Less noise • More sound

RT-2X

Expandable Audio Test System
For Analog & Digital Signals

User's Guide

Refers to firmware Rev. 5.20 or higher

V 2.1.0b / Feb 2003 / MBe

INTERNATIONAL WARRANTY

Limited Warranty

NTI guarantees the *RT-2X* system and its components against defects in material or workmanship, for a period of one year from the date of original purchase, and agrees to repair or replace any defective unit at no cost for parts or labor.

Important

This warranty does not cover damage resulting from accident, misuse or abuse, lack of reasonable care, the affixing of any attachment not provided with the product, loss of parts or connecting the product to another but the specified receptacles. This warranty is void unless service or repairs are performed by an authorized **NTI** service center.
In case of a damage, pack your *RT-2X* system in the original box and take or ship prepaid the unit to your nearest **NTI** service center. Transport damages are not covered by this warranty. Be sure to include your sales invoice as proof of purchase date.

Note

No other warranty, written or verbal, is authorized by **NTI**. Except as otherwise stated in this warranty, **NTI** makes no representation or warranty of any kind, expressed or implied in law or in fact, including, without limitation, implied merchantability or fitness for any particular purpose and assumes no liability, either in tort, strict liability, contract or warranty for products.

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WARNING	**Read this manual, and especially chapter *3 System Installation* carefully before operating the instrument. Important information about the proper mains voltage selection and fuse rating are given therein.** **Never open, modify or try to repair this instrument unless properly instructed by an authorized service technician.**

CE DECLARATION OF CONFORMITY

We, the manufacturer

NTI AG
Im alten Riet 102
FL-9494 Schaan

hereby declare that the product

Product Name	Rapid-Test
Model Number	RT-2X
Year of Construction	1998

conforms to the following standards or other normative documents

Harmonized Standards	EN 61326-1 FCC Part 15, according to ANSI C63.4-1992

This declaration becomes void in case of any changes on the product without written authorization by **NTI**.

Date	Schaan, 14. December 1999
Signature	
Position of Signatory	Technical Director

CE

Samples of this instrument have been tested and found to conform to the statutory protective requirements. Instruments of this type thus meet all requirements to be given the CE mark.

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FIGURES REFERENCE

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1 WELCOME

Congratulations and thank you for buying **NTI**'s *RT-2X*, an advanced system for fast and thorough performance tests of Audio devices. Its performance, flexibility, speed and wide range of measurement functions have been optimized to meet the requirements of today's industrial quality control. *RT-2X* is a remote controlled system that can be easily integrated into automated environments. We are convinced you will enjoy using it.

Please read the entire User's Guide thoroughly before you start operating the system, in order to avoid any damage to the unit or your equipment.

For detailed information about specific topics around the *RT-2X* operation please refer to the "***RT-2X Reference Manual***".

For technical support please contact your local **NTI** representative or visit the **NTI** homepage www.rapid-test.com.

2 SYSTEM OVERVIEW

The *RT-2X* base unit is a sophisticated analog test instrument with an independent generator and analyzer as well as a wide range of output & input impedance.
Several analog and digital plug-in boards and options may be installed in addition to extend the application range of the system.

Architecture	• Fully independent 2-channel generator & analyzer • Remote control through GPIB IEEE-488 or RS232
Bandwidth, Sampling Rate	• 20 Hz – 20 kHz @ f_s = 48 kHz • 20 Hz – 4 kHz @ f_s = 8 kHz
Outputs	• 4 mm "banana" or BNC connectors • 5x real + 1x complex + 4x user-defined output impedance • Output level –60 to +29 dBVp
Inputs	• 4 mm "banana" or BNC connectors • 6x real + 1x complex + 4x user-defined input impedance • 15 or 48 V microphone (Phantom) power supply • Input range –60 to +40 dBVp
Residual Distortion	< –86 dB

Table 1 RT-2X 'Base Unit' configuration

RL/LCL Interface	• Plug-in board with overvoltage protection. • Supports LCL, LCTL, RL, ERL and SRL measurements. • Wiring compensation procedure.
ISDN BRI interface	• Plug-in board with ISDN BRI input & output RJ45 jack. • ISDN signaling not supported; therefore, a NT (network terminator) is required for operation in an ISDN network. • Supports multitone measurements in A-D, D-A and D-D operation. • Output level –72.25 to +0 dBFSp.
T1 interface	• Plug-in board with T1 input & output through RJ45 jack and Bantam connectors. • T1 signaling supported. • Supports multitone measurements in A-D, D-A and D-D operation. • Output level –72.25 to +0 dBFSp
PureSound™	• License key for patented transient analysis. • Rub & Buzz detection. • Sound correlation. • Click detection.

