Products: SMIQ, SMR, SML, SME, SMP, SMT, SMV, NRVS, NRVD

Frequency Response Compensation for SMx Generator Series

Application Note

Devices such as wideband amplifiers are tested with precise input levels according to test specifications. The signal path from the generator to the device under test (DUT) can have a non-linear frequency response, especially in the upper frequency regions which can be compensated by the UCOR (User Correction) function of the generators SME, SMIQ, SML, SMP, SMR, SMT and SMV.

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1 Overview

Devices such as wide band amplifiers are tested with precise input levels according to test specifications. The signal path from the generator to the device under test (DUT) may have a non linear frequency response, especially in the upper frequency regions which can be compensated by the UCOR (User Correction) function of the generators SME, SMIQ, SML, SMP, SMR, SMT and SMV. The frequency response measured first and the negative offsets to the nominal level are stored in the generator's UCOR table. When the generator is set to a certain frequency, the corresponding UCOR offset is added to the nominal output level. The SMR and SMP can measure the frequency response directly with a NRVD or NRVS power meter via the GPIB interface and fill the UCOR list automatically. The remaining generators (SME, SMIQ, SML, SMT and SMV) cannot control a power meter. The program SMxUCor accompaning this application note is designed for generators with UCOR functionality but without the capability to control an external power meter. SMxUCor can import correction values from an ASCII file and provide data for the UCOR list accordingly.

2 Theory of Operation

The UCOR table of an SMx signal generator can contain a maximum of 160 points over a user defined frequency range. A correction value will be interpolated when frequencies are situated between two UCOR points.
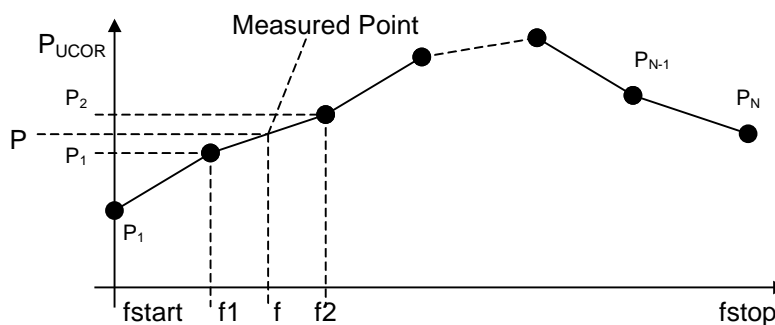

Fig. 1 UCOR linear interpolation

The correction value is calculated as

$$P = P_1 + \left(\frac{(f - f_1)}{(f_2 - f_1)} \right) * (P_2 - P_1)$$

P, P_2, P_3 are level offsets compared to the generator reference level. f, f_2 and f_3 are the corresponding frequencies.

<u>*Example 1:*</u> Ref level = -10dBm, P_{COR} = +0.3dB

$$P_{GEN} = P_{REF} + P_{COR}$$
$$= -10dBm + 0.3dB$$
$$= -9.7dBm$$

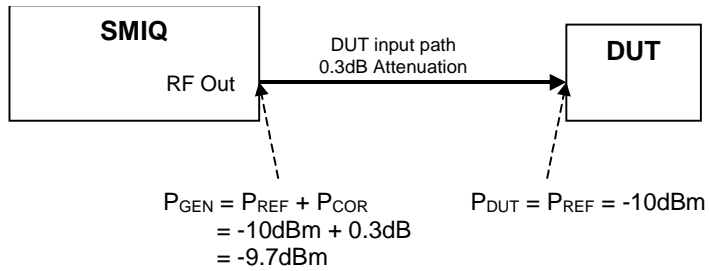$$P_{DUT} = P_{REF} = -10dBm$$

Fig. 2 DUT input path loss

<u>*Example 2:*</u> Ref level = -10dBm, Ampl.gain = 10dB, Pcor = 0.3dB -10dB = -9.7dB. The P_{COR} values can also be negative in case the DUT is an amplifier.

