R&S® ZNB Vector Network Analyzer – Intermodulation Measurements Made Simple.

Application Note

Products:

- ZNBx vector network analyzer

The family of ZNB vector network analyzers from Rohde & Schwarz has several features to provide effective characterization of intermodulation products of non-linear RF devices.

The "Intermodulation Wizard" quickly configures the instrument for use, including power calibration and formatted results. The extensive power range enables accurate and simultaneous measurement of up to four odd product orders, and presentation of the related intercept points.

Concurrent measurements of fixed and swept frequencies are further reduced in time with the optional second internal frequency source.

This Application Note provides guidance on using the "Intermodulation Wizard" through an example measurement.

Intermodulation Measurements made simple

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ROHDE&SCHWARZ

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1 Introduction

Measuring intermodulation products (IMP) of a non-linear RF device typically involves three pieces of test equipment, and time to connect and calibrate multiple cable path losses. Once the equipment is configured, the measurement is straightforward for a simple fixed frequency two tone measurement. However, preparing for a swept frequency response is more complex, requiring synchronization of frequency sources.

The R&S® ZNB vector network analyzer (VNA) is a versatile self-contained instrument able to measure intermodulation products accurately and effortlessly provides the following benefits:

- '**Intermodulation Wizard**' tool to efficiently configure the instrument.
- Faster measurements with an internal second source.
- Generous linear source output power.
- Excellent receiver sensitivity for detecting low level higher order products.
- Excellent receiver linearity (Absolute max input, +27 dBm).
- Simultaneous measurement of fixed and swept frequencies.
- Straightforward power calibration.
- Formatted results.
- Display of calculated odd order intercept points (3rd, 5th, 7th and 9th).

In this application note, step-wise instructions are presented on how to set up the R&S® ZNB VNA, leading to the successful measurement of intermodulation products. This compliments the information given in the *R&S ZNB, Vector Network Analyzers, User Manual*,[1] and the on-instrument "**HELP**".

It is assumed that the reader is familiar with the theory and limitations caused by the generation of intermodulation products in non-linear RF devices. Detailed information is given in chapter 2 of R&S® Application Note, *Intermodulation Distortion Measurements on Modern Spectrum Analyzers, (1EF79)*,[2] available on the Rohde & Schwarz website.

2 Test Equipment - Configurations

The measurement of intermodulation products involves the application of two RF sources of equal power and close in frequency, that are combined into a single path applied to a device under test (DUT). The RF output spectrum from the DUT is analyzed for the presence of spurious frequencies caused by the non-linear behaviour of the DUT. The source input power levels may need to be varied to observe the intermodulation products. Once measured, this information is used to calculate the intermodulation product intercept point, either referred to the DUT input or output.

2.1 R&S® ZNB Vector Network Analyzer

The R&S® ZNB VNA fitted with options **R&S®ZNB-K14** (*Intermodulation Measurements*) and **R&S®ZNB-K4** (*Frequency Converting Measurements*), is transformed into an effective test facility for measuring intermodulation products. Using the built in "**Intermodulation Wizard**" the R&S® ZNB VNA is quickly and accurately configured, calibrated and set up to display results for the required parameters.

The two and four port R&S® ZNB network analyzers both support intermodulation measurements and require an external power combiner. The two port analyzer requires an additional external signal generator.

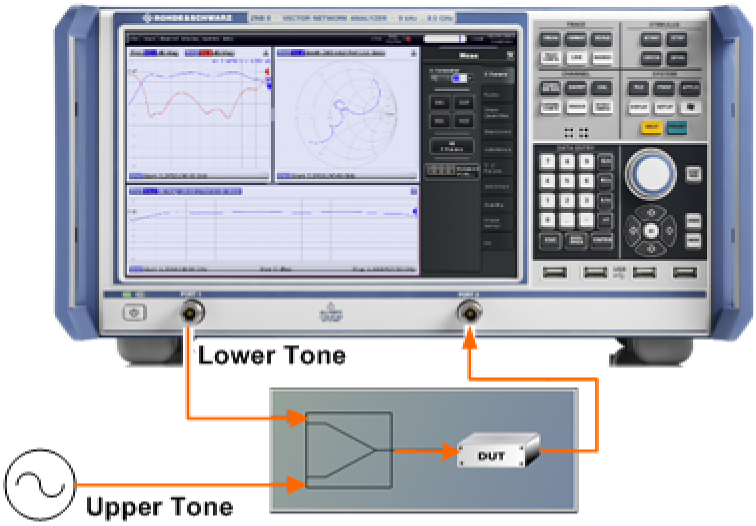

Figure 1 - Intermodulation testing with a 2-port R&S® ZNB network analyzer, external signal generator and combiner.

Figure 1 shows the configuration with a 2-port analyzer with the lower tone signal sourced from Port 1 and the upper tone sourced from an external generator. Both signals are combined externally and applied to the input of the DUT. The intermodulation quantities produced at the DUT output are analyzed at Port 2. The function of Ports 1 and 2 can be interchanged. The R&S® ZNB VNA can control the external signal generator using a USB, LAN or GPIB interface. Use of GPIB does require option **R&S®ZVAB-B44** (*USB-to-IEC/IEEE Adapter*).

Faster measurements are achieved with a four port R&S® ZNB VNA equipped with an internal second source, option **R&S®ZNB-B2** (*Internal second generator*). The versatile architecture allows any combination of analyzer ports that are supplied by different internal sources to generate the lower and upper tones. Figure 2 provides an example where Port 3 produces the upper tone.

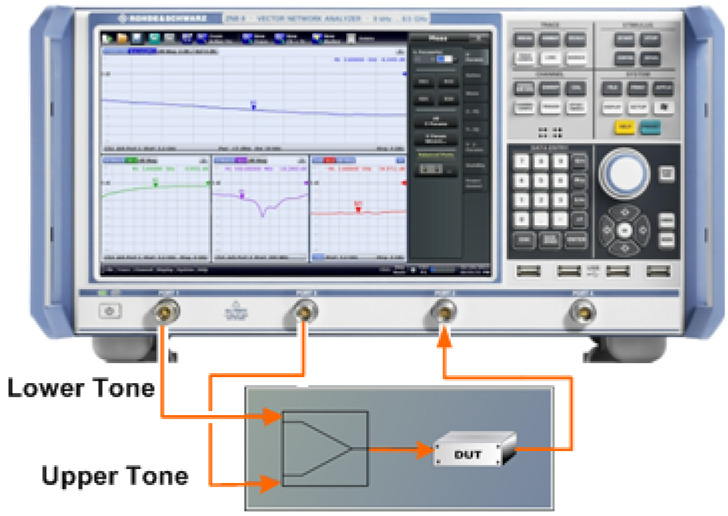

Figure 2 - Intermodulation testing using a 4-port R&S ZNB network analyzer with two internal sources and an external combiner.

This application note is based on the R&S® 4-port ZNB 8 (9 kHz → 8.5 GHz) vector network analyzer, fitted with option **R&S®ZNB-B2** (*Internal second generator*), and executing firmware version 1.70.

2.2 Support Test Equipment

2.2.1 Rohde & Schwarz Power Meter

For accurate measurement of intermodulation products and prediction of associated intercept points it is necessary to calibrate the following power levels:

- the two tones at the DUT input.
- power at the receiver port input.

Calibration of the power levels is effortless with a **R&S® NRP-Zxx** power sensor connected to and controlled by the R&S® ZNB analyzer.

The example given in this application note uses an **R&S® NRP-Z31** power sensor (10 MHz -> 33 GHz) connected directly to the analyzer USB ports using an **R&S® NRP-Z4** adapter cable.