Table 2 RT-2X options

RT-2X allows testing the audio quality of a device under test (DUT) in three ways:

a) Internal signal analysis: *RT-2X* generates the test signal and analyzes it after transmission through the DUT (p. ***9***).
b) External signal analysis: *RT-2X* analyzes signals that are generated by the DUT (p. ***12***).
c) Special test modes, i.e. arbitrary sine wave generation and DTMF analysis (p. ***12***).

2.1 Internal Signal Analysis

In this mode, *RT-2X* generates the test signal and analyzes it after transmission through the DUT. The user has the choice between three different types of test signals:

1. Multitone bursts, i.e. the simultaneous transmission of 1 – 31 sine waves with user-defined frequencies.
2. Stepped sweep, i.e. the transmission of a sine signal that changes its frequency stepwise (2 – 500 steps) in a user-defined frequency band.
3. Gliding sweep, i.e. the transmission of a sine signal that changes its frequency continuously in a user-defined frequency band. This type of signal is also called "chirp" and is only available with the PureSound™ option.

It is up to the user to select the type of test signal(s) for the actual application. Any combination of 1, 2 or all 3 test signals is allowed.

Multitone Bursts

Audio testing with multitone bursts is a sophisticated approach for an increasing number of applications. It has several advantages:

- Speed – the multitone approach is the fastest way of measuring audio parameters because the test cycle time is not affected by the number of frequencies or executed measurements.
- Flexibility – multitone testing can be used for a very wide range of applications in the telecom or other indstries. Actually, *RT-2X* provides 16 different analysis functions as well as 22 input & output configurations covering virtually all requirements of today's audio testing.
- Significance – multitone signals have a very close correlation to real-world signals as e.g. music or speech and provide accurate and reproducible results.

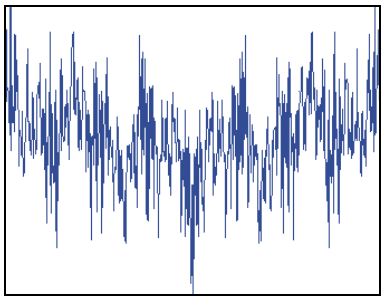

Fig 1 Multitone signal

- Noise immunity – multitone measurements are not or only marginally affected by ambient noise.

Typical devices that are tested with multitone signals are:

- Mobile or wired phones, headsets.
- ADSL modems, linecards, A-D & D-A converters.
- DUTs that comprise of a codec or similar modules that would filter out a single frequency stimulus.
- Signal transmission lines.

On the other hand, there are some products that are less well suited for multitone testing. For instance, if the DUT needs a single frequency test signal or a stimulus that comprises of a very large number of frequencies to let the defect appear, a stepped or gliding sweep must be applied (see next chapters).

Stepped Sweep

Using a stepped sweep as test signal is a simple and very common measurement technique in the Audio world.

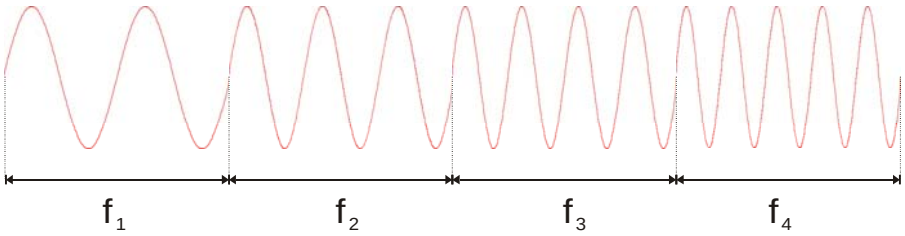

Fig 2 Excerpt of a steppped sweep

Stepped sweep are preferred for applications that require:

- High resolution, i.e. a high number of test frequencies. Typical DUTs that must be tested with a high resolution are electroacoustic transducers (e.g. woofers, drivers, tweeters, speakers etc.).
- Single frequency stimulus, possibly at a high level. Some DUTs comprise of special filters or signal processing modules (e.g. automated gain control, AGC) that must be driven by a single sine wave – possibly in combination with a high level – for testing.

On the other hand, stepped sweeps frequently suffer under the drawback of a longer test cycle time in comparison to multitone bursts. The reason is the time the analyzer needs to settle to every frequency step. Consequently, a high number of steps (i.e. frequencies) result in a longer test cycle time.