$$P_{GEN} = P_{REF} + P_{COR}$$
$$= -10dBm + 10dB + 0.3dB$$
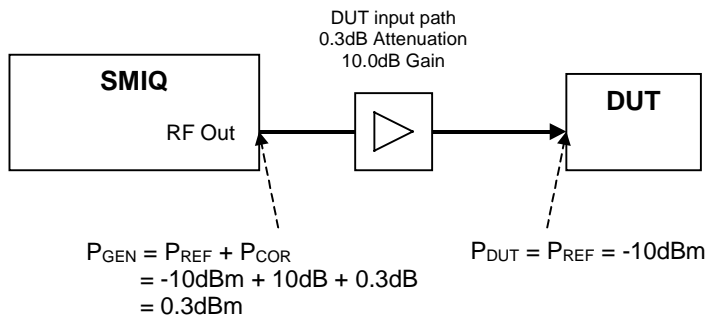$$= 0.3dBm$$

$$P_{DUT} = P_{REF} = -10dBm$$

Fig. 3 Amplifier as DUT

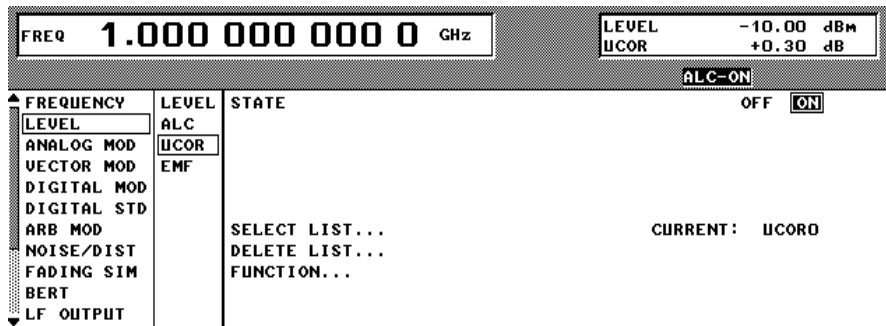The generator display when UCOR is active shows:

Fig. 4 SMIQ with active UCOR

3 Connecting and Configuring the Instruments

There are two different methods of UCOR data import. The SMR and SMP microwave generators can measure the frequency response data directly with a power meter (NRVD or NRVS) and store the corrected values into the UCOR table. The other generators require the frequency response data file which can be created with i.e. FreRes and the application note program SMxUCor for uploading the correction data to the generator's UCOR table. Both cases require the generator's maximum level resolution of 0.01dB which must be set manually.

Automatic UCOR Measurement with SMR/SMP & Power Meter

Fig. 4 shows the hardware configuration of an SMR or SMP with an external power meter for automatic measurement and storage of UCOR curves. The following description applies to an SMR (firmware revision 1.22 and above) but is similar for the SMP.
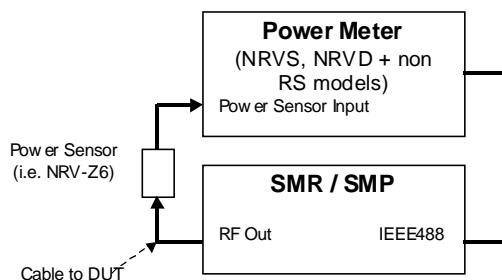

Fig. 5 Automatic UCOR Measurement with SMR or SMP and power meter

1. Calibrate the power sensor by turning the RF OFF with the **RF ON/OFF** button and pressing the **ZERO** button of the RS power meter NRVD or NRVS.

2. Set the signal generator to the desired level e.g. –10dBm.

Note: The level must be in the range of the power sensor.

3. Switch RF power on.

4. Select **Level** -> **UCor** in the SMR menu. Scroll the cursor to **EDIT LIST** and press the **SELECT** button. Choose one of the ten different lists, which in total contain a maximum of 160 points. For maximum resolution make sure to delete UCor1 to UCor9 (**DELETE LIST**) first and set UCor0 to a maximum of 160 points with **EDIT LIST** -> **INSERT** -> **RANGE** 160. The frequency list is generated by pressing with **EDIT LIST** -> **INSERT** -> **EXECUTE**.

5. Select the power meter in use from list; R&S-NRVD, R&S-NRVS, Agilent HP437 or Anritsu ML2438 (only SMR) with **LEVEL** -> **UCOR** -> **POWER METER TYPE**.

