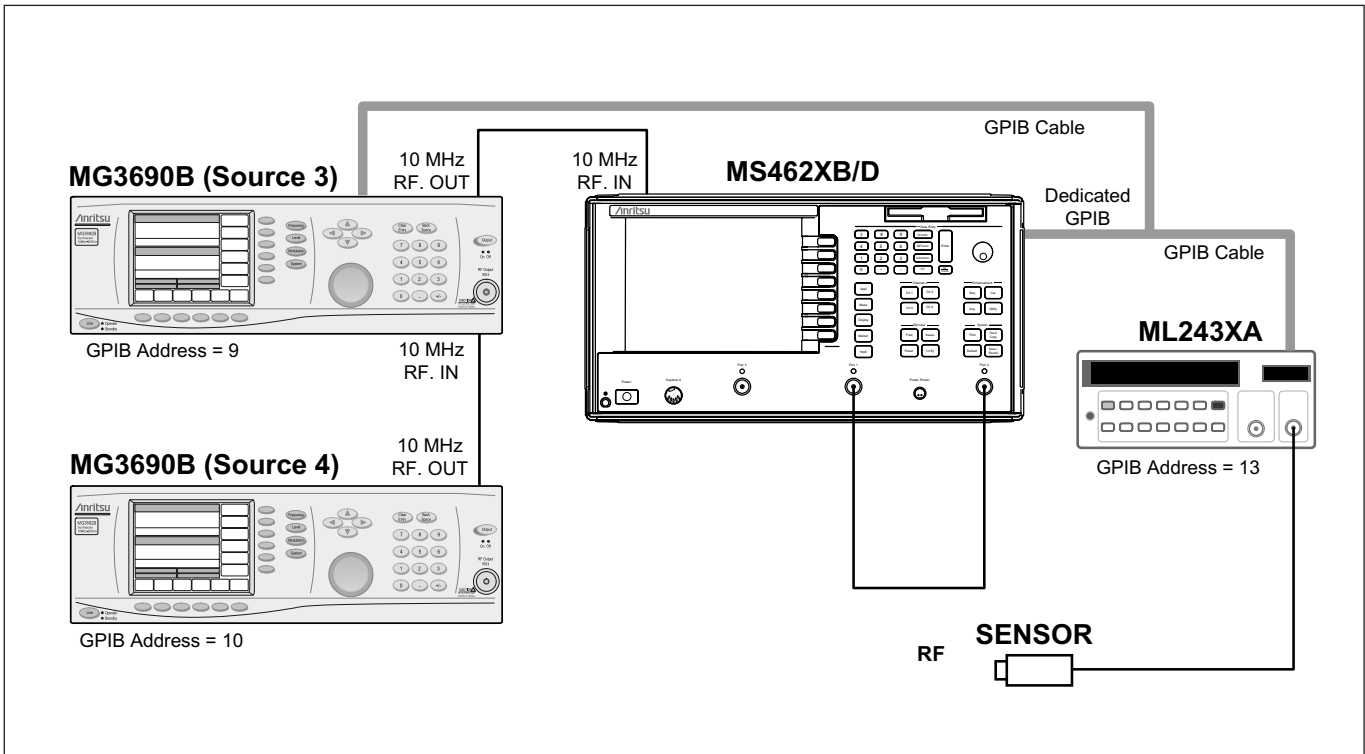


Figure 4. IF Receiver Leveling Connections

### Important Considerations

In order to guarantee accurate results it is important to make sure that the following conditions are met.

- 1) The MG3690B power level must be calibrated at the same power level that the MS462XB/D Port 1 IF power is calibrated.
- 2) The number of data points used on the MG3690B must match the MS462XB/D.