Gliding Sweep ("Chirp")

This test signal is only available with the PureSound™ option and is used to drive electroacoustic transducers.

The major advantage of this test signal is that it comprises of every possible frequency in the selected frequency band. This attribute is essential for the reliable detection of Rub & Buzz defects that normally have a very sharp resonance frequency.

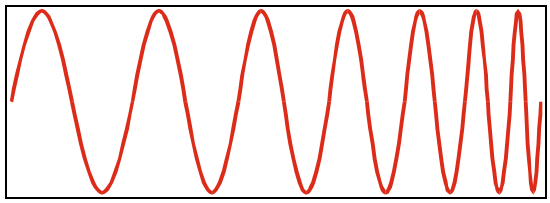

Fig 3 Gliding sweep

The DUTs can be divided into two groups:

- Electroacoustic transducers, e.g. woofers, drivers, tweeters, headphone capsules, microphones etc.
- Products that comprise of electroacoustic transducers, e.g. speaker boxes, PCs, radios, TV-sets, car-subassemblies etc.

The gliding sweep analysis of RT-2X is based on the measurement of transient steepnesses and differs completely from conventional audio measurements such as frequency response or distortion. For further information, please refer to:

- RT-2X Reference Manual
- **NTI** Technical Note "Transient Steepness Analysis"
- Homepages www.rapid-test.com or www.leonhardresearch.com

Overview Internal Signal Analysis

Test signal	**Multitone**			**Stepped Sweep**	**Gliding Sweep** *
Operation mode of generator – analyzer	**A-A**	**A-A or A-D, D-A (half channel)** *	**D-D** *	**A-A**	**A-A**
Sampling rate f_s	48 kHz	8 kHz	8 kHz	48 kHz	48 kHz
Typical test cycle time	400 ms – 1200 ms [1]	550 ms – 1600 ms [1]	550 ms – 1600 ms [1]	1 s – 10 s [2]	500 ms – 5 s [3]
Bandwidth	20 Hz – 20 kHz	20 Hz – 4 kHz	20 Hz – 4 kHz	20 Hz – 20 kHz	20 Hz – 1.5 kHz
Resolution	1 – 31 frequencies			2 – 500 frequencies	1 – 1000 steepness values
Noise immunity	High (regardless of system setup)			Proportional to test cycle time	Automatic noise compensation may prolong the test cycle time
Test signal transmission	Immediately after command ***OUTPut:MTONe:STARt***			Immediately after command ***OUTPut:STEPpedsweep:STARt***	Immediately after command ***OUTPut[1¦2]:PUR:CHIRp:STARt***
Analyzer initialization	• With timeout (***OUTPut:MTONe:STARt***) • Without timeout (***INPut:TRIGger:ARMed***)			***OUTPut:STEPpedsweep:STARt***	***OUTPut[1¦2]:PUR:CHIRp:STARt***
Analyzer triggers to (i.e. starts sampling after)	• Command ***OUTPut:MTONe:STARt*** • Multitone burst with proprietary header • Input signal exceeds user-defined threshold level			***OUTPut:STEPpedsweep:STARt***	• ***OUTPut[1¦2]:PUR:CHIRp:STARt*** • Input signal exceeds user-defined threshold level
Analyzer clock synchronization	• Internal RT-2X clock • "Clock Sync" block of incoming multitone burst			Internal RT-2X clock	Internal RT-2X clock
Measurement functions (multitone measurements are executed after signal transmission; therefore, the number of measurements has no impact on the test cycle time)	• Level (frequency reponse) • Level in a user-defined frequency band • Sound pressure level • Gain • Distortion, MT-SINAD • Noise • Crosstalk • Phase, Polarity • RL, ERL, SRL * • LCL, LCTL * • Dominant frequencies in user-defined bands • DTMF signals	• Level (frequency response) • Level in a user-defined frequency band • Sound pressure level (only in A-A and D-A operation) • Gain • Distortion, MT-SINAD • Noise • Crosstalk • Phase, Polarity • RL, ERL, SRL (only in A-A operation) * • LCL (only in A-A operation), LCTL * • Dominant frequencies in user-defined bands • DTMF signals (generation only in A-A and A-D operation; analysis only in A-A and D-A operation)	• Level (frequency response) • Level in a user-defined frequency band • Gain • Distortion, MT-SINAD • Noise • Crosstalk • Phase, Polarity • Dominant frequencies in user-defined bands	• Level (frequency response) • Sound pressure level	Steepness of transients