6. Start the measurement scan with **LEVEL** -> **UCOR** -> **MEASURE**. The absolute measured levels are automatically adjusted to the generator's output level setting and only the relative UCOR values are stored.

UCOR Setup with Custom ASCII or FreRes Data Files

Signal generators without the capabilty to control an external power meter via the GPIB interface (SMIQ, SMT, SME, SML and SMV) require a PC controller for setting up the UCOR table automatically (Fig. 2). First the frequency response of the DUT path is measured with, for example FRERES which stores the results in a file *.DAT (see application note 1MA09 available at http://www.rohde-schwarz.com). A short operating guide of FRERES is given in chapter 7. The supplied program SMxUCOR can transfer custom ASCII or FreRes data files to the generator's UCOR table (see chapter 6 for file format details).
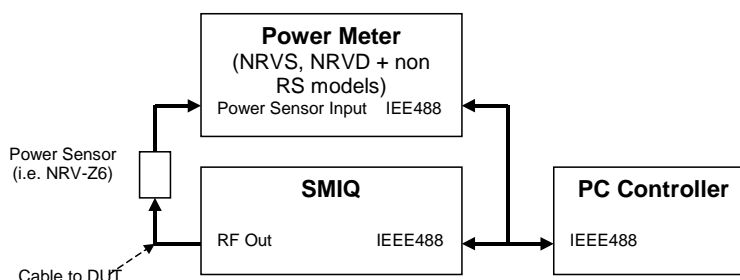
Fig. 6 Frequency response measurement with PC controller

The following examples show the compensation of a DUT input cable with UCOR function of different signal generators. The reference level is –10 dBm.

NOTE: The UCOR level is switched electronically limiting the correction range for SMIQ –40dB...6dB, SMR and SML ±20dB, SMP ±6dB. UCOR will not work correctly if

$$GenLevel + |UCorLevel| > \max .GenLevel .$$

Keep in mind to leave sufficient spare generator level, e.g. the SMIQ's maximum generator level is 13dBm meaning that the RF level can be set to +7dBm leaving 6dB for correction.

SMIQ

The lower curve in fig. 6 shows the characteristic of a regular RF cable from 1 to 6 GHz with –10dBm nominal generator RF level. The upper curve is the corrected with UCOR.
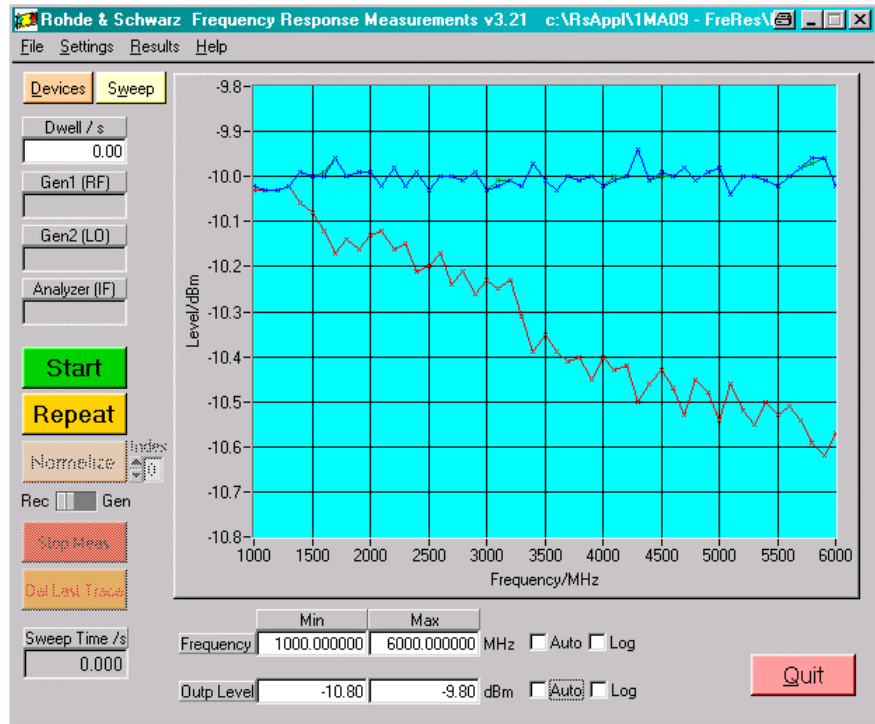