### Measurements

Now the test set is ready to perform the test. The following are the steps to perform the conversion loss test:

- Step 1. Set the correct Power Levels for the RF source by pressing the Power front panel key and the following soft keys:  
 SOURCE 3 SETUP  
 SOURCE 3 POWER – Enter the correct power level for the DUT RF input.  
 RETURN
- Step 2. Set the LO Source to the correct Power level, or if using the MS462XB/D to control the source, press the Power front panel key and the following soft keys:  
 SOURCE 4 SETUP  
 SOURCE 4 POWER – Enter the correct power level for the DUT LO input.  
 RETURN
- Step 3. Connect the DUT as shown in Figure 1.

Figure 5 shows a sample plot of a conversion loss measurement.

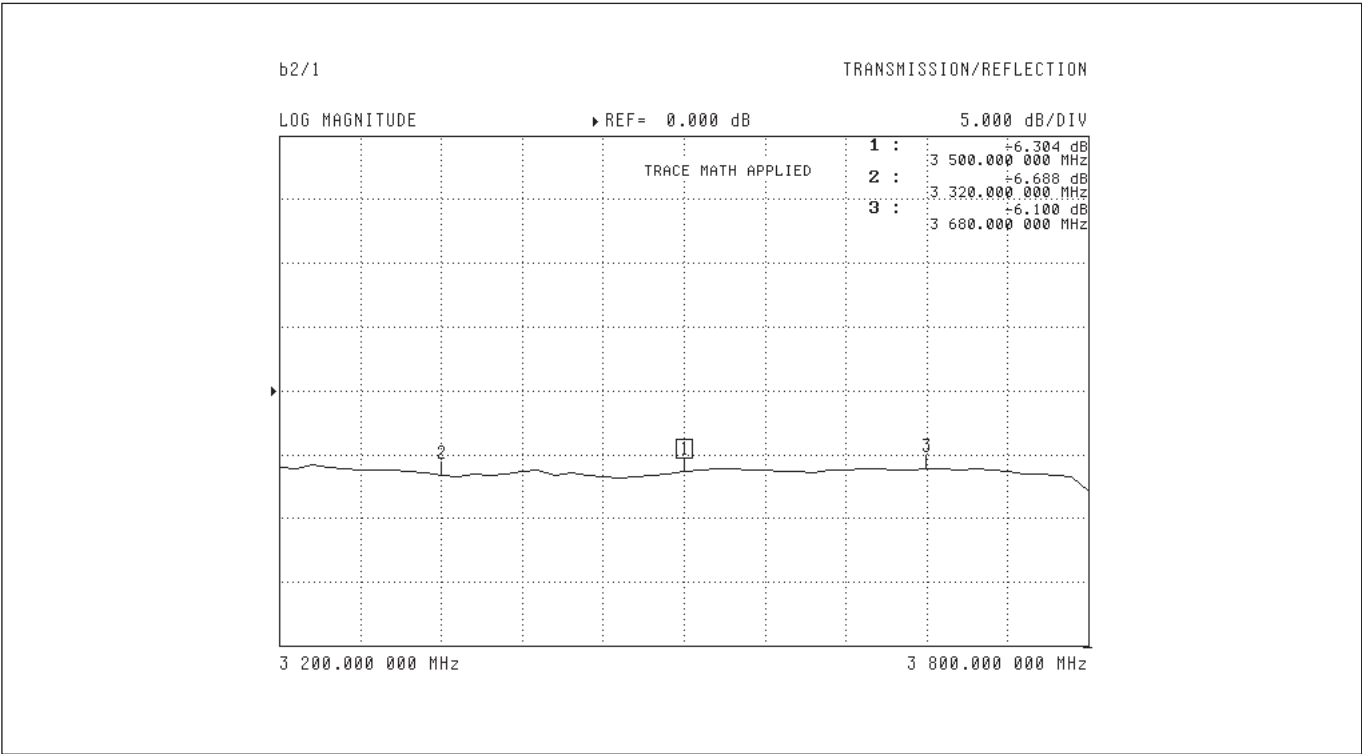


Figure 5. Conversion Loss Plot

### Conclusion

The MS462XB/D series Vector Network Analyzer can be a powerful tool for device characterization. The techniques outlined in this application note can save the user considerable time in measurement and provide accurate results for frequency translation conversion loss characterization.

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