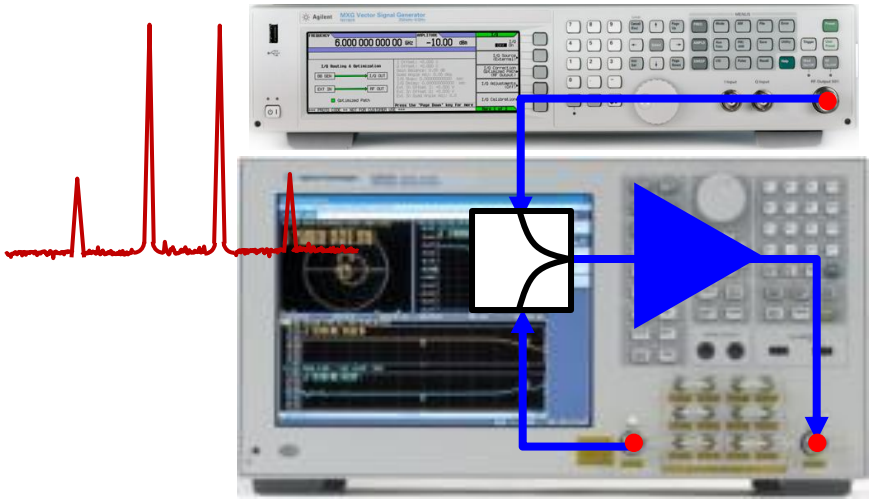
IMD Measurement with E5072A ENA Series Network Analyzer



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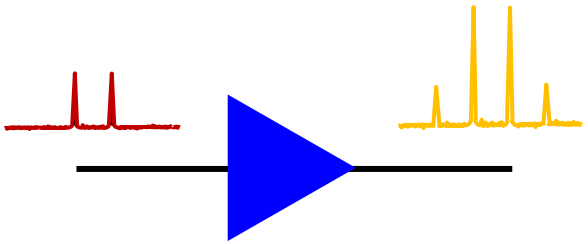
June 2012

Contents

- What is intermodulation distortion (IMD)?
- IMD Measurement Wizard for E5072A
- Measurement Results
- Summary

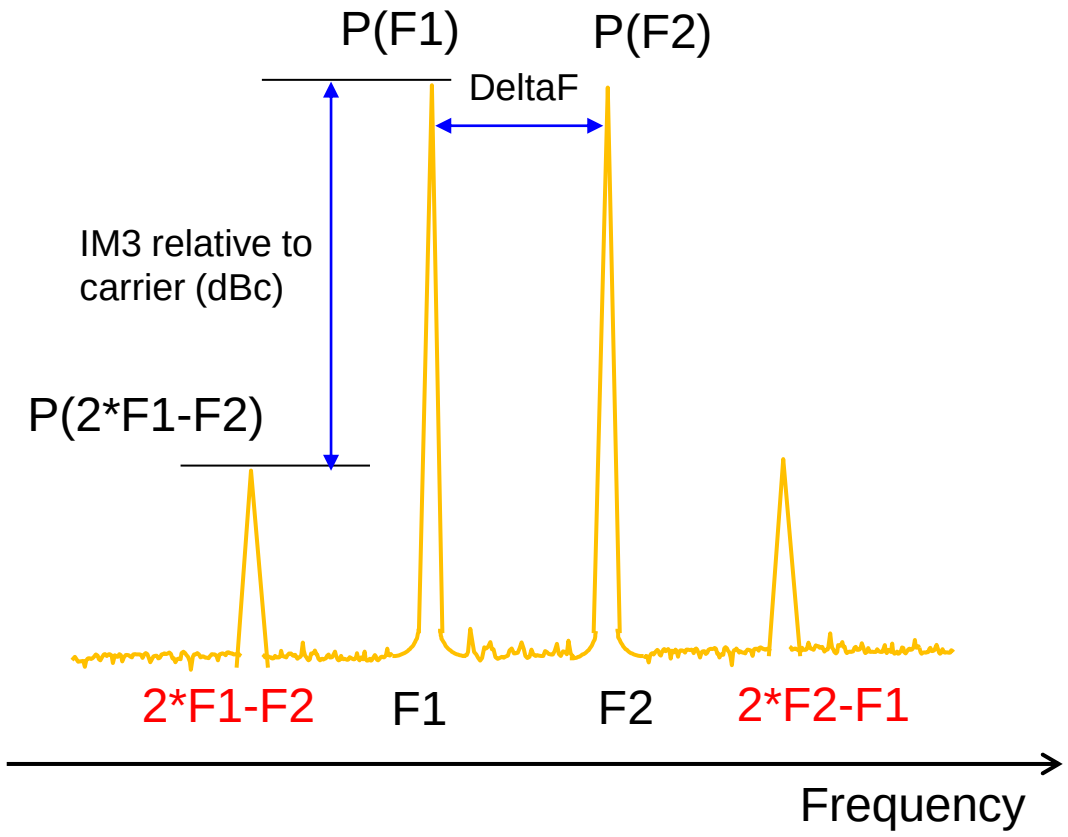
What is intermodulation distortion (IMD)?

- A measure of nonlinearity of amplifiers.
- Two or more tones applied to an amplifier and produce additional intermodulation products.
- The DUT's output will contain signals at the frequencies: n*F1 +m *F2.



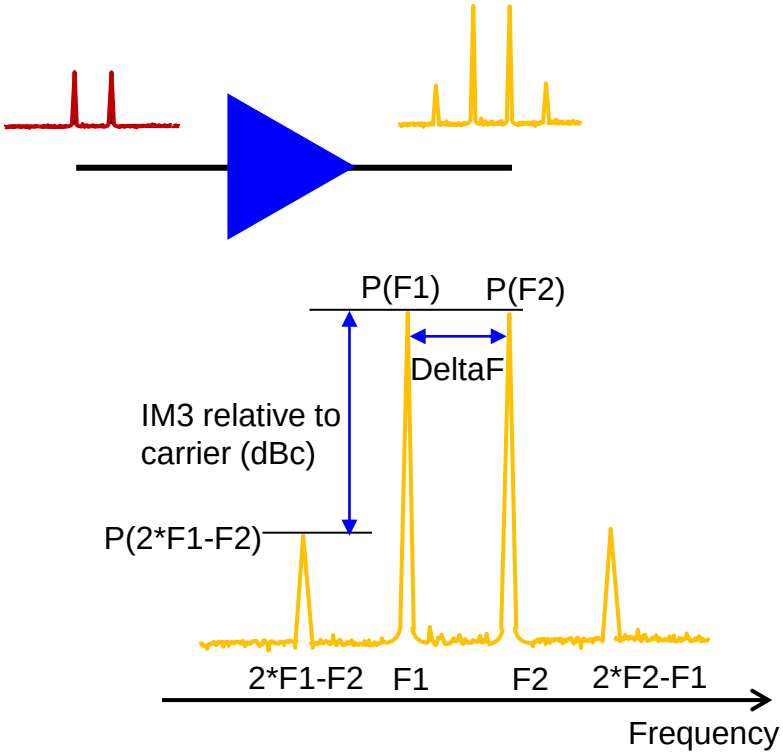
F_IMD = n * F1 + m * F2

ex.)
- Lo F_IM3 = **2 * F1 - F2**
- Hi F_IM3 = **2 * F2 - F1**
- Lo F_IM5 = **3 * F1 - 2 * F2**
- Hi F_IM5 = **3 * F2 - 2 * F1**
- Lo F_IM7 = **4 * F1 - 3 * F2**
- Hi F_IM7 = **4 * F2 - 3 * F1**

