Data Sheet

MT4463

A product of MAURY MICROWAVE CORPORATION

powered by NMDG

Large - Signal Network Analyzer

The MT4463 is a large-signal network analyzer (LSNA) and aims the characterization of active components that demonstrate nonlinear behavior. These components include diodes, transistors, power amplifiers etc... Basically the MT4463 measures, in a calibrated way, the incident and reflected waves or voltages and currents at the ports of a component under test under realistic conditions using a periodic stimulus. This information is essential to characterize the behaviour of components accurately in all its aspects from small - signal to large - signal with one connection. Through the calibration process all unknowns with respect to the effects of interaction of the component with the instrument are eliminated.

To characterize a active component it is crucial to test under conditions, close to reality. Therefore, the measurement system is very open to accommodate different stimuli and specific test needs. For example, one can connect source and load impedances, different from 50 Ω.

With an easy-to-use graphical user interface (GUI) the user configures and calibrates the system to perform accurate and complete measurements. Different data formats are supported to save the measurements. The measured data can be visualized in different ways, as time-domain waveforms similar to an oscilloscope, as spectra similar to a spectrum analyzer or as envelope waveforms at the fundamental and harmonics and more.

For the advanced user, who wants to process the measurements beyond offered capabilities, a powerful scripting language is available in parallel with the GUI[1]. *Mathematica*™ is offered as the powerful scripting language. For the user who wants to control the instrument from her/his own development tools[2], a DLL is provided. In the present offering, the DLL allows to acquire the calibrated data and to control the MT4463.

1. presently the commands in the scripting language and GUI are only partially synchronized
2. C, Agilent VEE, LabVIEW™, MATLAB™, ...

MT4463 version

Presently there are 2 MT4463 versions available:

- MT4463A: 600 MHz - 20 GHz version
- MT4463B: 600 MHz - 50 GHz version, suitable to mount on a probe station

Connectorized *On wafer*

MT4463A, 20 GHz version **MT4463B, 50 GHz version**

Figure 1. MT4463A and MT4463B versions

The 50 GHz version consists of a modular test set that contains two reflectometers and one calibration module that automates the calibration process, while minimizing the losses for adequate operation up to 50 GHz.

Thanks to the open system approach, both versions can be easily extended from a basic component characterization system to an advanced chararterization system.

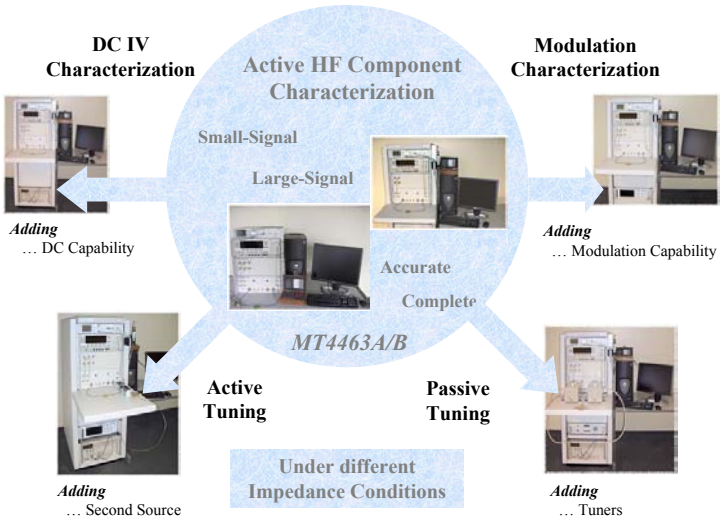


Figure 2. From basic to advanced component characterization system

The Block Diagram

The MT4463 is an open, customizable system consisting of a core, customizable and optional part, as shown in figure 3

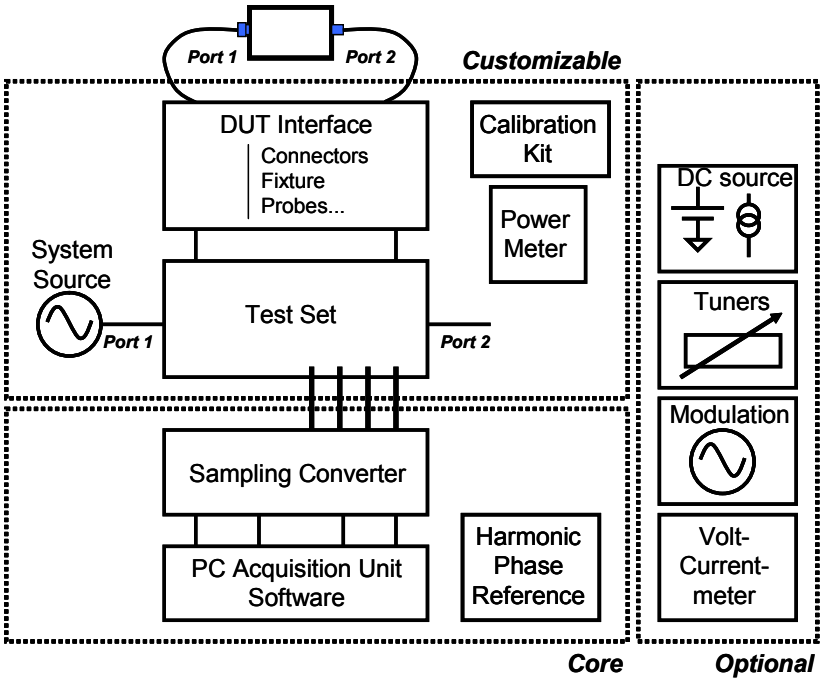


Figure 3. Core, customizable and optional components of the MT4463A LSNA.