Fig. 7 SMIQ UCOR function
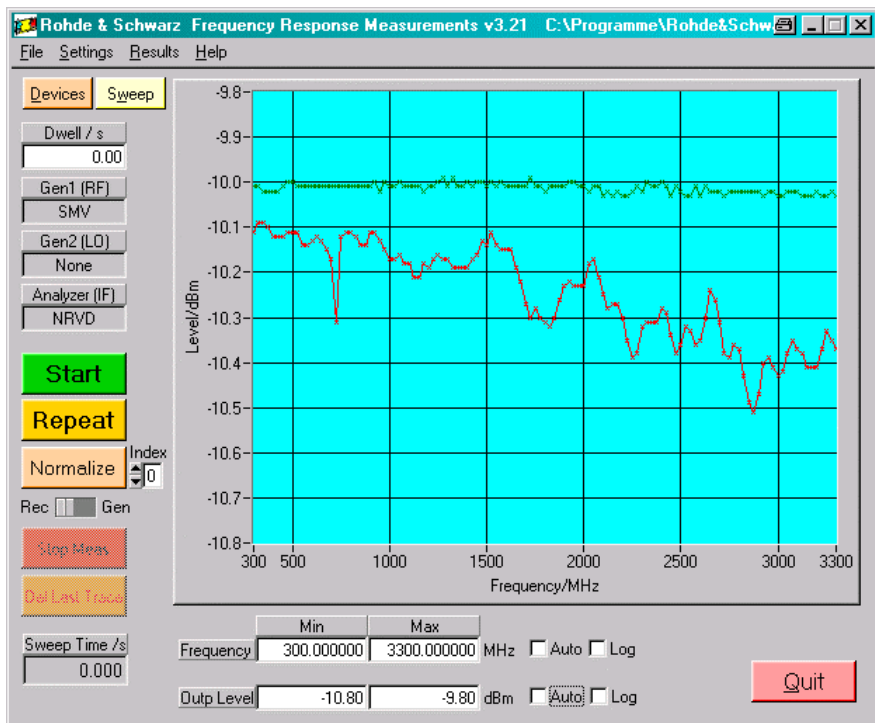
SMV

Fig. 8 SMV UCOR function

4 Hardware and Software Requirements

Hardware Requirements

The software runs on a PC with

CPU	Pentium 133MHz or better
RAM	64 MBytes or more
MONITOR	VGA color monitor
IEC/IEEE BUS	IEC/IEEE bus interface Rohde & Schwarz IEEE-488.2 bus interface **PS-B4**, 1006.6207.04, or National Instruments **AT-GPIB/TNT** or **GPIB-PCMCIA** card

It supports the following instruments:

- SME, SMIQ, SML, SMT, SMV signal generators and SMP and SMR microwave generators.

Software Requirements

WINDOWS 9X/NT/2000/XP	Microsoft operating system
NI-488.2 V1.6 (or above)	IEC/IEEE - bus driver from National Instruments. See http://www.natinst.com for the latest revision.
NI-VISA V2.01 (or above)	VISA driver from National Instruments. See http://www.natinst.com for the latest revision.
MICROSOFT INSTALLER	for MS operating systems Win95/98/NT

5 Installing the SMxUCor Software

SMxUCor installation on a PC controller requires the following files.

SMxUCor v1.xx.MSI

DistFile.CAB

Execute *SMxUCor v1.xx.msi* and select the installation directory. A new menu item *SMxUCor* will be created in *Start -> Program Files*. The installation directory will contain the file named below:

SMxUCor.EXE   SMx user correction executable

6 Running the SMxUCor Software

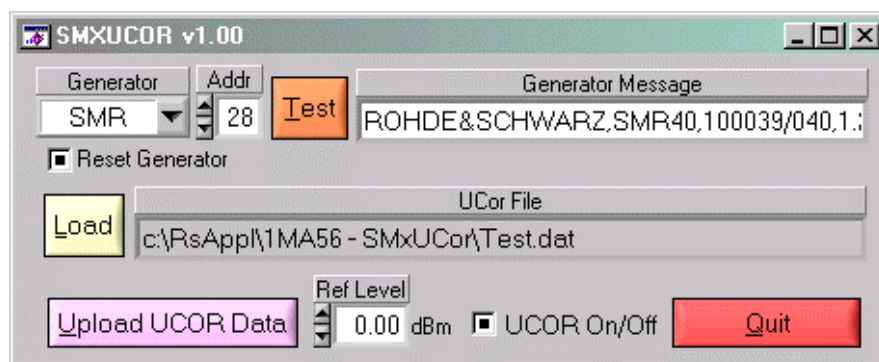The program is started by executing **SMxUCor.EXE**.

Fig. 9 SMxUCor menu

- **GENERATOR** – supported generator types: SME, SMIQ, SML, SMT, SMR, SMP and SMV.

- **ADDR** – GPIB primary device address. Range: 1...31.

- **TEST** – Initializes device and querys identification string which is diplayed at **GENERATOR MESSAGE** if successful.

- **RESET GENERATOR** – If checked a device reset will be performed after pressing the **TEST** button.

NOTE: After a RESET, set the generator's power level resolution (Level -> Power Resolution) manually to 0.01 dB. This parameter cannot be accessed remotely

- **LOAD** – opens the file dialogue for selecting an UCor Data file (*.dat). See chapter 3, FREERES QUICK INSTRUCTIONS for a detailed description of generating FreRes data files.
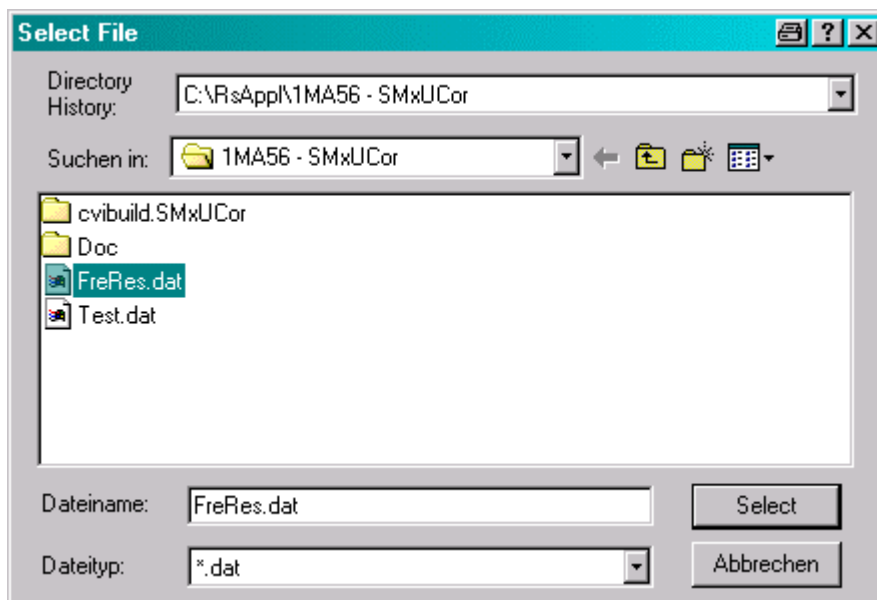
Fig. 10 File select menu

- **UPLOAD UCOR DATA** reads

  1. custom ASCII data files with the format:

     ```
     frequency₁/MHz        level₁/dBm
     frequency₂/MHz        level₂/dBm
     .........
     frequencyₙ/MHz        levelₙ/dBm
     ```

  2. files generated by FreRes with the format (Freq/MHz, Level/dBm) whereby only the first sweep level is considered, ie. 1100MHz – 39.516dBm, -1200MHz –39.974dBm. Make sure to insert the correct **REF LEVEL**, i.e. –40dBm.