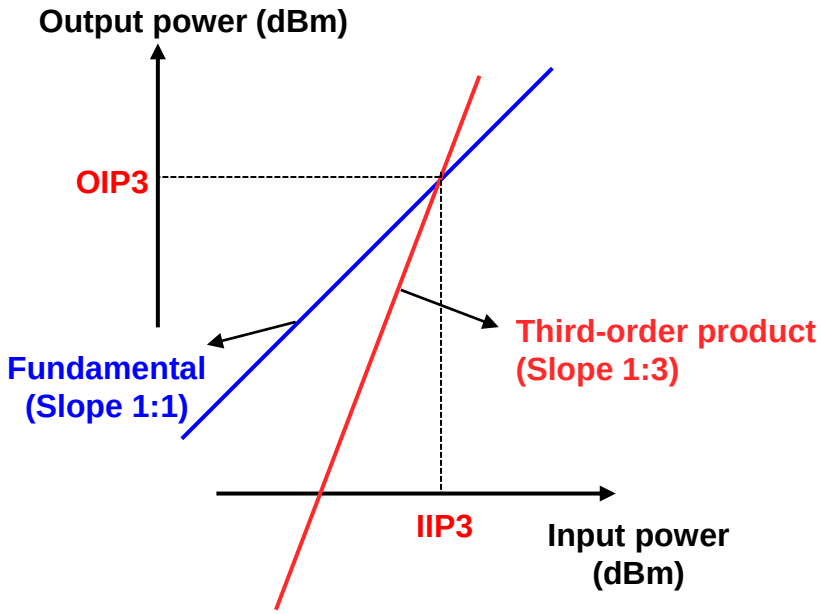


Third-order Intercept Point (IP3)

• The third-order intercept point (**IP3**) or the third-order intercept (**TOI**) are often used as figures of merit for IMD.



P(F1): Power level of low tone
P(F2): Power level of high tone
P(2*F1-F2): Power level of low-side IM3 signal
P(2*F2-F1): Power level of high-side IM3 signal



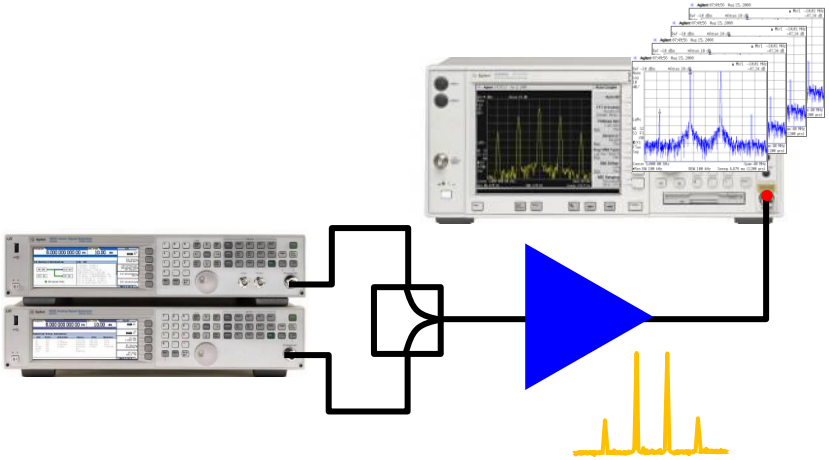
IP3 can be calculated by the equation using low-side IM3:
IP3 (dBm) = P(F1) + (P(F2) - P(2*F1-F2)) / 2

When high-side IM3 is used, the equation is:
IP3 (dBm) = P(F2) + (P(F1) - P(2*F2-F1)) / 2

Intermodulation Distortion

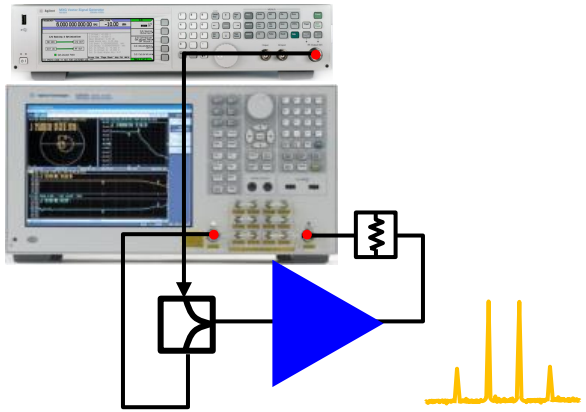
Solution with ENA

2x SG + SA



- Using two SGs and a SA with CW signals.
- It requires a controller to synchronize instruments.
- If many frequencies must be tested, **test time is increased dramatically**.

SG + ENA



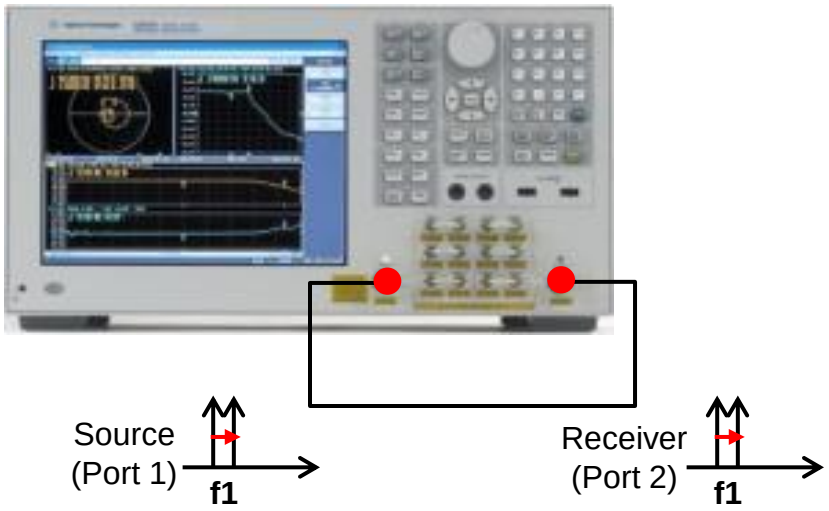
- ENA with **frequency-offset mode (FOM) option** can set different frequencies at the source and receiver.
- **Real-time** swept frequency IMD measurements can be performed.
- Source power calibration and receiver calibration is available with VNA for accurate absolute power measurements.