When the R&S® power sensor is first connected, an onscreen message may appear as shown in Figure 3, stating “Frequency out of range”.

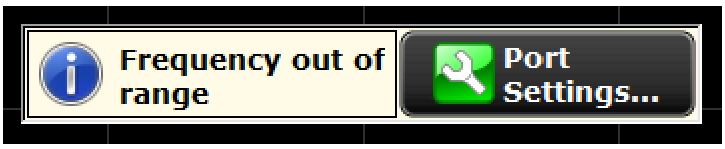

Figure 3 - Warning message after connecting NRP-Zxx power sensor

Selecting “**Port Settings…**” opens a window, as shown in Figure 4.

Figure 4 - Port Settings for Channel 1

In this example, the power meter has been correctly identified as being an **R&S® NRP-Z31**, and has a minimum frequency response greater than the minimum frequency response of the R&S® ZNB. Therefore, the user must ensure that the test configuration is within the operating limits of the instruments.

2.2.2 Power Combiner

Measurement of intermodulation products requires two test tones to be combined into a single RF path using a passive power combiner.

The choice of combiner should take into account:

- **Frequency bandwidth** — The operating bandwidth of the combiner must be considerably greater than the spectrum of the intermodulation products.
- **Coupling factor** — This should be kept to a minimum to reduce insertion loss through the combiner.
- **Isolation** — The combiner must provide sufficient isolation between the two sources (>6 dB).

In the following example, a resistive power combiner from Mini-Circuits (*ZFRSC-183+*[4]) is used, giving typically 6.5 dB of coupling loss and isolation, from DC to 18 GHz.

2.3 Device Under Test (DUT)

The RF amplifier example used in this application note is from Mini-Circuits (*ZJL-3G+*[3]). This has the following typical characteristics:

- Frequency range: 20 MHz → 3 GHz
- Gain: 19 dB
- Output 1 dB compression point: +8 dBm
- Output 3rd order intercept point: +22 dBm

3 Preparing for an Intermodulation Measurement

3.1 Presetting the R&S® ZNB Vector Network Analyzer

Presetting the R&S® ZNB network analyzer to its factory default settings will avoid the unexpected effects of any legacy settings. Refer to the *R&S ZNB, Vector Network Analyzers, User Manual*, or press the "**HELP**" button on the instrument front panel keypad for more information on preset conditions.

Selection of any function on the R&S® ZNB VNA is designed to be simple and is possible in at least two ways. Using "**Preset**" as an example:

1. Front panel keypad: "**SYSTEM**" key group > "**PRESET**".
2. Software menu structure: "**SYSTEM → Preset**".
3. Software based hard key panel: "**PRESET**".

The hard key panel is hidden by default, but is useful when operating the instrument remotely. The hard key panel can be displayed using "**DISPLAY → View Bar → Hard Key Panel**", as shown in Figure 5.

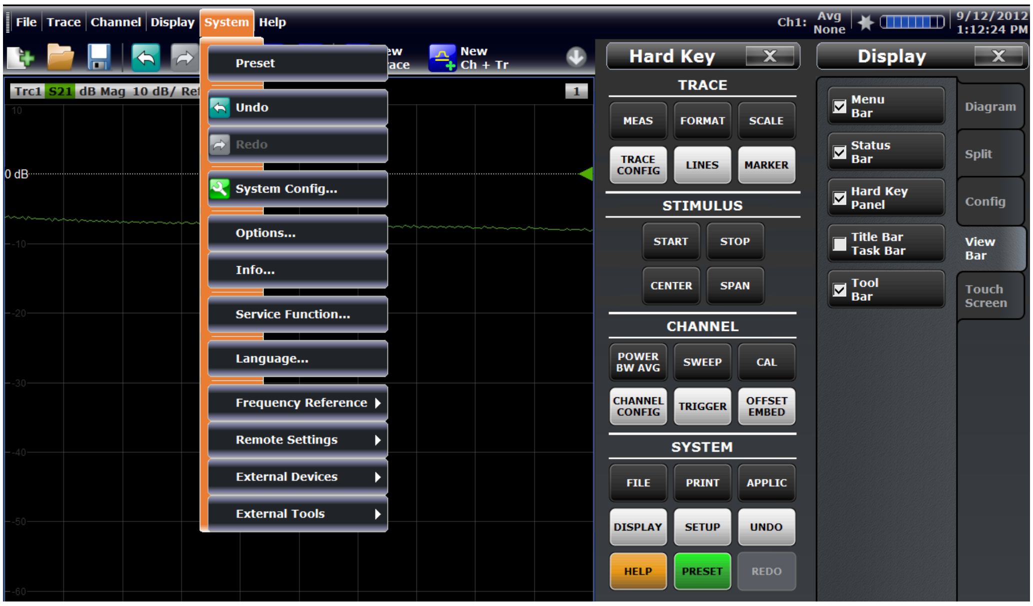

Figure 5 - Making the "Hard Key" panel visible and two methods of instrument "Preset".

3.2 Defining the Measurement Requirements

Before configuring the R&S® ZNB network analyzer for making measurements, consideration must be given to the DUT. Using the Mini-Circuits ZJL-3G+ low power amplifier as an example, there are three minimum considerations:

1. **Measurement frequency bandwidth:** The R&S® ZNB is able to synchronously sweep the two tones across a defined frequency range. The receiver input will contain the two primary tones and the broader spectrum containing the intermodulation products. Therefore, the bandwidth of the receiver needs to be set to capture the lowest and highest intermodulation products.

2. **DUT input power:** The DUT input power characteristic must be known to avoid over-driving or permanently damaging the device. For example, a review of the amplifier parameters given in section 2.3, states that the 1 dB compression point referred to the input is about -10 dBm. So, to ensure that the amplifier is measured out of saturation, an input power of -20 dBm will be used.

3. **DUT output power:** When measuring a high power amplifier, it is very important to know the level of the device output power. The maximum rated RF power of each receiver port is +27 dBm. To avoid permanent damage to the analyzer, the DUT output power must be significantly below this limit through either using attenuation at the DUT output, and/or by reducing the DUT input power. This is not an issue of concern for the low power amplifier characterized in this Application Note.

The R&S® ZNB VNA is ready to be configured once these considerations are fulfilled.

3.3 R&S® ZNB "Intermodulation Wizard"

The R&S® ZNB network analyzer "**Intermodulation Wizard**" is a straightforward tool to configure the instrument and access is through the menu "**Channel Config → Intermodulation → Intermodulation Wizard**", giving the window shown in Figure 6.