     ```
     Repetition  Count: 1
     Level Sweep Count: 5
     Measurement Count: 11
     1100.000000 –39.516 –36.738 –32.923 –28.101
     1120.000000 –39.974 –37.379 –33.381 –28.376

     .......
     ```

  The format detection is performed automatically. Since FreRes stores the data as absolute levels (dBm) now correct it with the reference level of the generator used in order to obtain the relative level.

  $$UCorLevel = (AbsLevel - refLevel)*(-1)$$

  with

  UCORLEVEL= value in UCOR list

  ABSLEVEL   = measured absolute level

  REFLEVEL   = generator reference level

- **UCOR ON/OFF** – Turns the generator's UCOR function **ON** or **OFF**.

7 FreRes Quick Instructions

Following steps must be performed to generate a FreRes data file:

1. Execute **FRERES V3.XX.EXE**.

2. Select **GENERATOR1** and **ANALYZER** type in the **DEVICES** menu. **GENERATOR2** must be set to none.

3. Select **GEN1 (RF)** Level, **START FREQ**, **STOP FREQ** and **STEP FREQ**. Make sure the sweep range and step size complies to your application's region of interest. Press **OK** to close the window.

4. Press **START** in the main menu to initiate the frequency response sweep.

5. Save the data to a file with **RESULTS** -> **SAVE DATA** -> ***.DAT**

8 Additional Information

Please contact **TM-APPLICATIONS@RSD.ROHDE-SCHWARZ.COM** for comments and further suggestions.

9 Ordering information

Spectrum Analyzer		
FSEA20	(9 kHz to 3.5 GHz)	1065.6000.20
FSEA30	(20 Hz to 3.5 GHz)	1065.6000.30
FSEB20	(9 kHz to 7.0 GHz)	1066.3010.20
FSEB30	(20 Hz to 7.0 GHz)	1066.3010.30
FSEK20	(9 kHz to 40 GHz)	1088.1491.20
FSEK30	(20 Hz to 40 GHz)	1088.3494.30
FSEM20	(9 kHz to 26.5 GHz)	1080.1505.20
FSEM30	(20 Hz to 26.5 GHz)	1079.8500.30
FSIQ3	(20Hz to .3.5GHz)	1119.5005.03
FSIQ7	(20Hz to .7 GHz)	1119.5005.07
FSIQ26	(20Hz to .26 GHz)	1119.6001.26
FSP3	(9 kHz to 3 GHz)	1093.4495.03
FSP7	(9 kHz to 7 GHz)	1093.4495.07
FSP13	(9 kHz to 13 GHz)	1093.4495.13
FSP30	(9 kHz to 20 GHz)	1093.4495.30
FSU3	(20 Hz to 3.6 GHz)	1129.9003.03
FSU8	(20 Hz to 8 GHz)	1129.9003.08
FSQ3	(20 Hz to 3 GHz)	
FSQ8	(20 Hz to 8 GHz)	
FSQ26	(20 Hz to 26.5 GHz)	
Vector Signal Generator		
SMIQ02B	(300 kHz to 2.2 GHz)	1125.5555.02
SMIQ03B	(300 kHz to 3.3 GHz)	1125.5555.03
SMIQ03HD	(300 kHz to 3.3 GHz)	1125.5555.03
SMIQ04B	(300 kHz to 4.0 GHz)	1125.5555.04
SMIQ06B	(300 kHz to 6.0 GHz)	1125.5555.06
SMV03	(9 kHz to 3.3 GHz)	1147.7509.13
Microwave Generator		
SMP02	(10 MHz to 20 GHz)	1035.5005.02
SMP22	(10 MHz to 20 GHz)	1035.5005.22
SMP03	(10 MHz to 27 GHz)	1035.5005.03
SMP04	(10 MHz to 40 GHz)	1035.5005.04
SMR20	(10 MHz to 20 GHz)	1104.0002.20
SMR27	(10 MHZ to 27 GHz)	1104.0002.27
SMR30	(10 MHz to 30 GHz)	1104.0002.30
SMR40	(10 MHz to 40 GHz)	1104.0002.40
Signal Generator		
SML01	(9 kHz to 1.1 GHz)	1090.3000.11
SML02	(9 kHz to 2.2 GHz)	1090.3000.12
SML03	(9 kHz to 3.3 GHz)	1090.3000.13
Power Meter		
NRVS		1020.1809.02
NRVD		0857.8008.02
NRP		