VNA features

Frequency Offset Mode (E5072A Option 008)

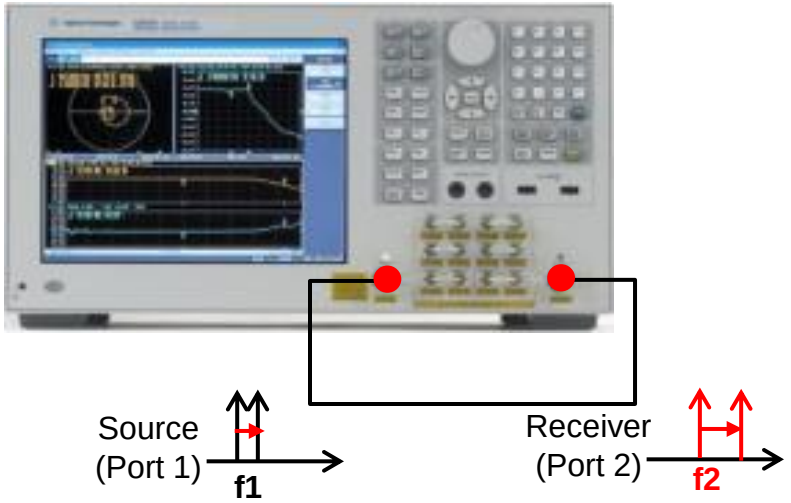
- Sets different frequency range for the source and receivers.
- Can be used for harmonics or intermodulation distortion (IMD) measurements with the VNA.

Normal Sweep



Source and receiver are tuned at **the same** frequency range. (i.e. S-parameter).

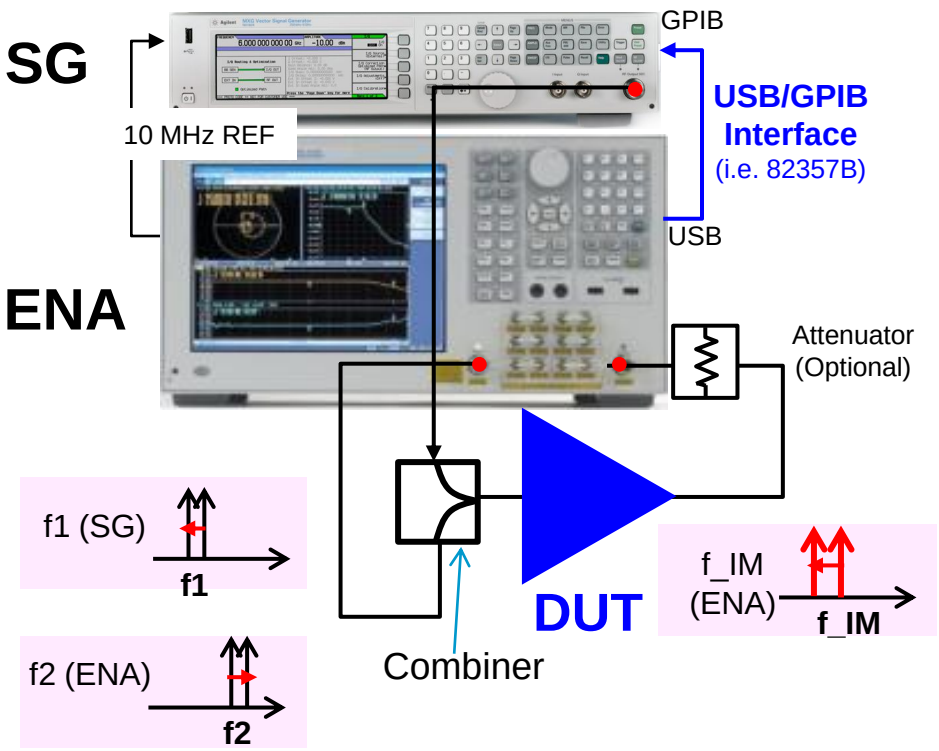
Frequency-offset Sweep



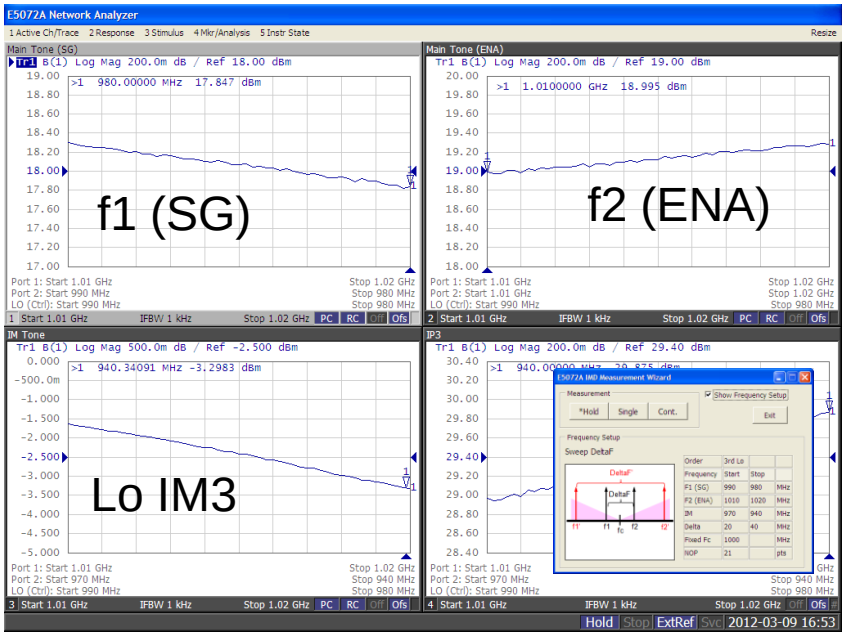
Source and receiver are tuned at the **different** frequency range (for harmonics, IMD test etc.)

IMD Measurement

Configuration of IMD measurement with VNA



Measurement example (sweep delta)



Power levels of main tones and IM products in swept frequencies can be monitored with the VNA's absolute measurements.