The DUT interface represents the hardware required to connect the device under test (DUT) to the test ports of the test set. This part is completely determined by the type of DUT, which can either be connectorized, on wafer or in a fixture.

The test set separates the incident and reflected waves at both ports, resulting in four measurement channels. The test set also allows to provide DC to the DUT via bias tees[1] and allows to connect one or more sources and/or tuners to both ports. Finally it also holds some switching hardware to simplify the calibration process.

The four output channels of the test set are connected to a sampling converter, which converts the microwave signals into IF signals. The sampling converter includes step attenuators to ensure that it remains in its linear range of operation, even when measuring large-signal behaviour of a device.

A data acquisition, in combination with a PC, takes care of the further processing. For the instrument control purpose, the PC also contains a PCI GP-IB interface which can be used for other instruments, in combination with the MT4463.

1. A bias tee is required due to the RF DC block at the ports where the source(s) and/or tuner(s) are connected.

A regular vector network analyzer calibration kit, covering the full measurement bandwidth, in combination with a power meter and harmonic phase reference are required to perform the absolute calibration. As with regular vector network analyzers calibration is necessary to perform accurate measurements.

During the calibration a microwave synthesizer is used as system source to provide the necessary single tone excitation across the full measurement bandwidth.

To provide different impedances to port 1 and port 2, it is possible to combine the MT4463 with passive and active tuners.

To measure the DC characteristics of the DUT in combination with high frequency data, a combination of voltmeters or current meters at both ports is required. A more sophisticated solution is based on DC analyzers or DC force / sense systems.

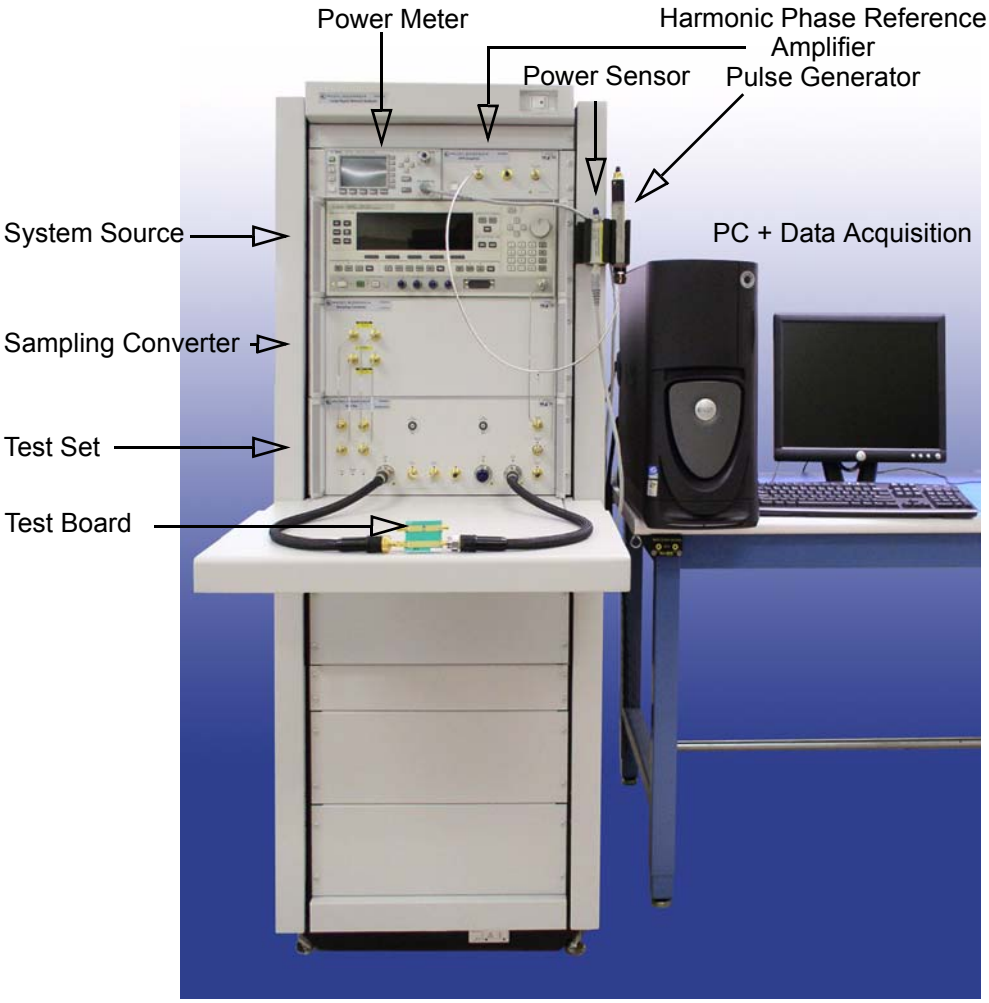


Figure 4. Typical configuration consisting of MT4463 core and customizable parts.