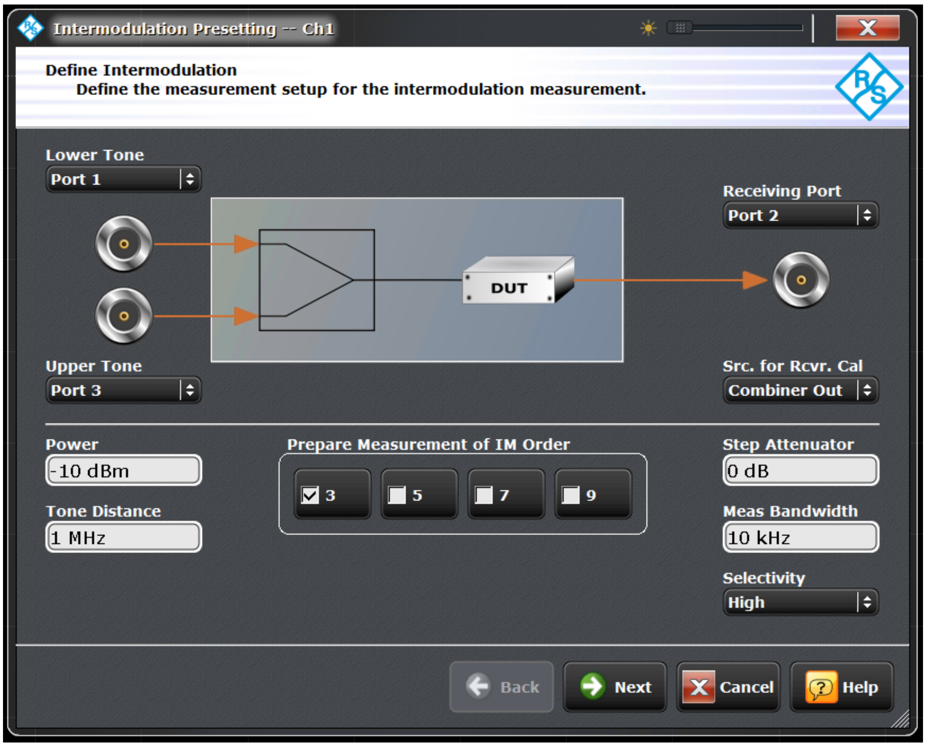

Figure 6 - Intermodulation Wizard, default screen

In this example, the intermodulation measurement will be made on channel 1.

Additional information and support is always available on the test instrument, accessible using the "**Help**" soft key, or "**HELP**" front panel key. It is also possible to exit the wizard at any stage using the "**Cancel**" soft key.

3.3.1 Defining the Ports and Intermodulation Products

Figure 6 shows the measurement hardware configuration. Quantities relating to the two signal sources are on the left, and those relating to the receiver are on the right. The upper part of the window shows three RF ports of the R&S® ZNB analyzer and how these are connected to the external power combiner and DUT, identified in the grey box.

"**Lower Tone**", "**Upper Tone**" and "**Receiving Port**" functions require ports to be allocated. The default setting is shown in Figure 6. A new port selection is made using the touchscreen interface or a computer mouse to activate the **Port** window, producing a drop down menu listing available ports. For the **Lower Tone**, only ports associated with the R&S® ZNB internal generator(s) are listed. For the **Upper Tone**, external signal generators connected to and for control by the R&S® ZNB analyzer are also listed.

Selection of unsupported port combinations will result in an error message which automatically clears when the test conditions are corrected.

"**Src. for Rcvr. Cal**" selects the signal source used for calibrating the power level at the receiver port. Figure 7 shows the available power sources from the drop down menu. By default, the output from the combiner and Port 4 of the analyzer are offered as power sources. Figure 7 also shows a **R&S® SGS 100A** signal generator connected to the analyzer, "**Gen 1**". For this example "**Combiner Out**" is used.

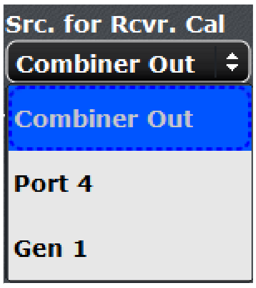

Figure 7 – Receiver calibration: Power source options

The bottom part of Figure 6 configures the source and receiver parameters. Values are input for source **Power**, **Tone Distance** and the receiver filter **Measurement Bandwidth**. The **Measurement Bandwidth** and **Tone Distance** values need to be chosen with care. The **Tone Distance** should be greater than 100x the **Measurement Bandwidth**, so that each frequency component is selected by the filter without interference. The analyzer will present an information window if this condition is not fulfilled.

"**Prepare Measurement of IM Order**" allows the intermodulation product orders of interest to be selected by placing a 'tick' in the appropriate boxes. This information allows the R&S® ZNB VNA to optimize its configuration, avoiding measurement of unnecessary data. Hence the wanted measurements are collected more quickly.

"**Step Attenuator**" refers to analyzers fitted with option **R&S®ZNB-B3x** (*Receiver Step Attenuator*) to allow measurement of higher input power levels.

"**Selectivity**" of the IF filter can be changed and by default is set to "**High**", to maximize rejection of adjacent spurious frequency components.

Example (*Amplifier ZJL-3G+*): All parameters are default except:

- Source **Power** level = -20 dBm
- All intermodulation orders are selected.

Once configured, press "**Next**". It is possible to come back to this window and change these parameters at any time.

3.3.2 Frequencies and Powers

Stage two of the **Intermodulation Wizard** defines the start and stop frequencies, and output power of the sources. If the start and stop frequencies exceed the hardware capabilities of the instrument, then a warning message will appear and the frequency range text will be highlighted in red for the port(s) attempting to operate beyond hardware limits, as shown in Figure 8.

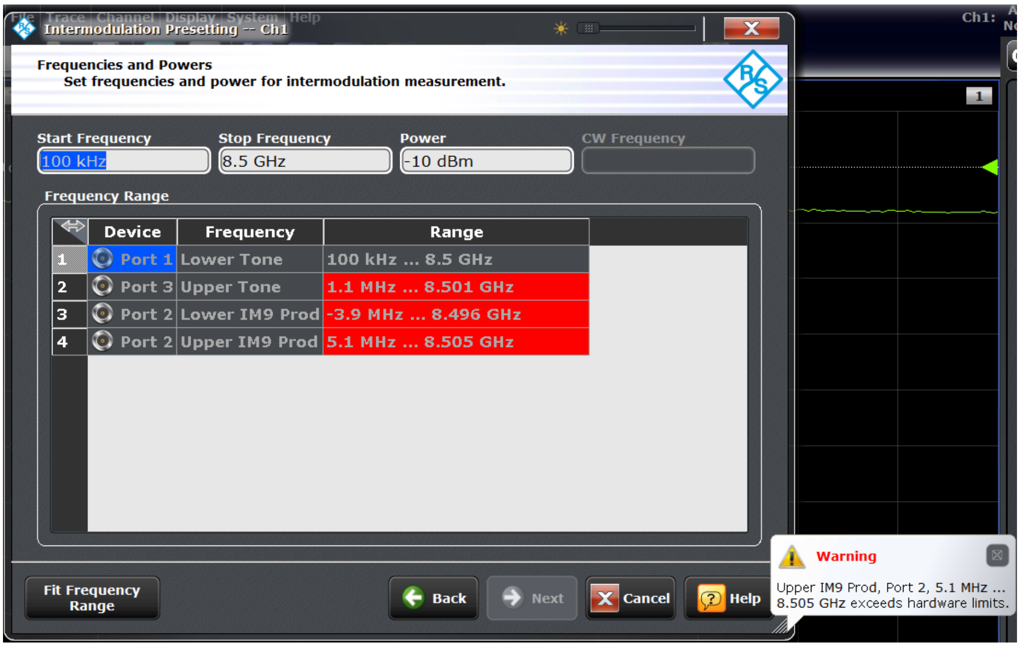

Figure 8 - Frequency range: Defining and viewing exceeded limits

The "**Start Frequency**" and "**Stop Frequency**" values are referenced to the port sourcing the lower tone. This port is used to set the frequency ranges for the other ports. In this example, Port 1 sources the lower tone and Port 3 the upper tone, offset by 1 MHz. Therefore the hardware upper limit of Port 3 is exceeded by 1 MHz, requiring that the "**Stop Frequency**" of Port 1 must be reduced by at least 1 MHz.

For the receiver (Port 2), Figure 8 shows that the hardware limits for the lower and upper frequency ranges are exceeded. When the two source tones are set to the minimum frequency, the calculated lower 9th order intermodulation product is below the measured frequency range. Similarly, when the tones are set to the maximum frequency limit, the higher 9th order intermodulation product is above the measured frequency range.