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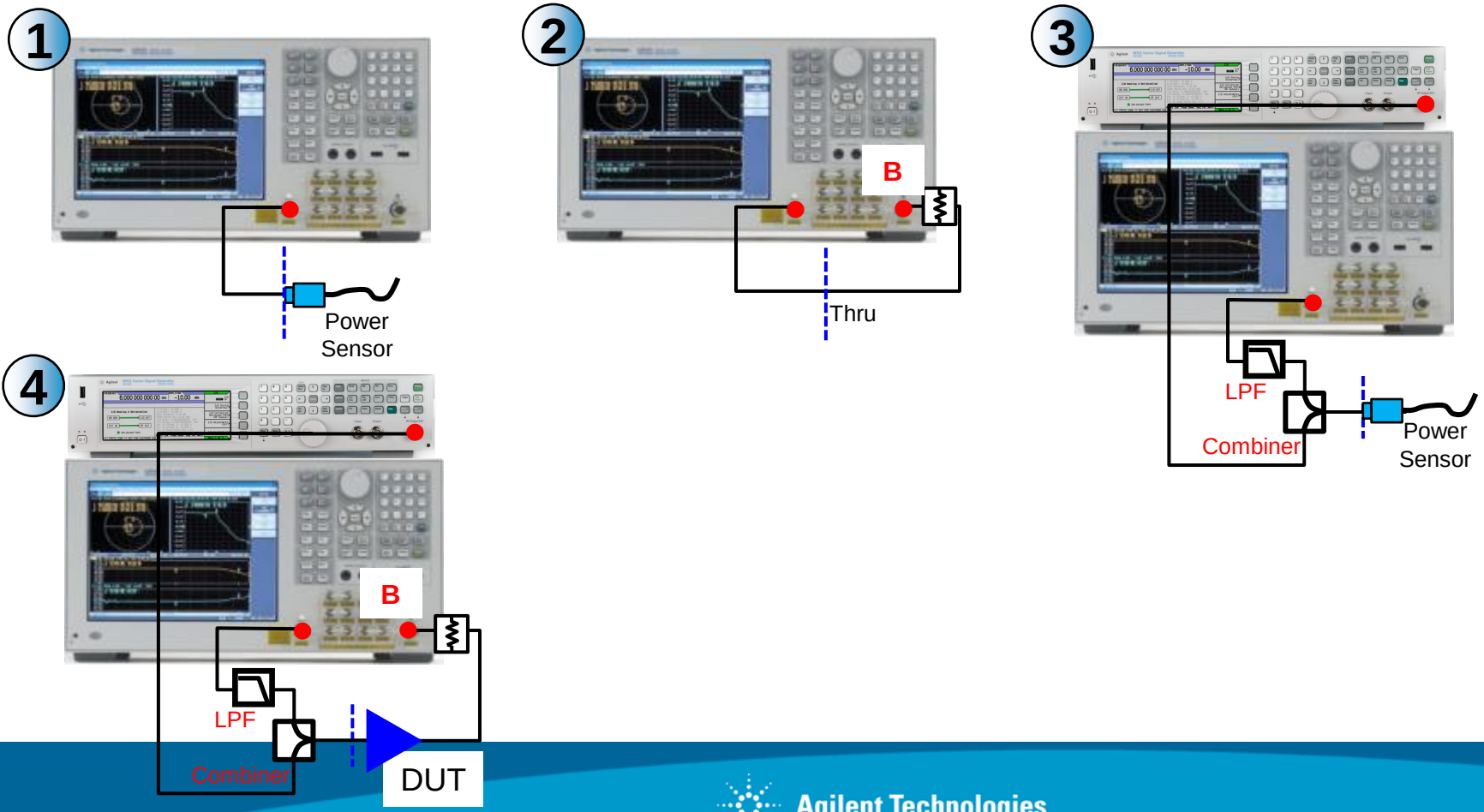
Measurement Procedure

Power calibrations for IMD measurements

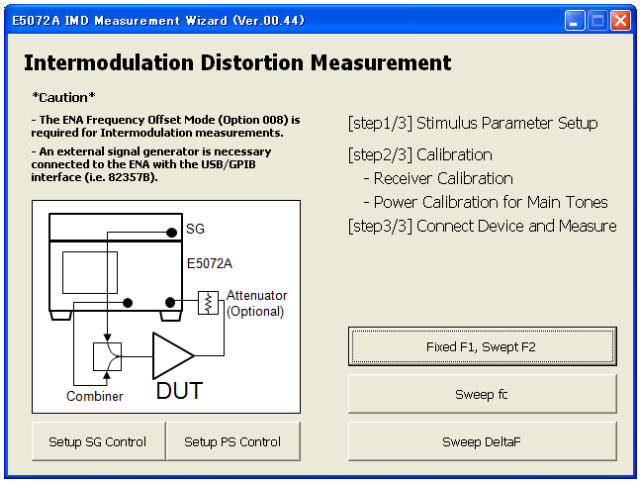
1. Perform source power cal with a connected power sensor. (power cal for receiver cal)
2. Perform receiver cal for the receiver B by connecting thru between port 1 and port 2.
3. Connect external components including a combiner. Perform source power cal for E5072A and SG at the calibration reference (DUT's input).
4. Connect DUT and perform measurements.



IMD Measurement Wizard for the E5072A

Key Features:

- Measurement macro running on the E5072A with intuitive GUI
- Quick setup of two-tone IMD measurements
- Control all necessary equipments from E5072A
  - MXG (connected via GPIB/USB interface)
  - Power meter & sensor (connected via GPIB/USB interface)
  - USB power sensor (connected directly to the ENA's USB port)
- Guided calibration wizard
- Various measurement sweep types
  - **Fixed F1 and Swept F2**
  - **Sweep Fc**
  - **Sweep DeltaF**
- Various IMD measurement parameters
  - Absolute power of fundamental tones (in dBm)
  - Power levels of IMD products (absolute in dBm), Low or High-side IM (3rd, 5th, 7th)
  - Calculated third-order intercept point (IP3)

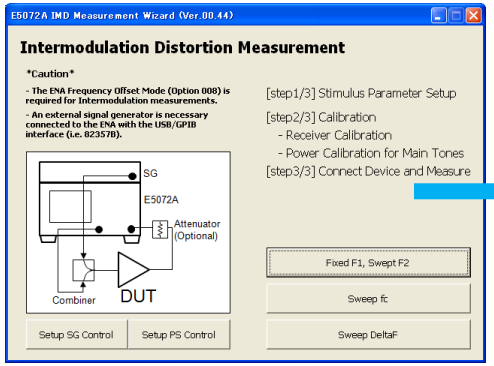


Available at: www.agilent.com/find/enavba

IMD Measurement Wizard

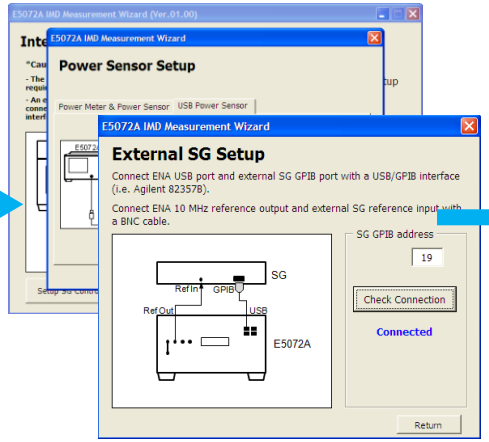
Overview

Introduction



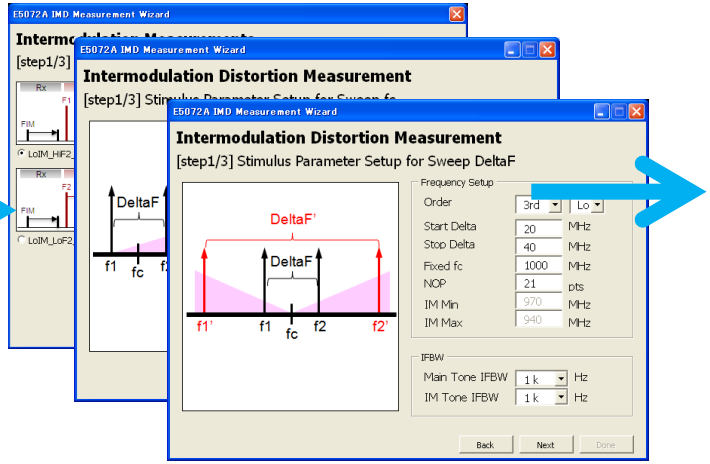
Peripherals Setup

(SG, Power sensor)