Table 3 Internal signal analysis with RT-2X

* Only available if the corresponding option (i.e. PureSound™ key, ISDN or T1 interface, LCL/RL board) has been installed.
[1] Multitone signal with 10 signal bins (i.e. frequencies) between 20 Hz and 20 kHz, including upload of level, distortion and noise measurement results to PC.
[2] Stepped sweep with 100 frequencies between 20 Hz and 20 kHz and with active settling, including upload of level measurement results to PC.
[3] Gliding sweep (chirp) from 20 Hz to 1.5 kHz and with active noise compensation, including upload of 100 steepness values to PC.

2.2 External Signal Analysis

RT-2X provides of a powerful toolset for a comprehensive analysis of signals that are generated externally, i.e. by the DUT itself.
The signal to be analyzed may be of any nature, e.g. electrical, acoustical or mechanical. In the latter cases, a conversion with a microphone or a vibration sensor may be necessary.

	Normal Mode	PureSound™ Mode
Specific Measurement Functions	• Energy (level) in a user-defined frequency band. • Dominant frequency in a user-defined band.	• Steepness of transients. • Sound correlation. • Click detection.
Independent Signal Analysis	• DTMF signals	
Analyzer Triggers to	• "Start" command • Incoming signal exceeds threshold	
Analyzer Synchronization	Internal RT-2X clock	

Table 4 External signal analysis with RT-2X

The level & frequency analysis is used e.g. to verify the presence and correctness of AC-signals:

- Buzzers.
- Vibra call modules of mobile phones.
- etc.

The more sophisticated PureSound™ analysis functions allow detecting a wide range of possible defects:

- Corrupt sound sequences, e.g. ringer melodies of mobile phones.
- Peaks or missing samples ("clicks").
- Packet loss of Bluetooth devices.
- etc.

2.3 Special Test Modes

RT-2X also supports the following two special test modes as a standard:

- Arbitrary sine signal generation, whereby the user has to define the frequency, level and duration of the signal.
- DTMF analysis (DTMF = Dual-Tone Multi-Frequency, i.e. dial tones of telephones). The module allows generating standard DTMF signals as well as de-tuning their frequencies and amplitude-ratio. On the analyzer side, incoming DTMF signals are automatically recorded, decoded and can be analyzed in detail.

3 SYSTEM INSTALLATION

1. Make sure that the AC voltage selector on the rear panel of the *RT-2X* is adjusted to the correct voltage (110, 120 or 230 VAC) before connecting the unit to mains power.

2. Link the *RT-2X* unit to the GPIB IEEE or RS232 interface of the controlling host PC. Adjust the DIP-switch on the *RT-2X* rear panel accordingly.

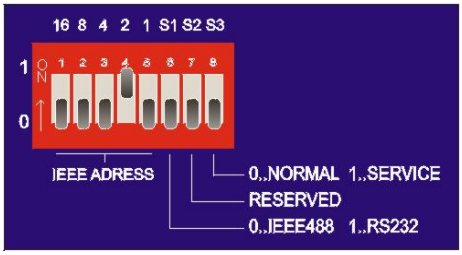

Fig 4 DIP switch setting for IEEE communication (adress #2)

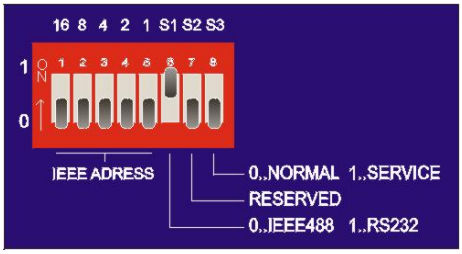

Fig 5 DIP switch setting for RS232 communication

3. Switch ON the *RT-2X* unit. After the initialization procedure, only the green "POWER" LED must be lit.

4. Install **NTI**'s RT-Eval software on your PC and select the appropriate interface settings (the package is enclosed to every new RT unit or can be downloaded from **NTI**'s homepage www.rapid-test.com).