A test board (SMA connectors) is delivered with the MT4463 for education and verification purposes. Appropriate adapters are required.

The MT4463 Partitioning

In support of the open system architecture, the MT4463 hardware can be subdivided in three categories as shown in figure 3:

- core MT4463 hardware
- additional required MT4463 hardware which is customizable
- optional hardware

Core MT4463

The core MT4463 consists of

- the 50 GHz MT4464 Sampling Converter (P/N MT4464A001)
- the PC acquisition unit (incl. the Large-Signal Network Analyzer software)
- the MT4465 Harmonic Phase Reference (HPR)
  - 20 GHz version (P/N MT4465A001 + MT4465B001)
  - 50 GHz version (P/N MT4465A002 + MT4465C001)

Additional required MT4463 customizable hardware

The MT4463 also requires

- a 20 GHz, 40 GHz or 50 GHz system source
- DUT interface hardware (connectors, fixture, probes, test port cables ...)
- a Test Set
  - 20 GHz version + interconnect kit
  - 40 GHz version (P/N MT4466A001) + interconnect kit
  - 50 GHz version (P/N 2x MT4466D001and 1x MT4466C001 + interconnect kit
  - based on customer specifications
- a power sensor and power meter (either 2.4 mm or 3.5 mm)
- a calibration kit (either 2.4 mm or 3.5 mm)
- 3.5 mm adapter kit for 20 GHz configuration (P/N 7927N01)
- 2.4 mm adapter kit for 50 GHz configuration (P/N 7921N01)

Optional hardware

Typical optional hardware consists of

- DC sources
- DC sensing hardware
- Tuners
- Modulation sources

MT4463 Specifications

Overall Specifications

- Bandwidth
  - lower limit: 600 MHz
  - upper limit: depends on the combination HPR, Test Set (limited to 50 GHz)
- Power: depends on selected Test Set
- IF Bandwidth: 10 MHz
- RF Frequency resolution: 1 kHz
- Noise Floor for a_1 signal with a standard configuration[1]

	RF at 1.0 GHz				RF at 20.0 GHz			
IF (MHz)	dBm (12 kHz RBW)		dBm (23 Hz RBW)		dBm (12 kHz RBW)		dBm (23 Hz RBW)	
	MT4463A	MT4463B	MT4463A	MT4463B	MT4463A	MT4463B	MT4463A	MT4463B
2.5	-57.0	-55.0	-77.0	-75.0	-53.0	-55.0	-73.0	-75.0
5.0	-52.0	-50.0	-72.0	-70.0	-50.0	-50.0	-70.0	-70.0
7.5	-52.0	-45.0	-72.0	-65.0	-49.0	-45.0	-69.0	-65.0
10.0	-52.0	-45.0	-72.0	-65.0	-48.0	-45.0	-68.0	-65.0

Table 1. Noise floor for MT4463A and MT4463B up to 50 GHz

	RF at 50.0 GHz	
IF (MHz)	dBm (12 kHz RBW)	dBm (23 Hz RBW)
2.5	-45.0	-65.0
5.0	-40.0	-60.0
7.5	-35.0	-55.0
10.0	-35.0	-55.0

Table 1-1. Noise floor for MT4463B up to 50 GHz

- Dynamic Range: mainly determined by the dynamic range of the Sampling Converter (see specifications for Sampling Converter), coupling factor and coupler losses. For a “standard” configuration of the Test Set, the “full-scale range” power for the a_1 signal, coming out of the reflectometer port is determined for different RF frequencies, without applying attenuation in the Sampling Converter.

1. minimal detectable power of the a_1 signal, coming out of the test set port with a LO frequency around 25.0 MHz

	1 GHz	20 GHz	50 GHz
a_1 signal (dBm)	9.0 / 8.0.	9.0	8.0

Table 2. Dynamic range for MT4463A and MT4463B

MT4466 Test Set Specifications (20 GHz)

Specifications on request

MT4466A001 Test Set Specifications (40 GHz)

- Bandwidth: 600 MHz - 40 GHz.
- Power capability: 10 Watt average (cold switching), 1 Watt average (hot switching)
- Bias tees: 0.5 A, 40 Volt - Standard bias tees (unsuited for pulsed applications)

Freq (GHz)	Max (dB)	Typical (dB)
5	-5.0	-3.0
10	-7.5	-6.0
20	-10.0	-8.0
30	-12.5	-11.0
40	-17.5	-15.0

Table 3. Insertion loss “Source Input” - “Test Port 1” in Measure Mode

Freq (GHz)	Max (dB)	Typical (dB)
5	-4.0	-2.5
10	-5.0	-3.5
20	-6.5	-5.0
30	-8.0	-6.5
40	-10.0	-8.5

Table 4. Insertion loss “Port 2 Input” - “Test Port 2” in Measure Mode

Freq (GHz)	Max (dB)	Typical (dB)
10	-0.75	-0.5
20	-1.2	-1.0
30	-1.5	-1.2
40	-2.3	-2.0
50	-2.75	-2.5

