Products: AMIQ, SMIQ, FSIQ, FSP, FSU, FSQ

AMPTUNE

Software for Measuring Amplifier Nonlinearity in Realistic Conditions

Application Note

With AMPTUNE amplifier nonlinearity can be measured with signals that are typical for the signals encountered by the amplifier in day-to-day use. The measurement can be checked by pre-distorting the control signal. Also, the results can be automatically stored for further processing with external programs.

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Contents

1   Overview

If the characteristics of modern amplifiers are measured with CW signals, say with a classic network analyzer, the results – depending on the amplifier design - depend on the sweep time, the sweep direction etc. The results are, therefore, useless if characteristic compensation is the purpose of the measurement.

The method described in this Application Note (AN), and implemented as the AMPTUNE software package, measures the characteristics with a signal that would actually be used when the amplifier is in service, i.e. a W-CDMA, IS-95 or QPSK signal. The results then indicate how to pre-distort signals to compensate for the amplifier characteristics.

The test signals are generated by a signal generator with a modulation source input. After passing through the amplifier, the signal is measured, sampled and stored by a spectrum analyzer. This data is read by AMPTUNE and converted to an output amplitude vs input amplitude (AM/AM) and phase difference between input and output vs input amplitude (AM/PM) characteristic. For verification of results, the control signal can be precorrected directly via an inverse characteristic to measure the increased signal quality such as the improvement of the adjacent-channel power suppression.

2 Fundamentals

A key RF-amplifier parameter, irrespective of whether the amplifier is used for mobile radio or TV broadcasting or to handle low or high powers, is linearity. For an amplifier to be perfectly linear, the ratio of the output signal to the input signal would have be constant for any input amplitude, frequency or phase, i.e. the amplifier would have to introduce a constant gain.

However, depending on its design, any real amplifier exhibits varying degrees of nonlinearity. The AM/AM and the AM/PM transfer characteristics are often used as measures of nonlinearity. The amplitude and phase of the input signal and the output signal are measured. The output amplitude is then plotted against the input amplitude and the difference between input phase and output phase plotted against the input amplitude.

However, these plots may not completely describe every amplifier because they can depend on the input phase or, more generally, there can be memory effects. Nevertheless, investigations have shown that AM/AM and AM/PM plots can completely describe many modern amplifiers - or at least provide a good approximation.

A 2-tone signal (= AM) is sometimes used to measure this characteristic However, the characteristics obtained in this way are not suitable for optimizing the amplifier for "real signals", such as W-CDMA signals, because the operating point of the amplifier moves due to thermal effects and the characteristic changes considerably when a 2-tone signal is applied. This is because, a 2-tone signal has, for example, a lower crest factor than a typical modulated signal and a different amplitude distribution. The ratio between the peak and rms power is, therefore, different and the thermal stress on the amplifier different. The signal used to determine these characteristics should be as similar as possible to the signals handled by the amplifier in service. The software described in this AN employs a noise signal with settable bandwidth as standard. It is a generic signal that can be used for IS-95, W-CDMA, etc. A WinIQSim-IQ data file can also be read so this means that a defined signal can be fed to the amplifier.

However, difficulties arise when generic modulated signals are used:

- The gain in the measurement path must be known so that the results can be scaled accordingly. To do this, the DUT is auto-leveled to the selected RMS test output level in a 3-stage leveling process with an accuracy of around 0.1 dB.

- The reference signal and the test signal must be exactly correlated in time. Approximate correlation can be obtained with an external trigger, but the remaining jitter is too great to allow the characteristic to be determined precisely. By implementing various mathematical methods with the AMPTUNE software, these corrections can be made entirely automatically.

When the software is used, non-linearities can be significantly reduced and even completely eliminated.

3 Software Features / Principle of Operation

AMPTUNE software has a facility for driving amplifiers with a suitably modulated signal and measuring the AM/AM and AM/PM compression characteristics. An SMIQ RF signal generator is modulated by an AMIQ IQ modulation source or the internal modulation generator of the SMIQ (SMIQ-B60). The signal is then amplified by the amplifier and measured with an FSIQ, FSP, FSU or FSQ signal analyzer. The analyzer converts the signal to the baseband and stores the IQ data in its memory. The software determines the amplifier characteristic from the reference data and the measured values.