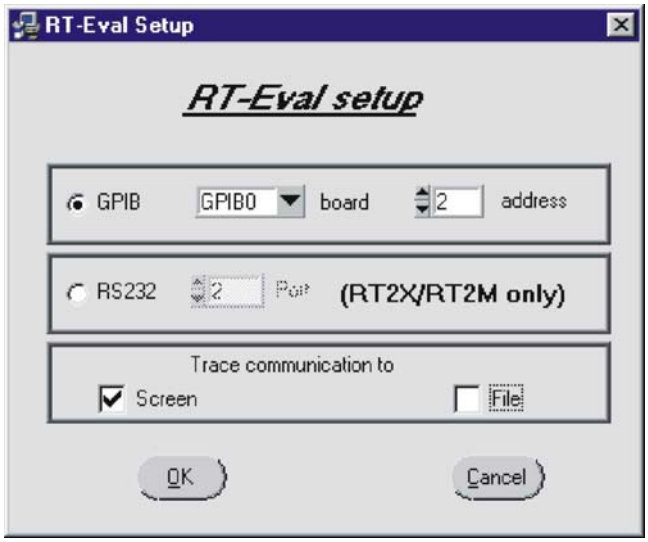

Fig 6 RT-Eval "Setup" panel

5. Start the RT-Eval software and check, whether the communication with *RT-2X* has been established properly.

6. Connect the *RT-2X* outputs & inputs to the DUT and its peripheral instruments. Apply balanced connections wherever possible to increase the noise immunity of the test stand.

4 INTERNAL SIGNAL ANALYSIS

This chapter describes the required test preparation, initialization and execution of an internal signal analysis with *RT-2X*. The following charts provide an overview on the procedures with a multitone burst, a stepped sweep and a gliding sweep (see p. *9*).