Table 5. Insertion loss contribution of bias tee

MT4466B001 Test Set Specifications (50 GHz)

- 2x Reflectometer MT4466D001 and 1x Calibration Module MT4466C001
- Bandwidth: 600 MHz - 50 GHz.
- Power capability: 10 Watt average (cold switching), 1 Watt average (hot switching)
- Bias tees: 0.5 A, 40 Volt - Standard bias tees (unsuited for pulsed applications)

Freq (GHz)	Max (dB)	Typical (dB)
5	-2.0	-1.5
10	-2.5	-2.0
20	-3.5	-3.0
30	-4.0	-3.5
40	-5.5	-5.0
50	-7.0	-6.5

Table 6. Insertion loss “Input” - “DUT Port” of Reflectometer MT4466D001

Freq (GHz)	Min(dB)	Typical (dB)
4	2.0	3.0
10	7.0	8.0
20	7.0	8.0
30	9.0	10.0
40	11.0	12.0
50	7.0	9.0

Table 7. Gain “Source” - “Port 1” / “Port 2” of Calibration Module MT4466C001

Freq (GHz)	Max (dB)	Typical (dB)
10	-0.75	-0.5
20	-1.2	-1.0
30	-1.5	-1.2
40	-2.3	-2.0
50	-2.75	-2.5

Table 8. Insertion loss contribution of bias tee

MT4464A001 Sampling Converter Specifications

- Damage Level: 10 dBm peak (± 1 V DC+AC, 0 dB attenuation)
- Operating Range: < 0 dBm (± 0.316 V DC+AC, 0 dB attenuation)
- Attenuator per channel: 60 dB, 10 dB / step
- Input impedance: 50 Ohm
- RF bandwidth: DC - 50 GHz.
- IF bandwidth: DC - 10 MHz

- reference clock 10 MHz input, 0 dBm
- reference clock 10 MHz output, standard TTL
- Noise Floor and Dynamic Range (with default settings and f_{LO}=25 MHz) at 0 dB attenuation (Table 9 and Table 10)

IF Frequency (MHz)	dBm (12 kHz Resolution BW)	dBm (23 Hz Resolution BW)
2.5	-70.0	-92.5
5.0	-66.0	-91.0
7.5	-66.0	-91.0
10.0	-65.0	-90.0

Table 9. Typical Noise Floor without any signal applied

Input Signal: -6 dBm (maximum for linear operation range)			
f_{RF} (GHz)	1.0	20.0	50.0
f_{IF} (MHz)	2.5	2.5	2.5
Output (dBm)	10.0	7.0	-2.5
Noise Floor (dBm) RBW = 12 kHz / 23 Hz	-60.0 / -85.0	-45.0 / -70.0	-45.0 / -70.0
Dynamic Range (dBc) RBW = 12 kHz / 23 Hz	70.0 / 85.0	50.0 / 70.0	40.0 / 60.0

Table 10. Typical Noise Floor and Dynamic Range with signal applied

- Phase noise spurious: input signal: f_{RF}= -6 dBm at 20 and 50 GHz, f_{LO} = 25 MHz, measurement resolution BW: 20 Hz (Table 11)

f_{RF}	dBc (1kHz from carrier)	dBc (10 kHz from carrier)	dBc (25 kHz from carrier)
20 GHz	-40.0	-50.0	-60.0
50 GHz	-35.0	-45.0	-50.0

Table 11. Typical Phase Noise Spurious

MT4465A001/MT4465B001 Harmonic Phase Reference Specifications (20 GHz)

- 100/120 Volt - 0.75 A (fuse 0.75 A - 250 Volt - fast)
- 220/240 Volt - 0.4 A (fuse 0.4 A - 250 Volt - fast)
- Drive frequency: 600 MHz - 1.2 GHz
- Drive power: 11 dBm - 12 dBm
- Pulse bandwidth: 20 GHz
- Phase repeatability of phasors: < +/- 1.75 degree up to 20 GHz[1]
- Max systematic phase error of phasors: < +/- 0.75 degree at 20 GHz[1]

1. Based on Agilents licensed Nose-2-Nose Calibration Technique

MT4465A002/MT4465C001 Harmonic Phase Reference Specifications (50 GHz)

- 100/120 Volt - 0.75 A (fuse 0.75 A - 250 Volt - fast)
- 220/240 Volt - 0.4 A (fuse 0.4 A - 250 Volt - fast)
- Drive frequency: 600 MHz - 1.2 GHz
- Drive power: 16 dBm - 17 dBm
- Pulse bandwidth: 50 GHz
- Phase repeatability of phasors: < +/- 6 degree up to 50 GHz[1]
- Maximum systematic phase error of phasors: < +/- 13 degree up to 50 GHz[1]

10 MHz reference clock

The system source must supply the 10 MHz reference clock.

PC Acquisition Unit Specifications

A state of the art PC is delivered with the system, equipped with a standard GPIB interface: the National Instruments GPIB Controller Card for PCI, Windows 2000/XP/Me/98.