The software has the following features:

- Use different test signals for driving the amplifier:
  - band-limited noise with settable bandwidth
  - dual tone with settable tone spacing
  - any WinIQSIM-file (generated by WinIQSIM or imported from any application using IQWizard

- Sets the frequency and RMS output level of the DUT

- Sets the measurement bandwidth, the sampling depth and sampling rate of the signals to be tested.

- Combined measurement with verification by measuring the improvement in adjacent-channel suppression with signal precorrection.

- Manual and/or automatic saving of results (numeric and graphic results) in HTLM format for easy import in any application or data base system.

4 Hardware and Software Requirements

Hardware (Instruments)

The following equipment is required to perform the measurement:

- **IQ signal source:**
  AMIQ or Arbitrary Waveform Generator SMIQ-B60 as option for SMIQ

- **RF signal source:**
  Signal Generator SMIQ

- **RF and baseband Signal Analyzer:**
  FSIQ with option FSIQB70 / FSP / FSU / FSQ

- BNC cable to connect external references

- BNC cable for AMIQ or SMIQ-Z5 for SMIQ trigger connection to signal analyzer

Software (PC Controller)

Minimum requirements to run AmpTune on your PC:

- *Operating system:*
  Windows 95 / 98 / NT 4.0 / 2000 / Me / XP

- *Generic PC requirements:*
  - Pentium 133 MHz
  - 32 MByte
  - 10 MByte free harddisc space
  - VGA monitor

- *IEC/IEEE bus interface:*
  Rohde & Schwarz IEEE-488.2 bus interface PS-B4, 1006.6207.04, or National Instruments GPIB card

Recommended system configuration:

- *Operating system:*
  Windows 98 / 2000 / Me / XP
  Microsoft Internet Explorer 5.0 or higher

- *Generic PC requirements:*
  - Pentium II 450 MHz or higher
  - 128 MByte
  - 50 MByte free harddisc space (to store measurement reports)
  - XGA monitor (1024x768)

- *IEC/IEEE bus interface:*
  Rohde & Schwarz IEEE-488.2 bus interface PS-B4, 1006.6207.04, or National Instruments GPIB card

5   Installing the Software

Microsoft Installer is used to install AMPTUNE. The software must first be installed on the PC. To do this, run:

- InstMSIA.EXE under Windows 95

- InstMSIW.EXE under Windows 98 and Windows NT 4.0

Then start SETUP.MSI and install the program.

If you are using Windows 2000, Windows Me od Windows XP, or if you have already installed software with Microsoft Installer, Microsoft Installer is already installed on your PC. In this case, just start the SETUP.MSI file.

During installation, the program files are copied to the directory of your choice and an icon is created on the desktop of your PC to start AmpTune.

Release history and additional basic informations can be found in the README.TXT file in the same folder.

6   Connecting the Computer and the Instrument / Test Setup

Connecting up the instruments

Connect the IQ signal source, the signal generator and the signal analyzer to the PC via the IEC/IEEE bus. Each instrument must be assigned a unique IEC/IEEE-busaddress.
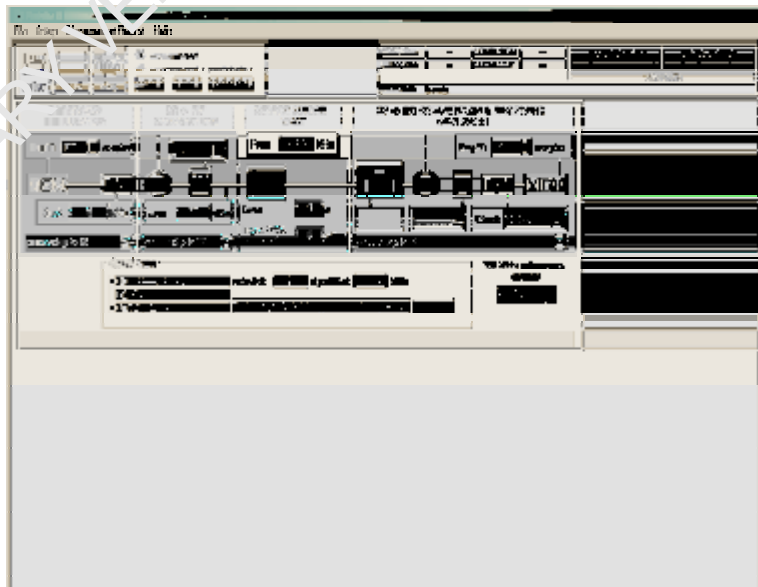
Test setup