Therefore the measurement frequency range must be configured so that all of the VNA ports and the power meter are within their operating frequency ranges. For the analyzer only, this can be done automatically using the "**Fit Frequency Range**" soft key. When using this method, take care to ensure that the power meter frequency range matches or exceeds the required test measurement frequency range.

Example (*Amplifier ZJL-3G+*): The lower tone frequency range and power level are set as follows, and implemented as shown in Figure 9:

- Start frequency = 15 MHz
- Stop frequency = 3.5 GHz
- Power = -20 dBm

The 10 MHz low frequency limit of the **R&S NRP31** power sensor defines the **Start Frequency**. At 15 MHz the lowest 9th order product is safely measured at 11 MHz. The **Stop Frequency** is 3.5 GHz, since the amplifier is not specified beyond 3 GHz.

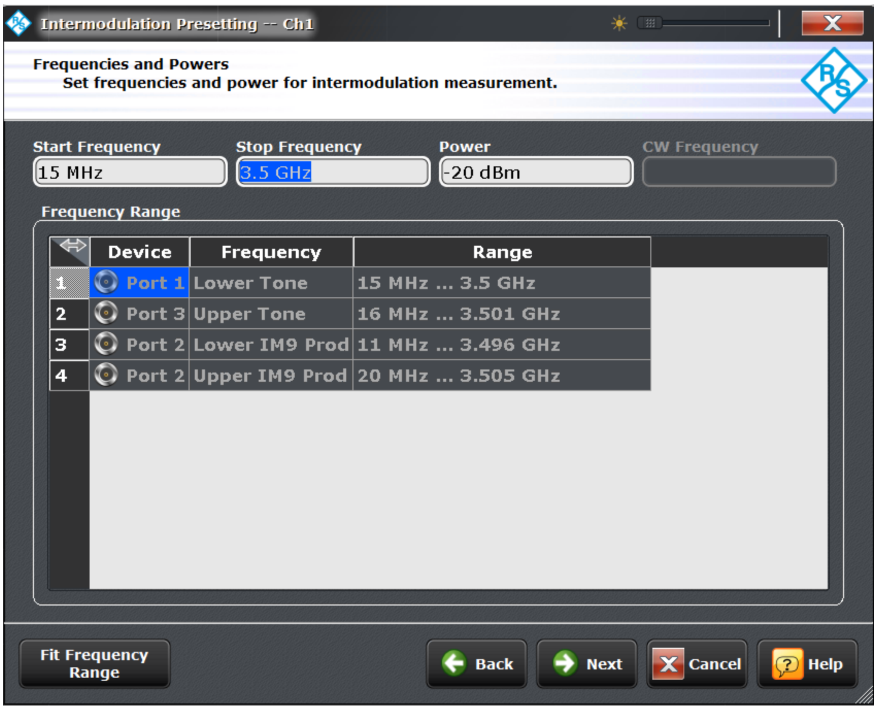

Figure 9 – Setting the reference frequency range and power level

Once configured, press "**Next**". It is possible to come back to this window and change these parameters at any time. Or go "**Back**" to the previous step if necessary.

3.3.3 Measurement Parameters

The measured parameters that will be displayed need to be chosen. The selected items will each have a trace and will be shown together on one display. The available measurement parameters are shown in Figure 10 and are selected by placing a tick in the adjacent box: The available parameters are:

- Output intermodulation products
- Calculated intercept points
- Input tone levels
- Output tone levels

If parameters are greyed out, then the associated intermodulation product order was not selected in step 1 of the **Intermodulation Wizard**, "**Define Intermodulation**" (see Figure 6). It is possible to change the selected order using the "**Back**" button to return to step 1 of the wizard.

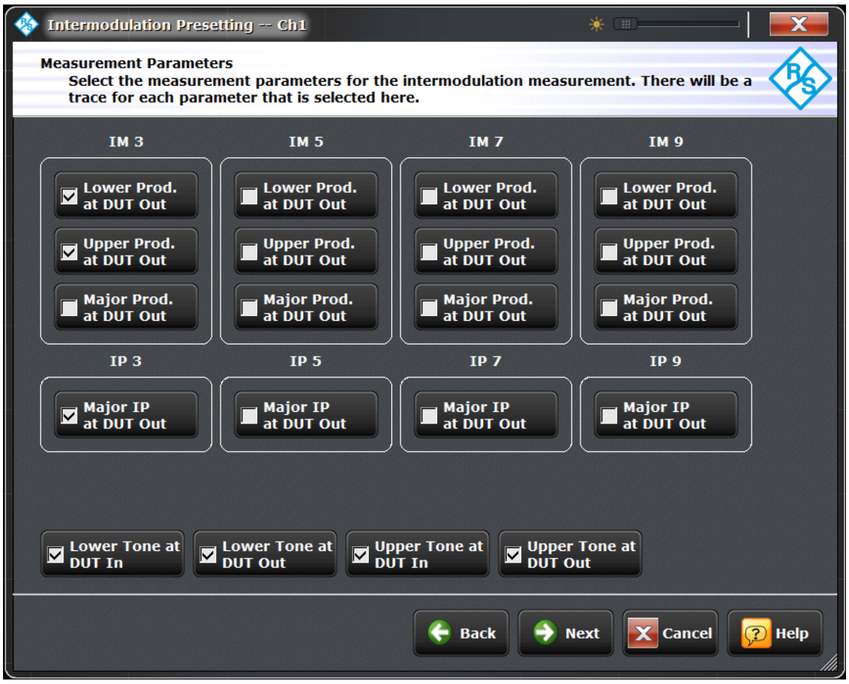

Figure 10 – Selection of available measurement parameters

Intermodulation Products – These are all referenced to the DUT output and for each order of intermodulation product, any of the following can be shown:

- Low side intermodulation product
- High side intermodulation product
- "Major Prod." – Derived from the greater of the upper and lower products at each measured frequency point.

Intercept Point - Calculated from the "Major Prod." result for each order.

Tone Power Level – Measurement of the input and output levels of the two tones are selected at the bottom of the window.

Example (*Amplifier ZJL-3G+*): Figure 10 shows that the following parameters have been selected for measurement.

- 3rd order intermodulation lower and upper products
- 3rd order intercept point
- Lower and upper tone levels at the DUT input
- Lower and upper tone levels at the DUT output

Once configured, press "**Next**". It is possible to come back to this window and change these parameters at any time. Or go "**Back**" to the previous step if necessary.

3.3.4 Completing the Intermodulation Wizard

With the measurement defined and results parameters selected, the final step in the wizard is shown in Figure 11. This provides two options, either to perform a power level calibration, or to finish without a calibration.