The required analog modem for remote support comes installed and configured as part of the PC workstation.

A four channel PCI-based A/D board is used to digitize the IF signals generated by the MT4464 Sampling Converter and uses the common 10 MHz reference clock to generate its internal sample clock. This board comes installed in the PC, which is delivered as part of the measurement system.

- PCI-based 14 bit A/D
- > 10 MHz analog -3 dB bandwidth
- default sampling rate: 25 MHz
- max. number of points (4 channels): 2 MSamples / channel
- default input range: 1 Vp
- default input impedance: 50 Ohm

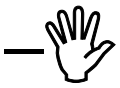
Customizable and optional parts

Presently a limited number of instruments are supported. Other instruments can be added on request.

System Source

Freq Range	Type
20 and 40 GHz	Agilent 836*X*0A/B
20 and 40 GHz	Agilent PSG CW E8247C opt 5*X*0
20 GHz	Agilent PSG Vector E8267C opt 520
20, 40 and 50 GHz	Agilent PSG CW E8257D-5*X*0
40 GHz	Agilent E8244A PSG
50 GHz	Agilent 83650B
50 GHz	Agilent PSG CW E8247C opt 540 + 83555A mm-wave source module
20, 40 and 50 GHz	Rhode & Schwarz SMR Series[a]
20, 40 and 50 GHz	Anritsu MG3690A/B Series

a.Tested for continuous wave measurements as master source



CAUTION *The source must be able to drive the Harmonic Phase Reference during the calibration procedure. Check the required power levels for the Harmonic Phase Reference.*

Power Sensor

Freq Range	Type
20 GHz	Agilent 8485A
50 GHz	Agilent 8487A
18 GHz	Agilent N1921A
40 GHz	Agilent N1922A

Power Meter

Type
Agilent E4418B
Agilent E4419B
HP436
HP438

Calibration Kit

Freq Range	Type
18 GHz	Maury 2660S series Cal Kit 7mm
20 GHz	Maury 8050U series Cal Kit 3.5 mm
50 GHz	Maury 7950U series Cal Kit 2.4 mm
6 / 18 GHz	Agilent 85031B, 85050B/D Calibration Kit, 7 mm
20 GHz	Agilent 85052D Economy Mechanical Cal Kit 3.5 mm
50 GHz	Agilent 85056D Economy Mechanical Cal Kit 2.4 mm

DC Stimulus and Measurement

Type
Agilent 4142B Modular DC Source/Monitor
Agilent 4156C Semiconductor Parameter Analyzer
Agilent E5270A 8-Slot Parametric Measurement Mainframe
Agilent E3631A Triple Output Programmable DC Power Supply
Agilent E3634A 200 W Power Supply, 25 V, 7 A or 50 V, 4 A
Agilent 34401A Digital Multimeter, 6.5 Digit
Agilent 662xx System Power Supply
Keithley 4200-SCS for DC Characterization

Modulation Source

Freq Range	Type
250 kHz - 2 GHz	Agilent E4431B ESG-D Opt UND, 1E5, UN9
250 kHz - 4 GHz	Agilent E4433B ESG-D Opt UND, 1E5, UN9
250 kHz - 4 GHz	Agilent E4438C-602 ESG Vector Signal Generator

Software

Presently, the software that comes with the MT4463, is focused on measurements. Using the supported DC, RF and microwave sources, different stimuli can be applied. For the time being, there is no support for the customer to add unsupported sources[1] in a flexible way. It is possible though, for the customer to control these sources, either manually or programmatically with the tool of choice, and to perform measurements using the MT4463A software.

Graphical User Interface

The GUI allows to run the hardware in 2 major modes of operation:

- S-parameter measurements in uncalibrated and calibrated mode (figure 5)
- Large-signal measurements in uncalibrated and calibrated mode (figure 7)