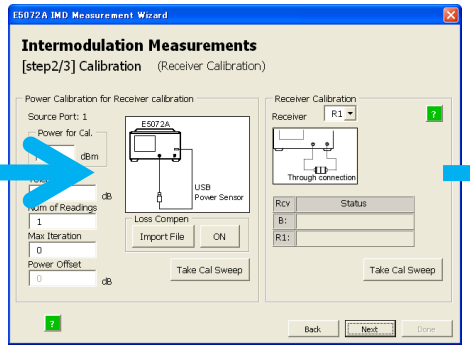


Stimulus Parameter Setup

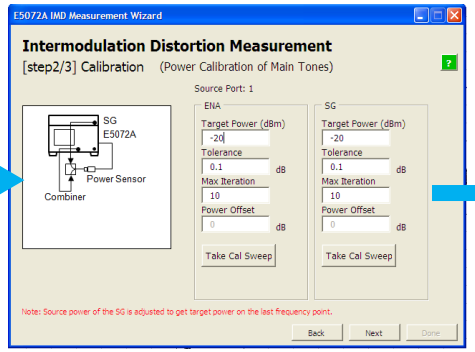
(IM order, frequency, NOP, IFBW etc.)



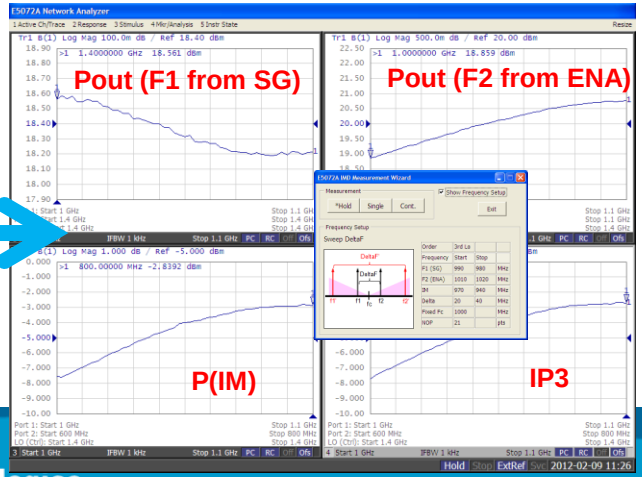
Calibration (Receiver cal)



Calibration (Power Cal)



Measurement Result



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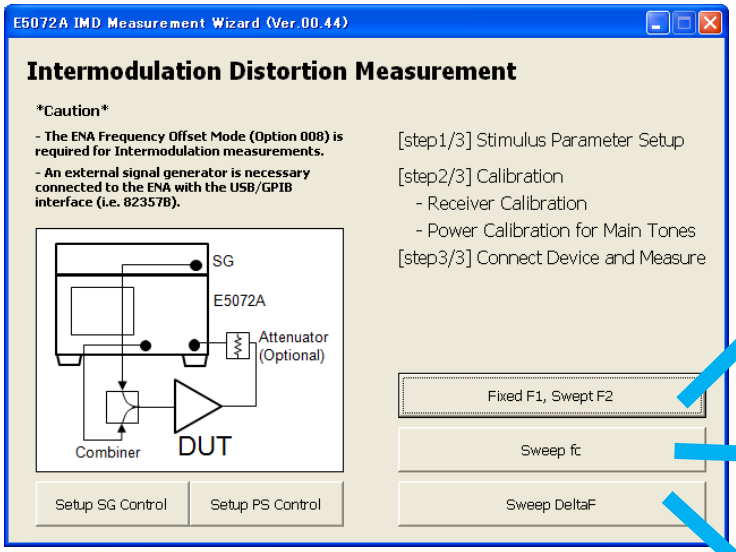
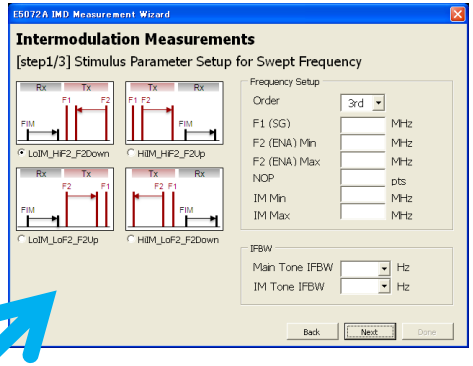
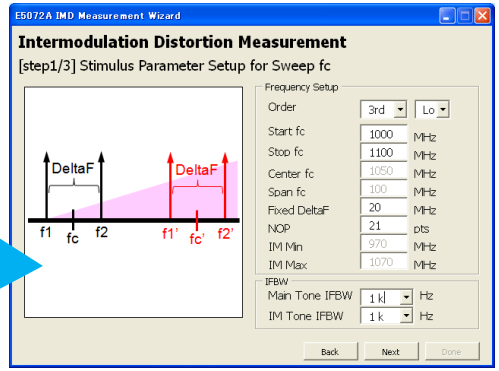
IMD Measurement Type

Introduction

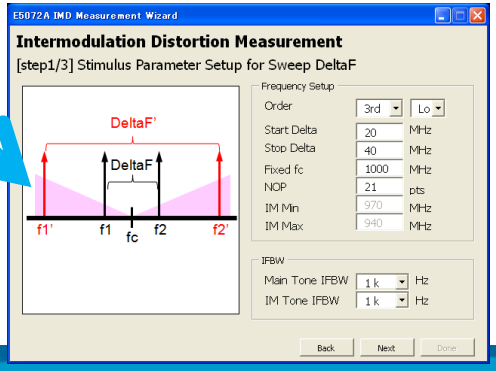




1. Fixed F1, Swept F2



2. Sweep fc



3. Sweep DeltaF

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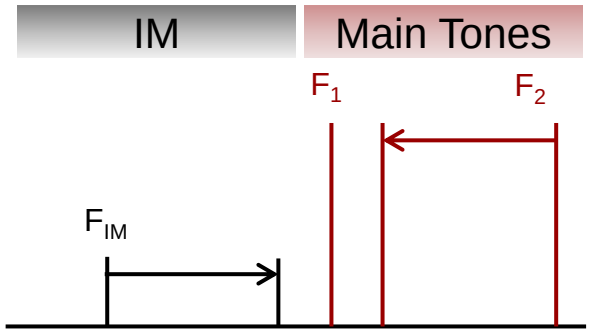
IMD Measurement Type

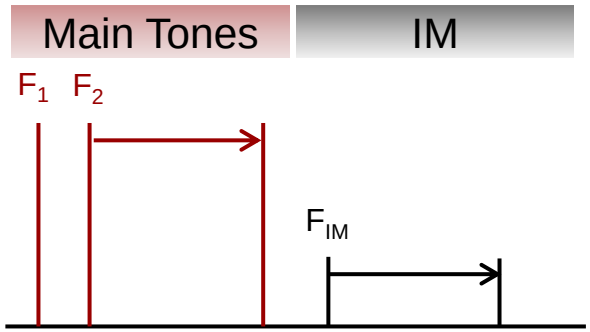
1. Fixed F1, Swept F2

• One of the main tones from the SG is fixed at a certain frequency (F1), while the other F2 from the ENA's source is swept.