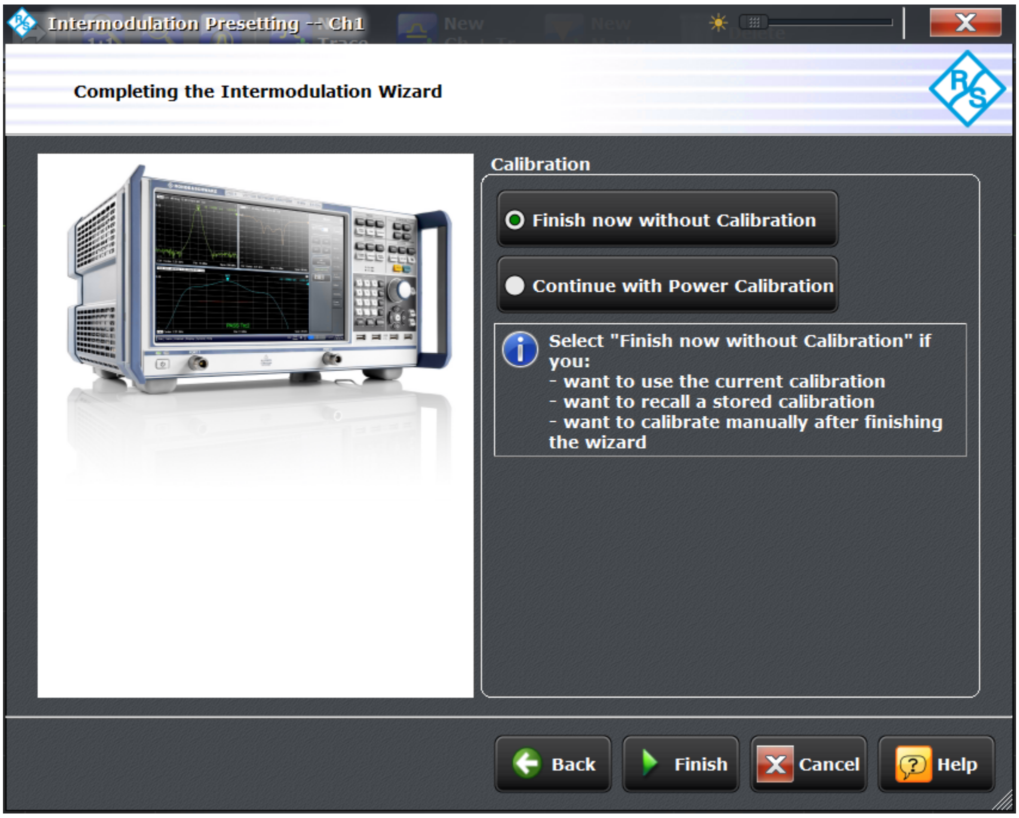

Figure 11 – Completing the Intermodulation Wizard

This is a good opportunity to review the measurement configuration. If changes are needed, use the "**Back**" soft key to reverse through the set up menus.

Select the calibration requirement and press "**Finish**" to complete the **Intermodulation Wizard**. Regardless of the calibration state, the R&S® ZNB VNA will close the Wizard and open a display with the frequency response of the parameters that were selected in step 3 of the **Intermodulation Wizard**, "**Measurement Parameters**".

3.4 Intermodulation Power Flatness Calibration

Coupling a **R&S® NRP-Zxx** power sensor to the R&S® ZNB VNA, allows the use of an inbuilt calibration tool, "**Intermodulation Power Calibration**". This ensures that the source power levels at the input of the DUT and the measurement of the intermodulation products at the **Receiving Port** are accurate across the frequency range.

There are two ways of starting the power flatness calibration tool, either at the end of the **Intermodulation Wizard**, or if in the measurement mode, through the menu: "**Channel → Channel Config → Intermodulation → Start Power Cal…/Intermod. Pwr. Cal…**".

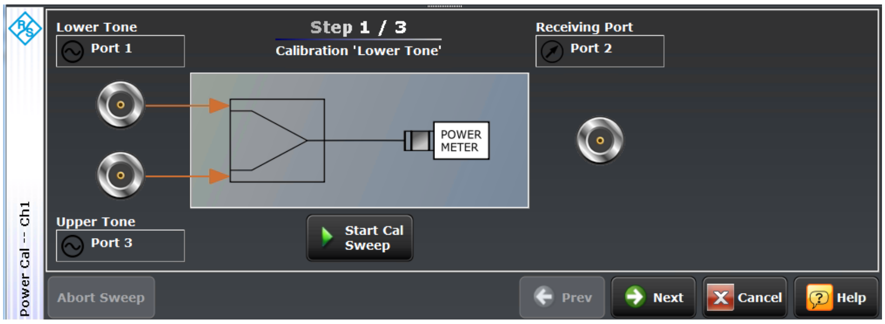

Figure 12 – Power calibration window

Figure 12 shows the power calibration window, with the sources on the left and the receiver port on the right. The calibration is performed in three steps:

1. With the power meter connected to the calibration plane (normally the combiner output), press "**Start Cal Sweep**", and the power response of the **Lower Tone** will be characterized over frequency. The **Upper Tone** is off.
2. Once the **Lower Tone** is completed, characterization of the **Upper Tone** proceeds automatically.
3. With the two sources calibrated, the port allocated to the **Lower Tone** is then automatically configured to provide a reference tone at the receiver frequency range for calibration of the **Receiving Port**, as shown in Figure 13. The user is prompted to connect the combiner output to the **Receiving Port** and then press "**Start Cal Sweep**".

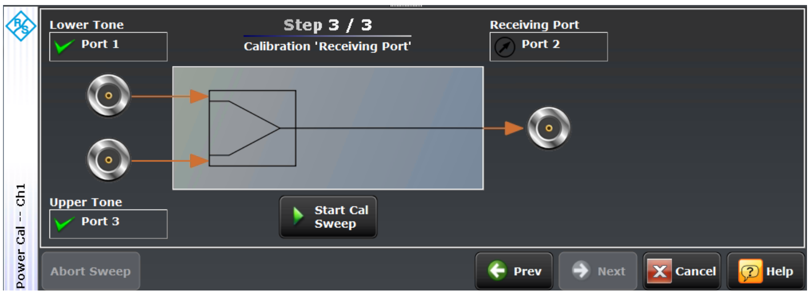

Figure 13 - Power calibration of the receiving port using the lower tone

In the first window of the **Intermodulation Wizard** (Figure 6), the user selects the source for calibrating the power flatness of the **Receiving Port**. If a free analyzer port or a signal generator is selected, this will be presented in the calibration window as shown in Figure 14. This introduces an extra step to the power flatness calibration, necessitating connection of the power meter to the source for calibration, before connecting the source to the **Receiving Port**.

It is possible to step back and forth through the steps of the power flatness calibration using the "**Prev**" and "**Next**" soft keys.

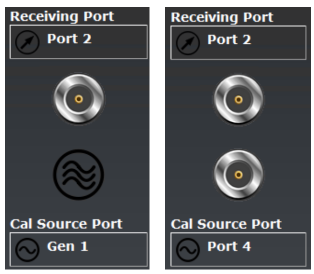

Figure 14 – Receiver port calibration with (*left*) **signal generator,** (*right*) **analyzer port 4**

Once calibration is complete, the "**Next**" soft key is replaced by an "**Apply**" soft key, which will apply the calibration.

3.4.1 Power Meter Settings

When starting the intermodulation power flatness calibration, in addition to presenting the calibration tool (Figure 12), the "**Pwr Cal Settings**" menu is automatically displayed (Figure 15). This menu allows connected power meters to be configured. For the power flatness calibration, there are three variables:

1. **Max Iterations** – An upper limit to the number of times that the flatness calibration is performed, if performance within the tolerance limit has not been achieved.
2. **Tolerance** – Defines a window of accepted performance, centered on a target value. This is used during calibration and when successfully completed, performance is checked to be within tolerance limits.
3. **Convergence** – During the power flatness calibration, the amount of power correction for each sweep is multiplied by the convergence factor. The power correction is calculated from the difference in measured power level at the power meter to that at the analyzer port reference receiver. The convergence factor is generally left set to unity.

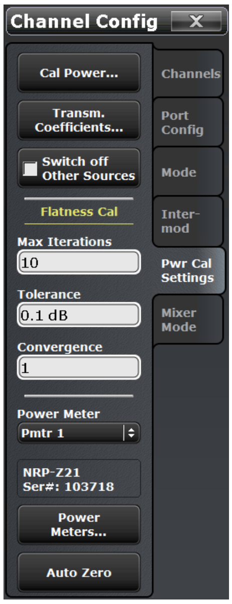

Figure 15 - Power Sensor settings

Figure 16 presents results with the **Receiving Port** connected directly to the combiner output after calibration. These responses are a measure of the R&S® ZNB VNA intermodulation performance. The power level has been adjusted to 0 dBm so that the instrument intermodulation products are above the measured noise floor. Therefore the R&S® ZNB VNA has a calculated 3rd order intercept point greater than +30 dBm.