The basic setup is shown below:
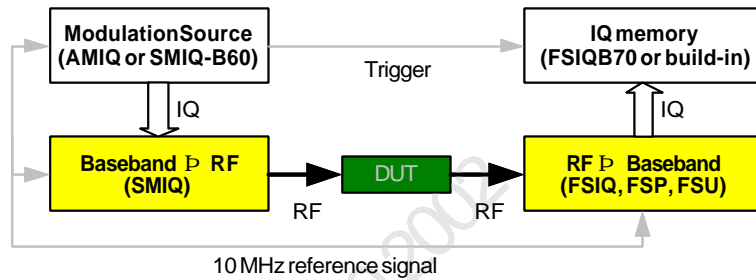
Picture 4

7   Starting the Software

Click on the icon on the desktop or select AMPTUNE in the start folder. The start screen is shown below:

Picture 5

For details on how to operate the software, and for a deeper look into the signal processing,... please have a look at the manual which is also available for download.

8 References

- **F. Zavosh**, et all, "Digital Predistortion Techniques for RF Power Amplifiers with CDMA Applications", *Microwave Journal,* Vol. 42, No. 10, October 1999, pp. 22-50

- **F. Zavosh**, et all, "Digital Predistortion Linearizes CDMA LDMOS Amps", *Microwaves & RF,* March 2000, pp. 55-61+164

- **F. Bonn**, "Limitations in feed-forward-linearization", *Microwave Journal,* August 2000, pp. 24-40 (Part I), September 2000, pp. 94-106 (Part II)

- **P. Kenington**, "Linearized RF Amplifier and Transmitter Techniques", *Microwave Engineering Europe,* November 1998, pp. 35-50

- **P. Kenington**, "Methods Linearize RF Transmitter And Power Amps", *Microwave & RF,* December 1998, pp. 102-116

- **P. Kenington**, "A Wideband Lineariser for Single and Multi-Carrier 3G CDMA, *IEEE Vehicular Technology Conference,* Fall '99, Vol. 1, pp. 248-252

- **Martin Weiß**, Measuring the Dynamic Characteristic of High-Frequency Amplifiers with Real Signals, *European Wireless 2000,* September 2000, Dresden

- **Martin Weiß**, Check Amplifier Dynamic Behaviour With True Test Signals, *Microwaves & RF,* December 2000

- **Martin Weiß**, Entwicklung und Verifikation eines Verfahrens zur Ermittlung der dynamischen Kennlinie von Hochfrequenzverstärkern bei breitbandigen Eingangssignalen, *Diplomarbeit, Institute for Communication Engineering,* TU München

9   Ordering Information

Modulation generator		
AMIQ	Up to 16 Msamples I and Q	1110.2003.04
or		
SMIQ-B60	Up to 512 Ksamples I and Q	1136.4390.02
SMIQ-Z5	BCN adaptor for PARDATA	1104.8555.02
Vector signal generator		
SMIQ02B	0.3 to 2.2 GHz	1125.5555.02
SMIQ03B	0.3 to 3.3 GHz	1125.5555.03
SMIQ04B	0.3 to 4.4 GHz	1125.5555.04
SMIQ06B	0.3 to 6.4 GHz	1125.5555.06
Signal analyzer (and baseband options)		
FSIQ3	20 Hz to 3.5 GHz	1119.5005.13
FSIQ7	20 Hz to 7 GHz	1119.5005.17
FSIQ26	20 Hz to 26.5 GHz	1119.6001.27
FSIQ40	20 Hz to 40 GHz	1119.6001.40
FSIQB70 (required)	25.6 MHz sampling rate	1119.6747.02
or (baseband included)		
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 30 GHz	1093.4495.30
or (baseband included)		
FSU3	20 Hz to 3,6 GHz	1129.9003.03
FSU8	20 Hz to 8 GHz	1129.9003.08
or (baseband included)		
FSQ3	20 Hz to 3,6 GHz	1155.5001.03
FSQ8	20 Hz to 8 GHz	1155.5001.08
FSQ26	20 Hz to 26,5 GHz	1155.5001.26

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