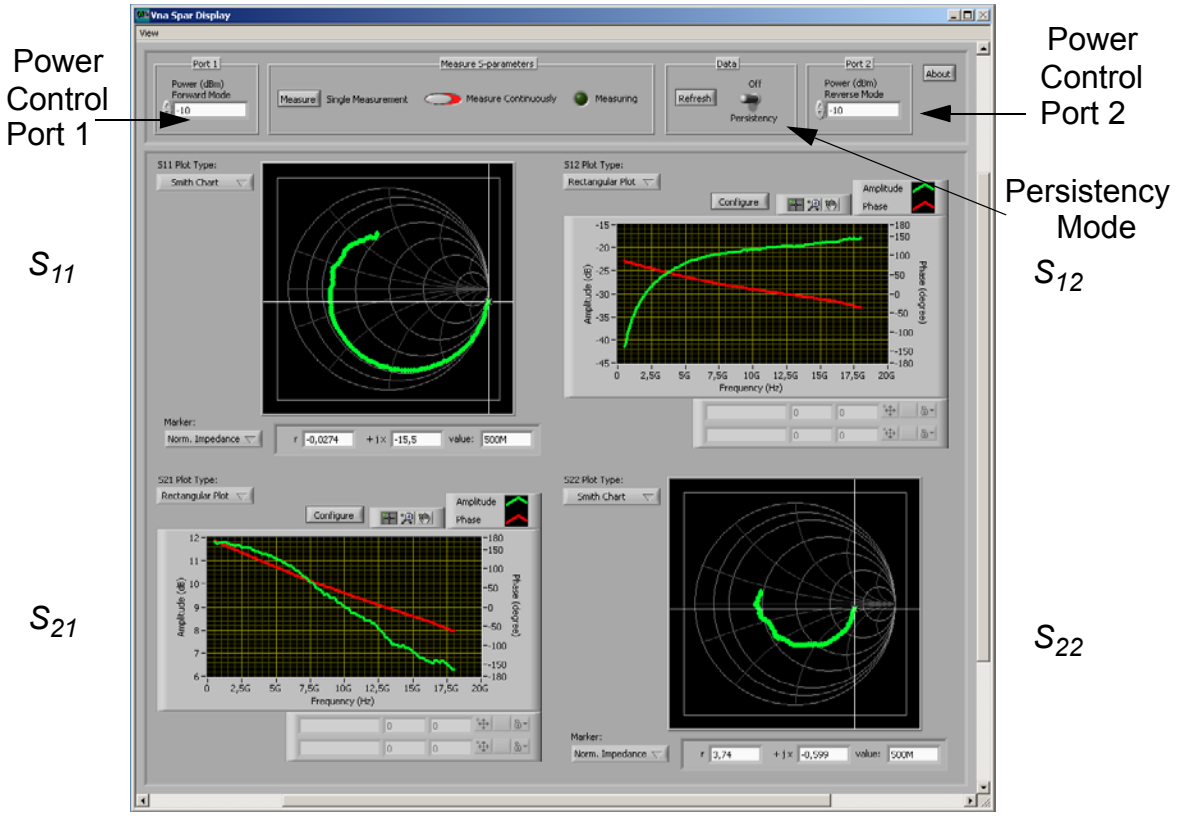


Figure 5. S-parameter measurements.

The GUI provides support for:

- Configuring the MT4463 system

1. On request, drivers can be added.

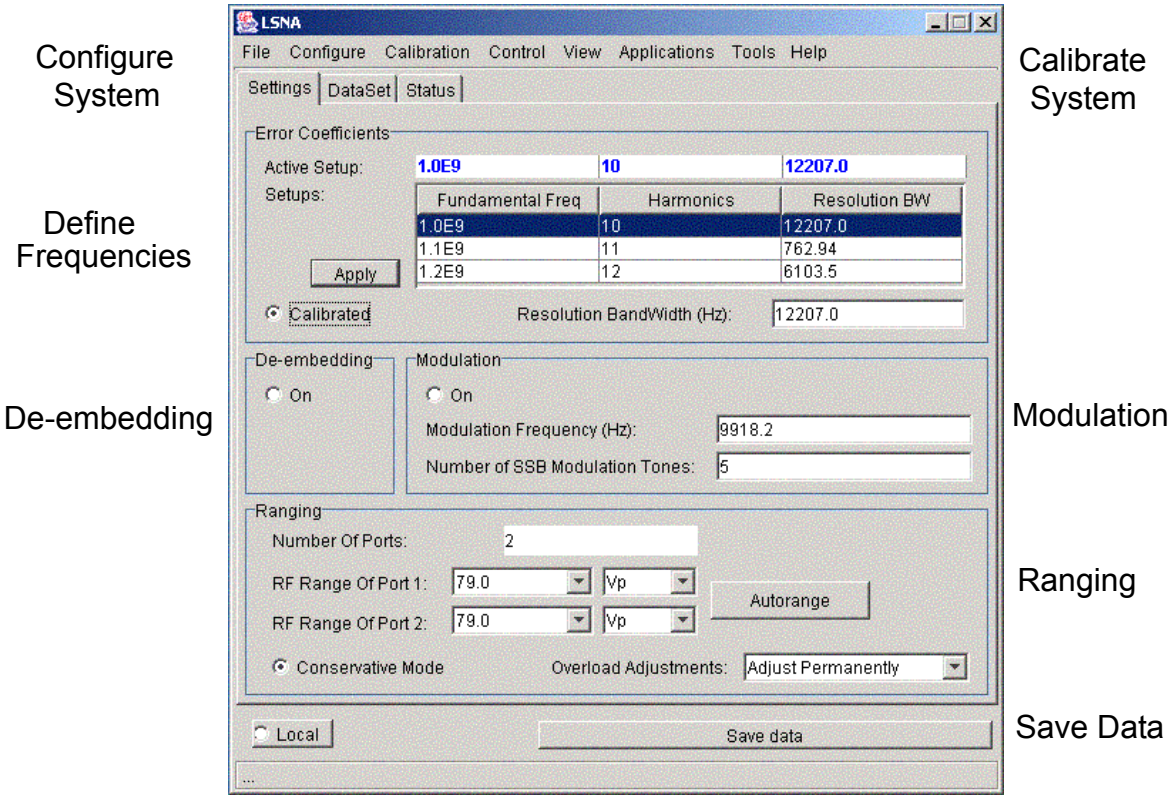


Figure 6. Control part of the Graphical User Interface

- Performing large - signal calibrations
  - SOLT
  - LRRM
  - TRL
  - SOL (one - port relative calibration)
- Performing VNA calibrations
  - SOLT
  - LRRM
  - TRL
- Performing system - level calibrations
  - Frequency response calibration of sampling converter for modulation measurements
  - Characterization of test set losses to optimize power levels during calibration
- Setting up fundamental frequencies and harmonics
- Modulation measurements
- De-embedding
- Ranging
- Displaying the measurements in different ways (figure 7)
  - Voltage - Current at all ports