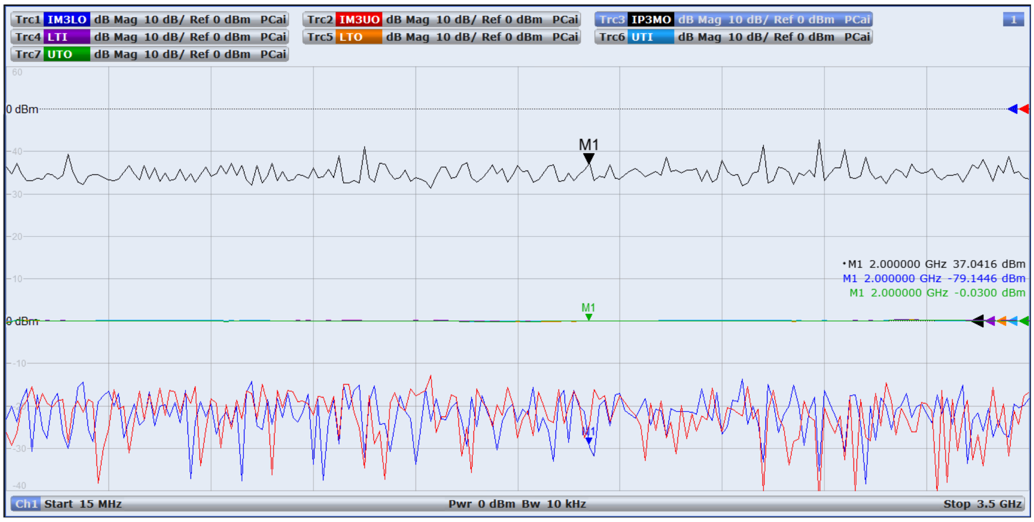

Figure 16 - Example of default screen after calibration

4 Making an Intermodulation Measurement

4.1 Swept Frequency Measurement

Following a successful calibration, the amplifier is inserted between the combiner output and the **Receiving Port**. Figure 17 shows the frequency response of the input tones; the output tones; the output 3rd order intermodulation products; and the calculated output 3rd order intercept point.

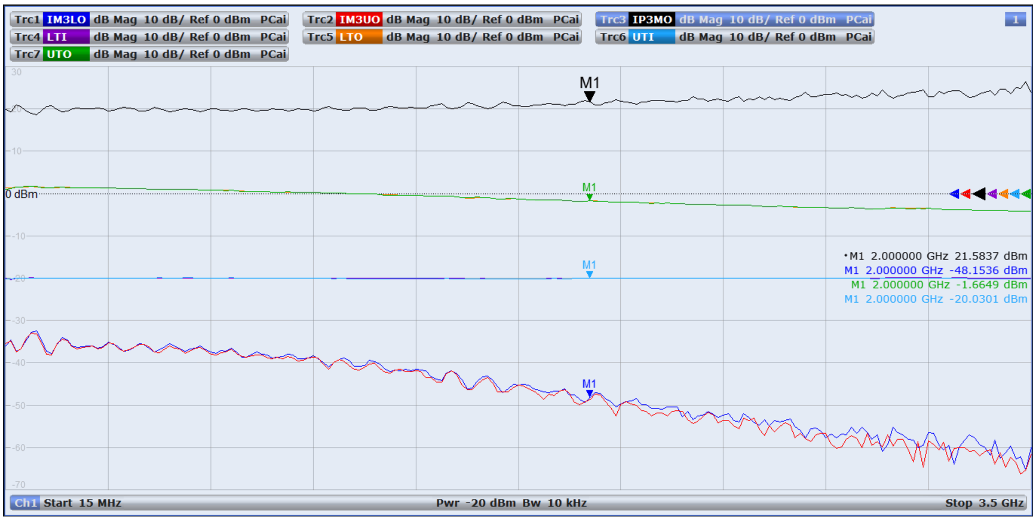

Figure 17 - 3rd order intermodulation characteristic of Mini-Circuits ZJL-3G+. Input and output tone levels; intermodulation products and intercept point.

Example (*Amplifier ZJL-3G+*): Using the marker information in Figure 17, the performance of the amplifier at 2 GHz is summarized as:

- Gain ~18.3 dB
- Output 3rd order intermodulation products (2 GHz) ~-49 dBm
- Output 3rd order intercept point (2 GHz) ~21.5 dBm

For the gain and 3rd order intercept point, this aligns with the data sheet information (see 2.3 Device Under Test (DUT)).

NOTE: *The ripple on the traces is due to the effects of impedance mismatch between the combiner, DUT and analyzer ports. Use of attenuators reduces the effects of mismatch at these transitions. Care must be taken not to saturate the analyzer sources (~+12 dBm) when compensating for any additional attenuating losses before the DUT input. Figure 18 and Figure 19 provide an example of the use of attenuators and the improvement in performance, when compared with Figure 17 without attenuators. In this example, 10 dB attenuators have been placed between the sources and the combiner to provide increased isolation between the sources. The Mini-Circuits combiner common port has a typical return loss of ~35 dB at these frequencies, therefore providing a good input match to the DUT.*

Other results in this application note are measured without any attenuators.

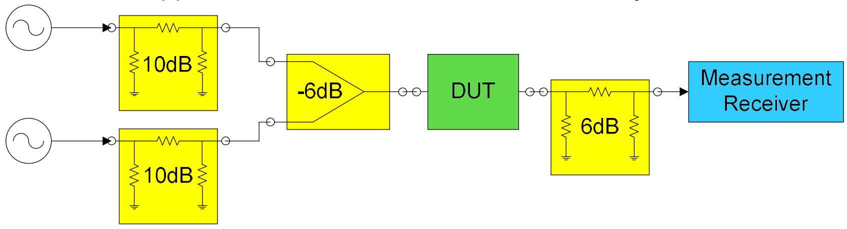

Figure 18 – Use of attenuators to reduce impedance mismatch at test interfaces

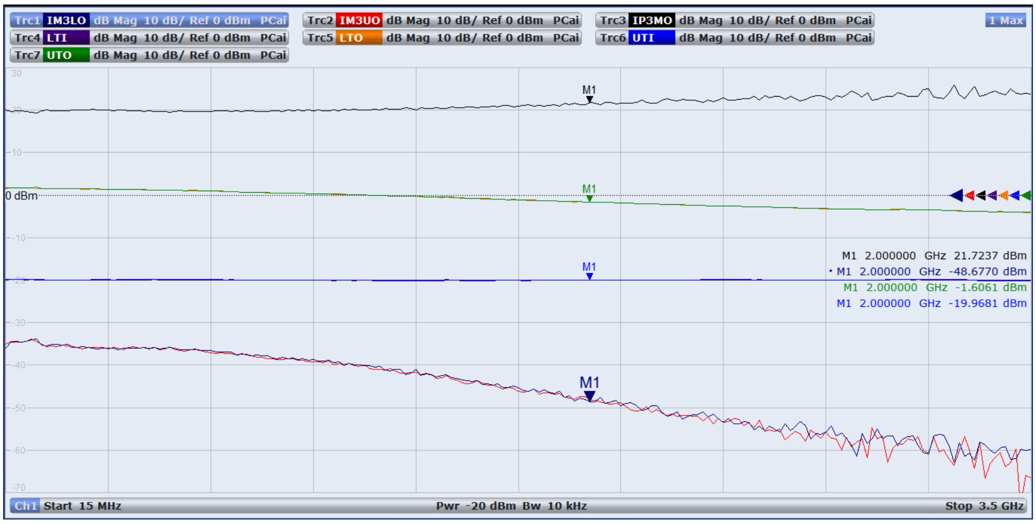

Figure 19 - 3rd order intermodulation characteristic of Mini-Circuits ZJL-3G+ with attenuators inserted as shown in Figure 18.