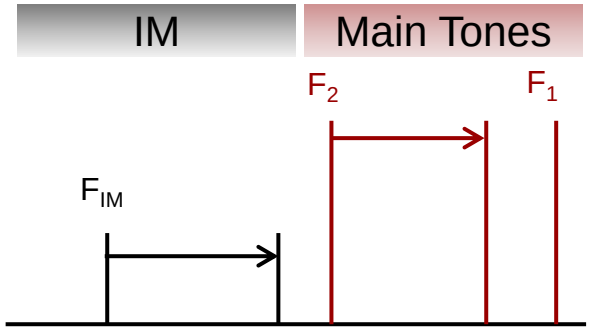
(1-1) Lo IM (Fixed F1, downward-swept F2)



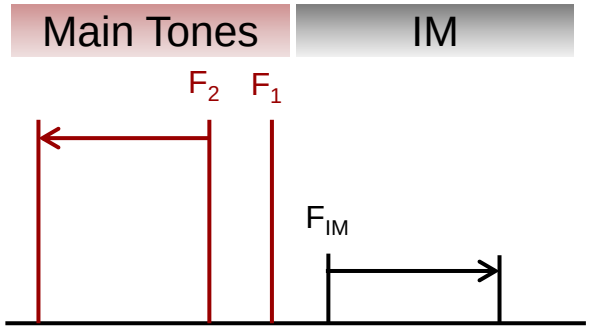
(1-3) Hi IM (Fixed F1, upward-swept F2)



(1-2) Lo IM (Fixed F1, upward-swept F2)



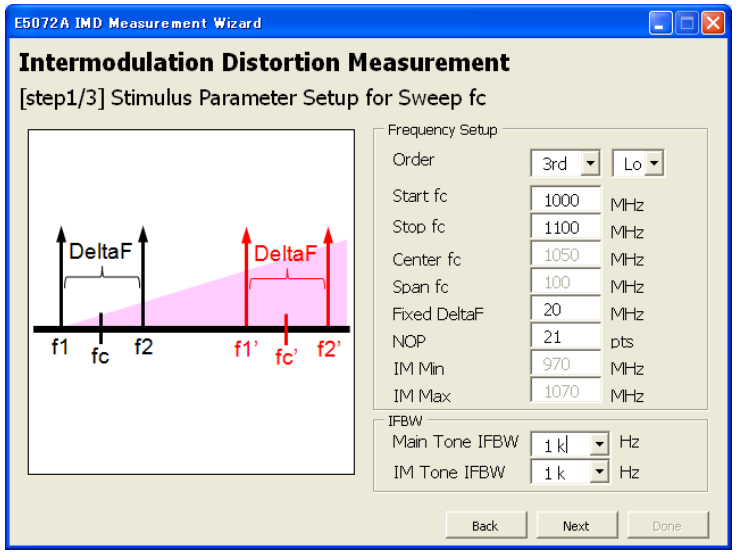
(1-4) Hi IM (Fixed F1, downward-swept F2)



IMD Measurement Type

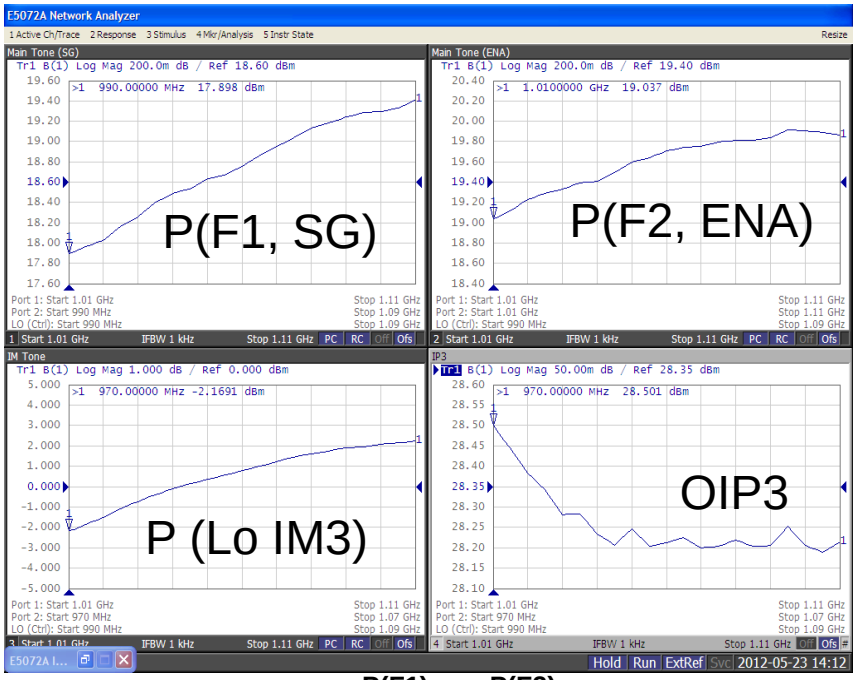
2. Sweep fc

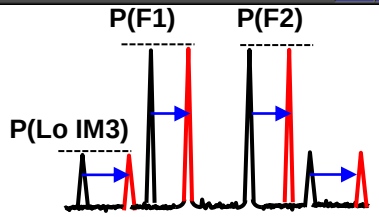
Stimulus setup



- Center frequency of the main tones is swept in the frequency range, while the delta frequency is fixed.
- 3rd, 5th, or 7th-order IM product can be tested for either high-side or low-side.

Measurement Result



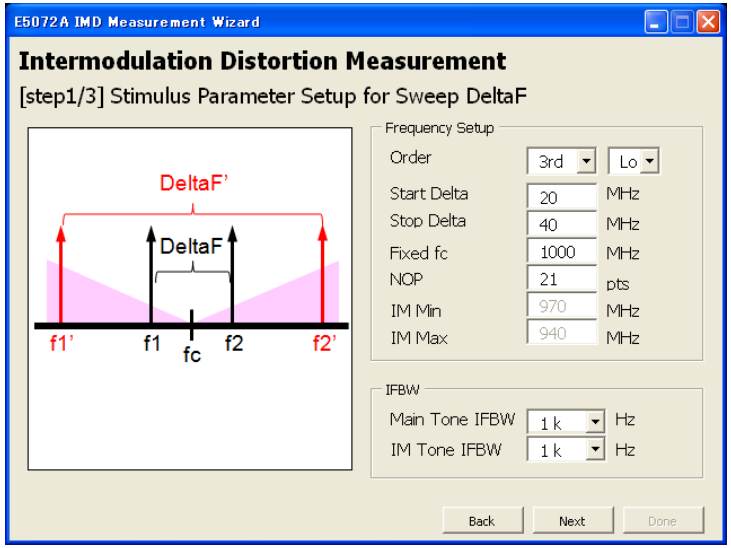


- Output power of the main tones and IM power level is displayed to calculate output IP3 of the DUT.