- Incident - Reflected waves at all ports
- Frequency, time and frequency - time domain
- Dynamic source-line and load-line
- Smith Chart at input and output
- AM/AM and AM/PM under modulation
- Harmonic Distortion Analysis under modulation

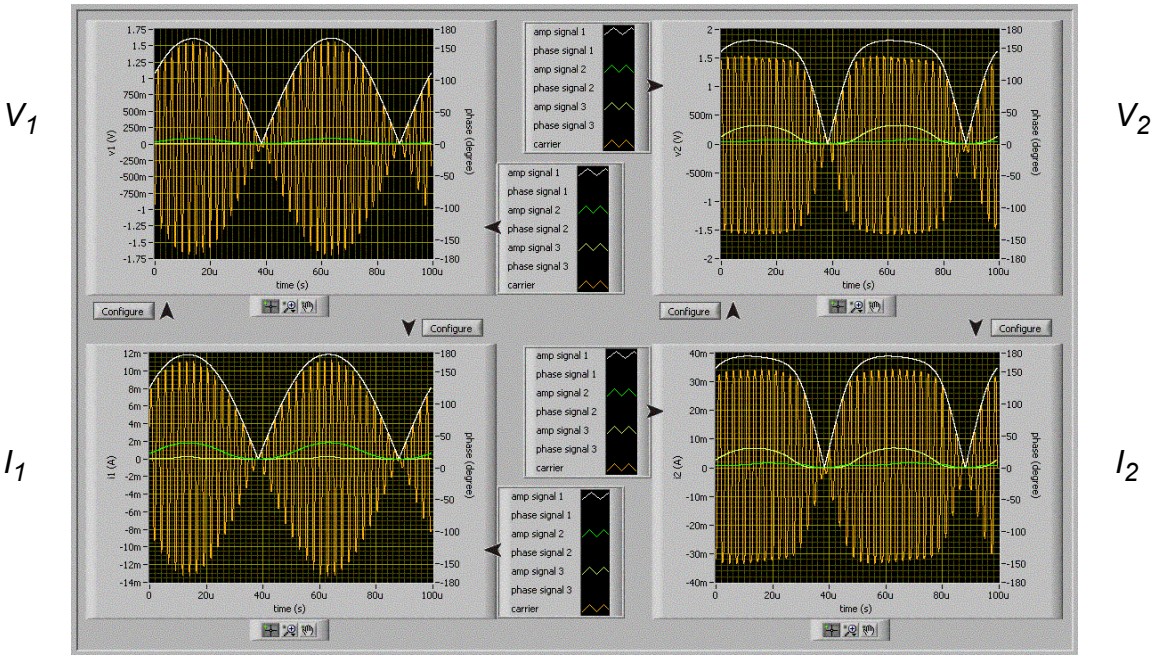


Figure 7. Frequency - time representation of voltage / current at input and output

- Saving, retrieving and reviewing measurements in a raw format
- Exporting measurements in CITIFile, table and CSV format (spreadsheets)

Scripting Language

For the advanced user, who wants to perform different types of processing on top of the measurements, powerful scripting capability is provided through the use of *Mathematica*™. In parallel with the GUI, the measurements can be accessed via a *Mathematica*™ notebook, where all the *Mathematica*™ processing capability is available for further processing and visualization.

The standard configuration includes the *Mathematica*™ software. The LSNA software uses JLink and MathLink which is included with the *Mathematica*™ software. Optionally the customer can provide the *Mathematica*™ software taking the compatibility requirements into account.

Mathematica Version	JLink	MathLink	
5.2	3.1.0	15	Preferred configuration
5.1.1	3.0.1	14	
5.1.0	3.0.0	13	
5.0.1	2.1.1	12	
5.0.0	2.1.1	11	
4.2	2.1.1	10	

Table 12. Compatibility matrix for the *Mathematica*™ software

CAUTION *Once Mathematica 5.1 or higher is installed, the LSNA sofware v1.1 or higher cannot run without manual intervention with a previous Mathematica version. Mathematica installation installs libraries under Win system32 which causes incompatibilities starting from 5.1.*

Connectivity

Users, who want to control and to retrieve data from the MT4463, using the environment of their choice (e.g. LabVIEW™, MATLAB™, Agilent VEE, C etc.), can do so if their environment allows to connect to a DLL using a C header file that describes the interface to the MT4463. The user can then process and display the data in that environment (figure 8).