4.1.1 Trace Label Descriptions

To help the User, the **Intermodulation Wizard** labels the result traces with suitable acronyms. Examples are given in Table 1, and most are self-explanatory.

Label	Parameter description	Order	Reference (input/output)	Unit
IM3LO	Low side intermodulation product	3	Output	dBm
IM5UO	Upper side intermodulation product	5	Output	dBm
IM7MO	Major intermodulation product	7	Output	dBm
LTI	Lower tone		Input	dBm
UTO	Upper Tone		Output	dBm
IM3MOR	Major intermodulation product relative to input tone	3	Output	dBc
IP5MO	Intercept Point – based on largest IMP	5	Output	dBm
IP7MI	Intercept Point – based on largest IMP	7	Input	dBm
NLO	Noise measured at: $f_{noise} = f_{lower\ tone} - (f_{upper\ tone} - f_{lower\ tone}) / 2$		Output	dBm

Table 1 - Examples of trace labels

4.1.2 Editing Measurement Traces

In step 1 of the **Intermodulation Wizard**, the intermodulation orders for measurement are chosen. Choosing only the wanted product orders gives a faster measurement.

In this example, 3rd, 5th, 7th and 9th orders were selected, but are not all shown in Figure 17. However, the R&S® ZNB VNA still makes the measurements for all of the selected intermodulation products. To view the other results, either create another trace or highlight an existing trace for change by using the touchscreen interface. The other intermodulation orders are accessed by entering the "**Meas → Intermod**" menu structure. Figure 20 shows this self-explanatory menu, which allows single button selection of all 3rd order and tone parameters.

Figure 20 – Selecting measured parameters

Figure 21 - Selecting Intermodulation Products

"**More IM Products…**" provides access to all measured intermodulation orders, as shown in Figure 21. "**Relative (dBc)**" shows the products relative to the tone levels.

"**More Intercept…**" gives access to the calculated results for the intercept points. Figure 22 also shows that the selected intercept point result can either be referred to the DUT input or output.

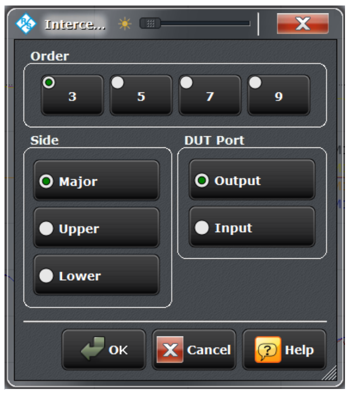

Figure 22 - Selecting intercept points

Figure 23 shows the largest measured or "**Major**" intermodulation product and intercept point for each order. In this example, the input power of the two tones has been increased to -15 dBm allowing the higher order products to be measured above the noise floor. The trace label "**PCao**" reflects the power level change and shows that the power calibration is still applied.

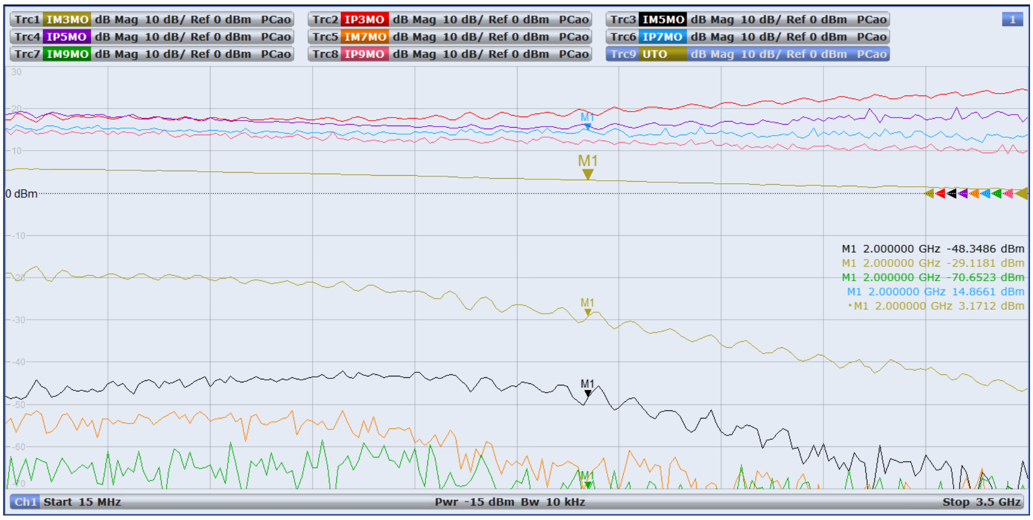

Figure 23 - Amplifier measurement with 3rd, 5th, 7th and 9th intermodulation products and intercept points.

4.2 Continuous Wave (CW) Measurement

The frequency response with two fixed frequency tones can also be displayed. This measurement starts a new channel, which will add a trace to the existing display. Therefore, it is best if the new channel trace is viewed on a new display ("**Display → Diagram → Add Trace + Diagram"**). To start CW mode, access the **Intermodulation** menu, "**Channel → Channel Config → Intermodulation → Add CW Mode**".

Figure 24 shows the instrument 3rd order intermodulation product response when the **Receiving Port** is connected directly to the combiner output with the lower tone set at 1 GHz and "**Max IM Order**" set to 3. The IF bandwidth has been changed to 10 Hz, to demonstrate the available dynamic range (~80 dB). Note that the source power has changed, but the power calibration is still applied. Care should be taken when using tone levels greater than -20 dBm at the **Receiving Port** since the instrument intermodulation performance may influence the DUT results. For higher input power levels at the **Receiving Port**, consider using suitable attenuation.

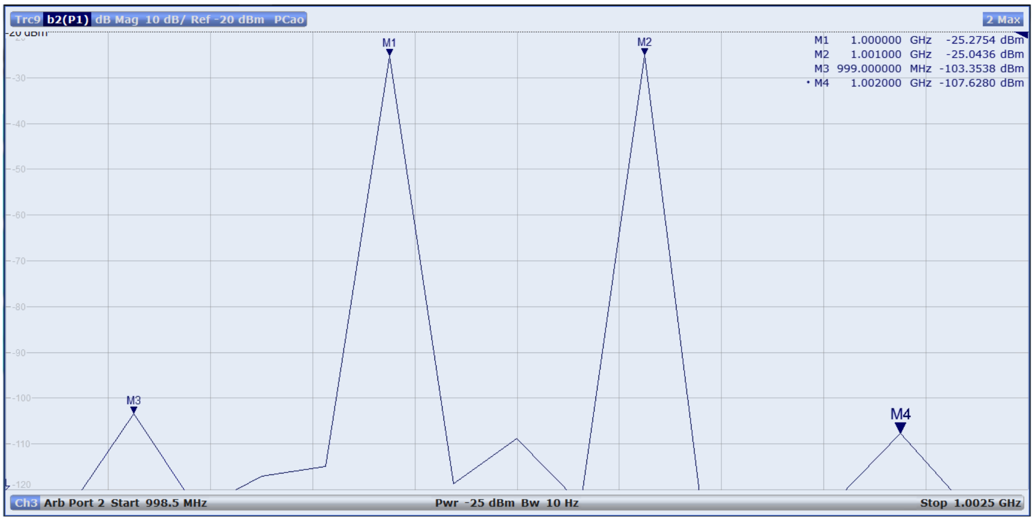

Figure 24 - CW response of the R&S® ZNB analyzer at 1 GHz.