IMD Measurement Type

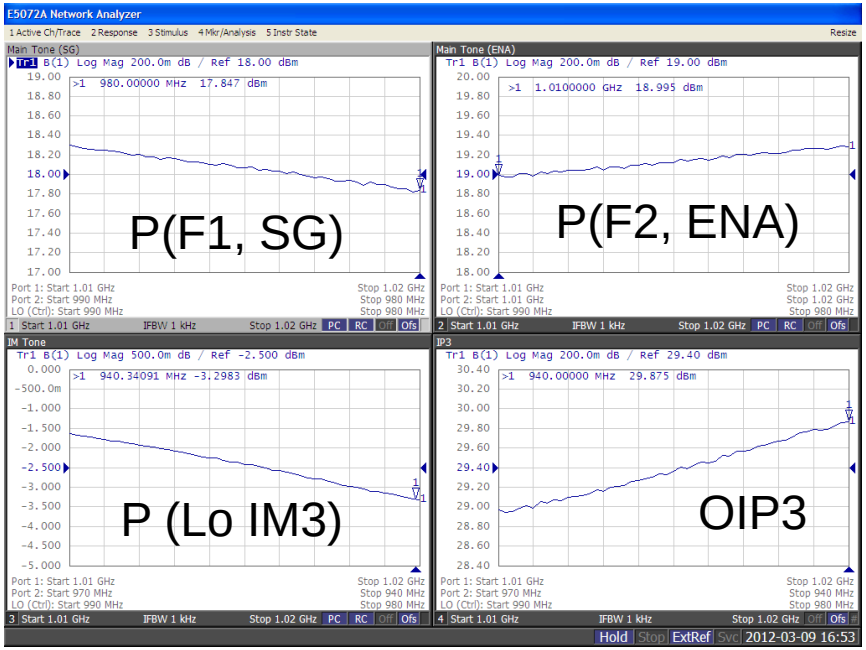
3. Sweep DeltaF

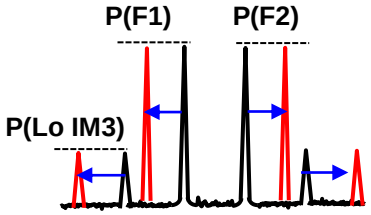
Stimulus setup



- Delta frequency between the main tones is swept in the frequency range, while the center frequency is fixed.
- 3rd, 5th, or 7th-order IM product can be tested for either high-side or low-side.

Measurement Result





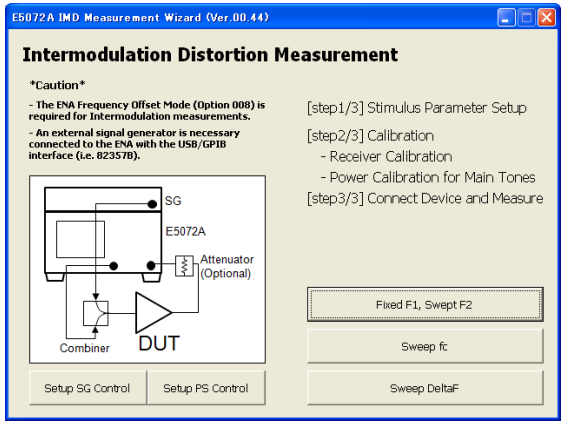
- Output power of the main tones and IM power level is displayed to calculate output IP3 of the DUT.

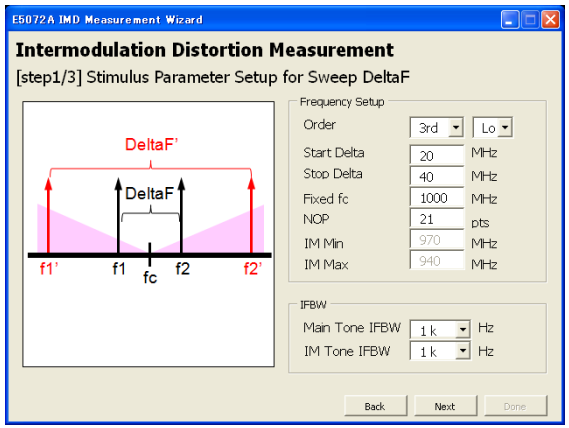
Summary

- IMD measurements can be performed with the combination of the ENA (E5072A with option 008) and connected SG.

- Test time can be reduced when swept-frequency IMD tests are necessary.

- IMD measurement wizard is offered for the ENA that provides:
  - Various sweep types to fully characterize the DUT
  - Quick and easy measurements with intuitive GUI
  - Step-by-step power calibrations





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Resources

- Application Notes
  - Amplifier and CW Swept Intermodulation-Distortion Measurements (1408-9)
  - Making Accurate Intermodulation Distortion Measurements with the PNA-X (1408-17)
  - Basics of RF amplifier measurements with the E5072A (5990-9974EN)

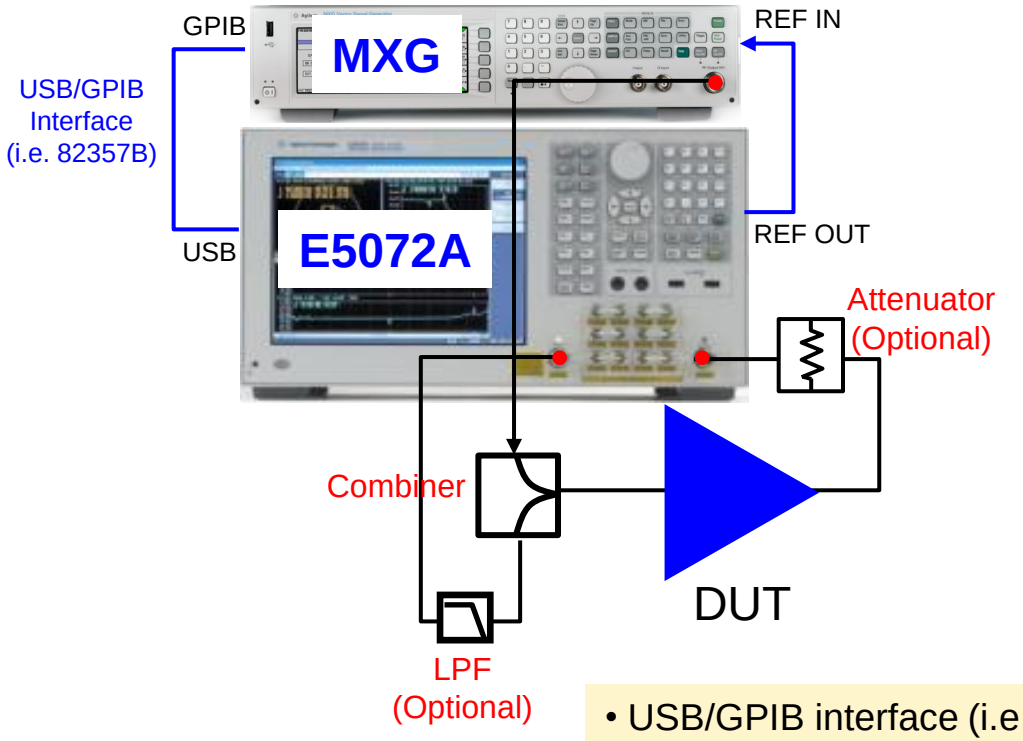
- E5072A Literatures
  - Configuration Guide (5990-8001EN)
  - Data Sheet (5990-8002EN)
  - Quick Fact Sheet (5990-8003EN)
  - Technical Overview (5990-8004EN)