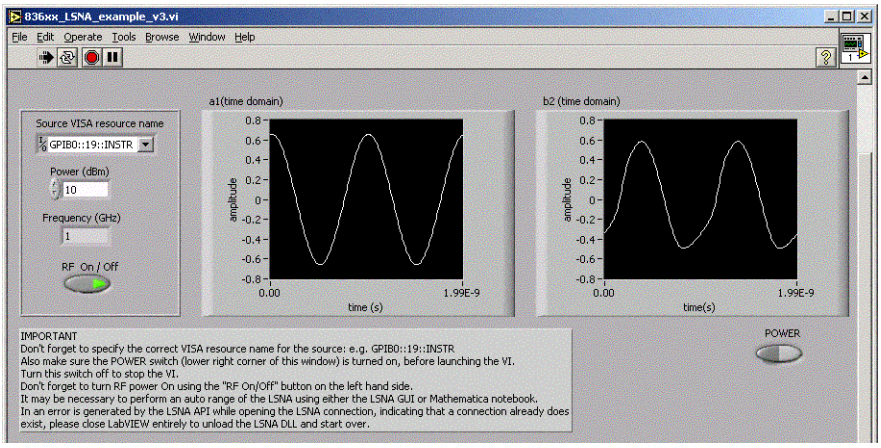


Figure 8. LabVIEW™ example using the C API.

Add-On Software Modules

Additional software modules, not included in the standard MT4463 software, are available. For most recent information, please visit http://www.nmdg.be.

ATS - LSNA connection

ATS, PC-based application software for automated RF Device Characterization Solutions and a product of Maury Microwave, does contain a connection to the MT4463. This allows to display voltage and current or incident and reflected wave information in different formats for different impedance states.

Real - Time Power Amplifier Analysis

The MT4463 in combination with this RTPAAnalysis toolkit, a product of NMDG Engineering, allows to perform real-time PA analysis under real-time changing tuning conditions. This software helps shortening the PA design cycle drastically.

This software module requires a modulation source and one or more tuners, which are available as options for the MT4463 product offering (figure 9).

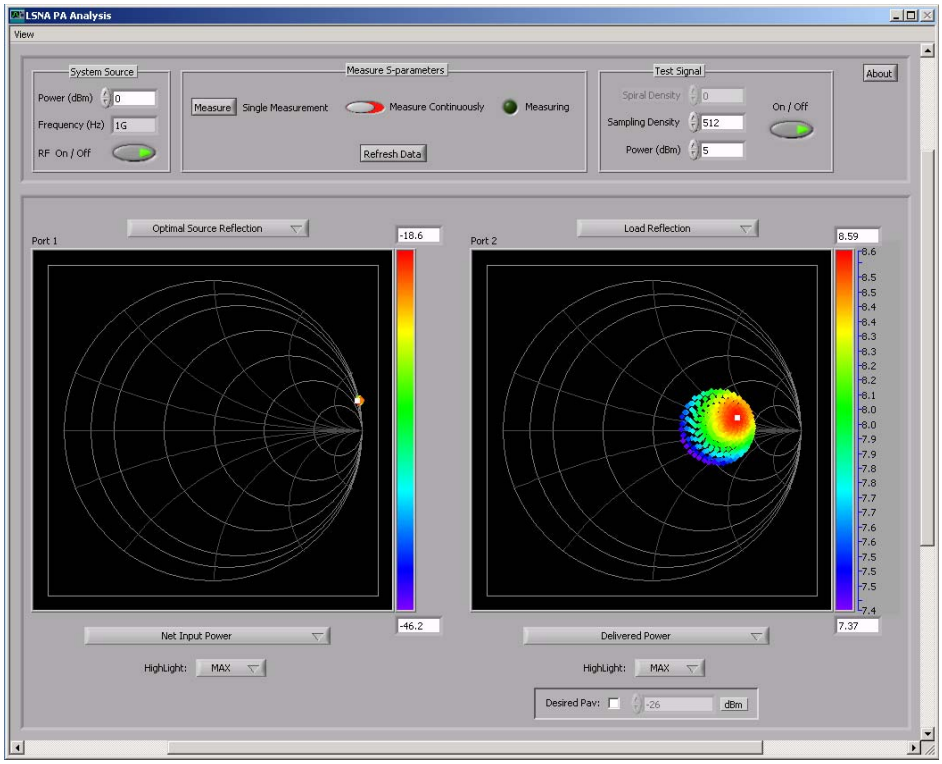


Figure 9. Real - time PA Analysis by measuring real - time combined PA characteristics.

Trademark information

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Microsoft®, Windows®, Windows® 2000, Windows® XP and Microsoft® Visual C++ are registered trademarks of Microsoft Corporation.
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Mathematica™ is a registered trademark of Wolfram Research.
MATLAB is a registered trademark of The MathWorks.

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Agilent SICL[1] is an I/O library developed by Agilent Technologies.

Contact Information

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  Email:
  Web: http://www.maurymw.com

Product Information: **http://www.nmdg.be/index_jump.html?goto=products_center**

Support Information: **http://www.nmdg.be/index_jump.html?goto=support/support_center**

Printing history

- Version 1.0.0. - July 2004
- Version 1.1.0.1 - June 2005
- Version 1.1.0.2 - January 2006
- Version 1.1.1 - May 2006

1. Standard Instrument Control Library