The R&S® ZNB analyzer is optimized for sweep time and performs measurements at discrete frequencies for the tones, products and the intermediate noise floor. The instrument therefore automatically configures itself, selecting the appropriate **Number of Points** for the intermodulation product order chosen. For example, measurement of 7th order IMP requires 33 points. Manually changing the **Number of Points** will give erroneous results.

The amplifier intermodulation performance is shown in Figure 25.

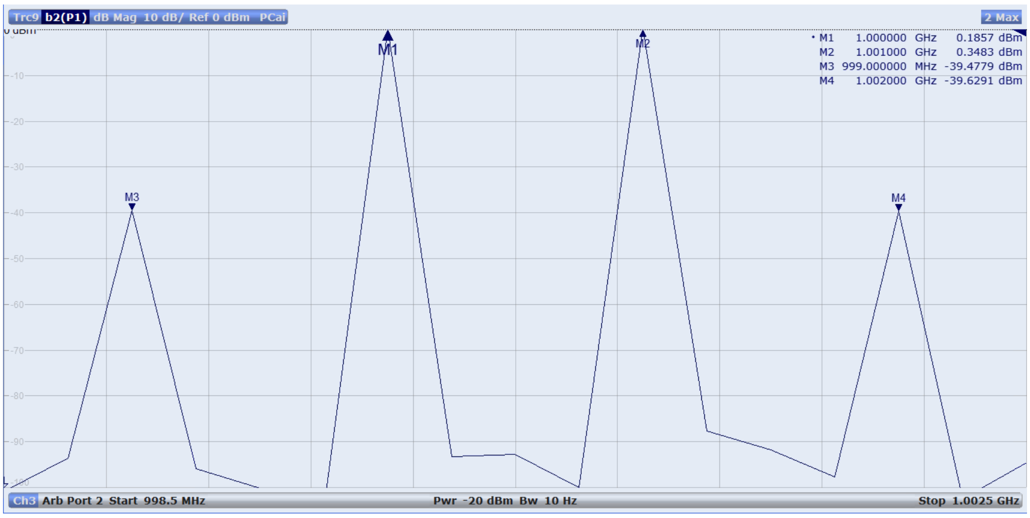

Figure 25 – Output 3rd order intermodulation products and carrier tones

5th, 7th and 9th order intermodulation products can be displayed by changing the "**Max IM Order**" value. Figure 26 gives an example where the input power has been increased from -20 dBm to -15 dBm, showing intermodulation products up to and including the 9th order.

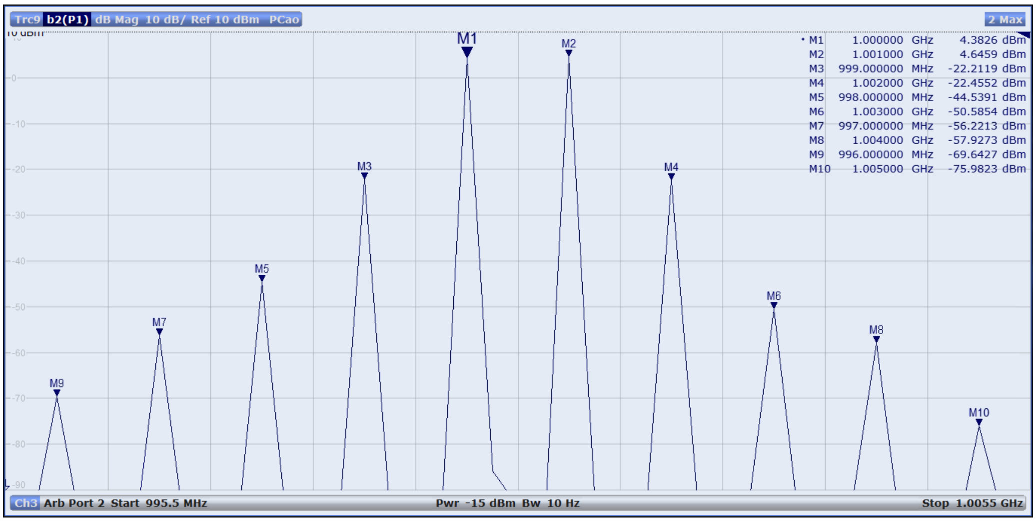

Figure 26 – CW response of amplifier showing odd intermodulation products up to 9th order

For information, the "**Max IM Order**" value is independent of the IMP order entered into the **Intermodulation Wizard** (Figure 6).

5 Editing the Intermodulation Measurement Configuration.

It may be necessary to change the configuration of the intermodulation measurement and this is achieved by returning to "**Channel Config → Intermodulation**" (Figure 27). It is then possible to access the following options, which return the User to the set up steps in the **Intermodulation Wizard**.

- "**Define Intermod…**" – Step 1 of the wizard, 3.3.1 Defining the Ports and Intermodulation Products.
- "**Frequencies Powers…**" – Step 2 of the wizard, 3.3.2 Frequencies and Powers

The other functions in the menu are used as follows:

- "**Reset Freq Conv Intermod**" – The intermodulation measurement mode uses frequency conversion, i.e. the sources and the receiver are not on the same frequency. This soft key returns the analyzer to normal operation, turning off the high tone frequency source and replacing the intermodulation traces by a default trace (S_{21}). All other settings are maintained.

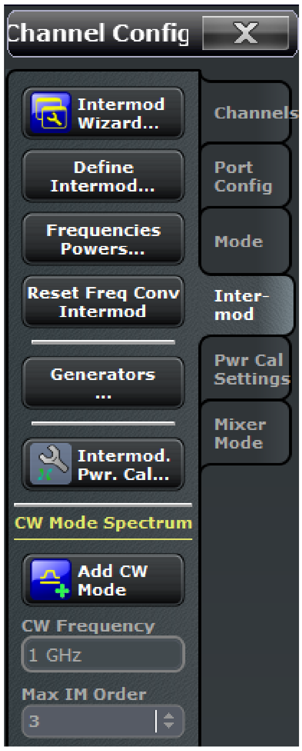

Figure 27 - Editing the intermodulation measurement configuration

- "**Generators…**" - If an external generator source is to be used for calibrating the receiver port, it is configured in this menu path. More details are contained in the *R&S ZNB, Vector Network Analyzers, User Manual*[1], and the on-instrument "**HELP**" function.
- "**Intermod Pwr. Cal…**" – Provides access to the intermodulation power calibration routine. See section 3.4 Intermodulation Power Flatness Calibration.

  NOTE: *CW mode uses a second channel. Performing a repeat intermodulation calibration will give an invalid response for the CW mode channel. Correct performance is achieved through: 1) deletion of the CW mode channel; 2) perform the intermodulation power calibration; and 3) create a new CW mode channel.*

6 Bibliography

[1] R&S ZNB, Vector Network Analyzers, User Manual, (1173.9163.02 – 12).

[2] R&S Intermodulation Distortion Measurements on Modern Spectrum Analyzers, (1EF79).

[3] Mini-Circuits ZJL-3G+ Low Power Coaxial Amplifier Data Sheet.

[4] Mini-Circuits ZFRSC-183-S+ Power Splitter/ Combiner Data Sheet

7 Additional Information

This Application Note is subject to change without notice. Please visit the website http://www.rohde-schwarz.com to download the latest versions.

Please send any comments or suggestions about this application note to TM-Applications@rohde-schwarz.com.

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