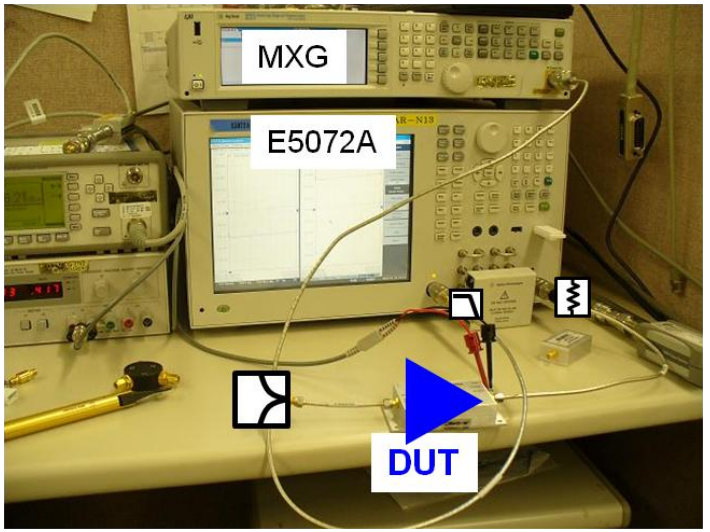
- Web Page:
  - ENA Series: www.agilent.com/find/ena
  - E5072A Product page: www.agilent.com/find/e5072a
  - Passive intermodulation (PIM) solution page: www.agilent.com/find/pim

Appendix

Test Configuration

Using the external combiner





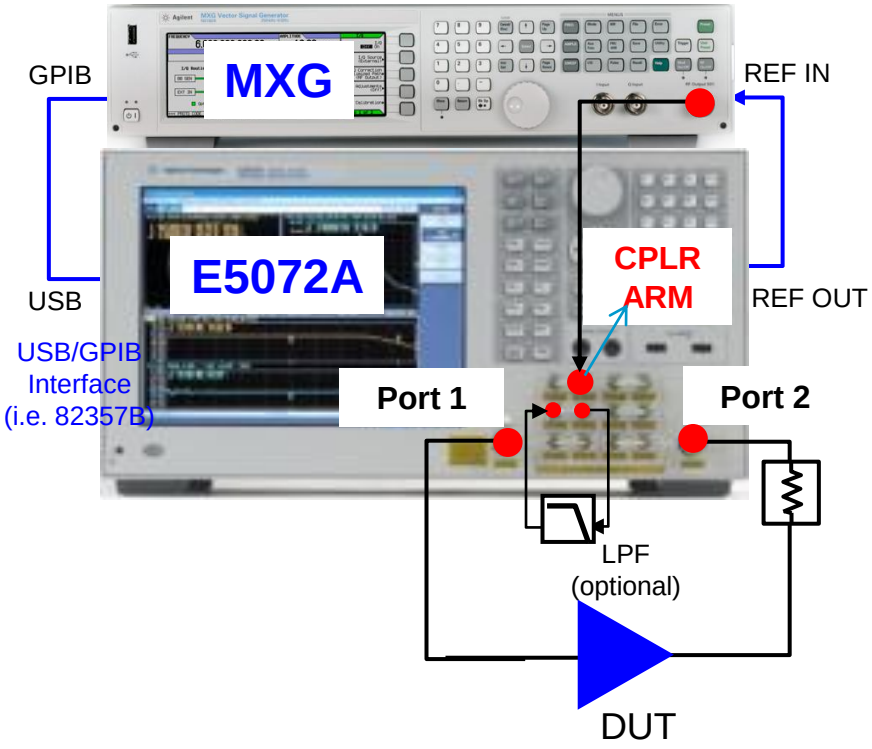
- USB/GPIB interface (i.e. Agilent 82357B) is necessary to control the SG from the ENA firmware.
- 10 MHz reference is connected between the instruments.
- A high-isolation combiner is recommended.
- An optional LPF is needed to eliminate source harmonics from the ENA.
- An optional attenuator is needed to protect ENA's receiver.

Test Configuration 2

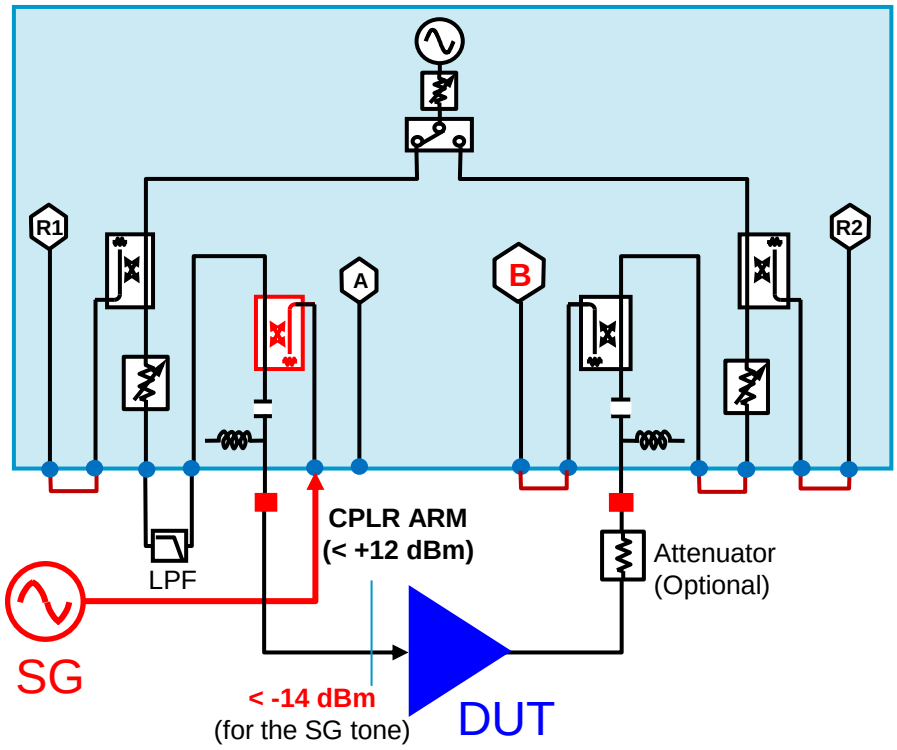
Using the internal bridge as a combiner

- The E5072A's internal bridge can be used as a combiner for two-tones.
- No external combiner is required in the test setup.

Configuration - Test setup



E5072A Block Diagram



- Input power at the port ("CPLR ARM") should be at least below +12 dBm as the damage level of the input is +15 dBm.
- Input power at the DUT is **below -14 dBm** for the main tone from the SG due to the coupling factor (i.e. 26 dB) of the E5072A's internal bridge.