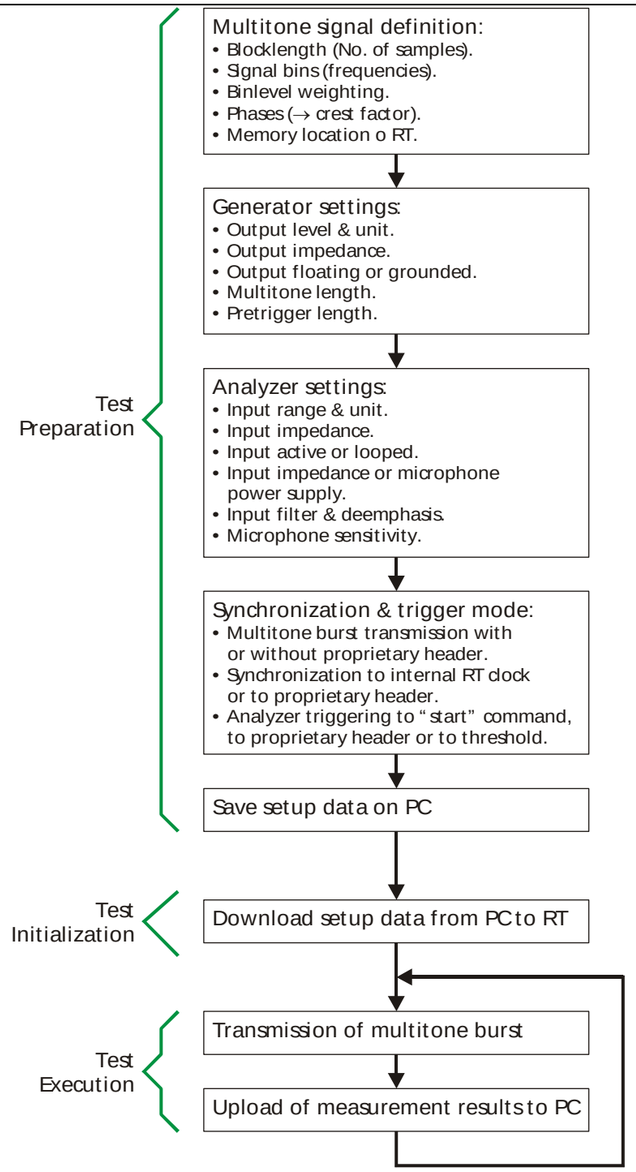

Fig 7 Internal signal analysis with multitone burst

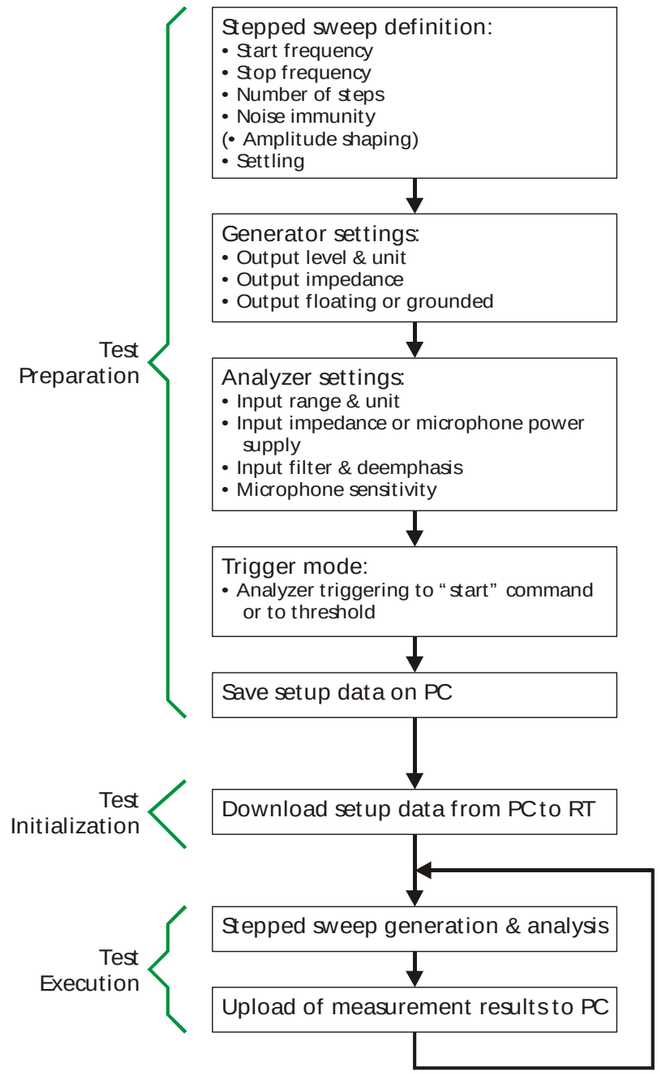

Fig 8 Internal signal analysis with stepped sweep

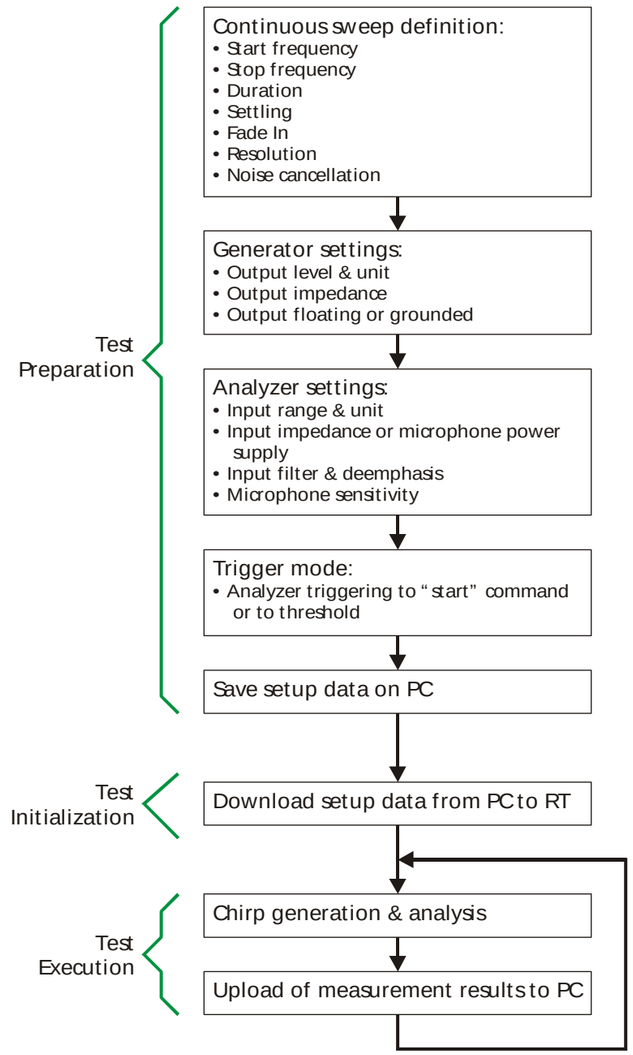

Fig 9 Internal signal analysis with gliding sweep ("chirp")

4.1 Test Preparation

The instructions refer to the operation of RT-Eval, i.e. the PC-software that is enclosed to every new *RT-2X* unit (also available as download from **NTI**'s homepage www.rapid-test.com).

More details about specific adjustments are filed in the chapter ***Test Procedure*** (p. ***31***) and in the ***RT-2X Reference Manual***.

Wiring

Connect RT-2X to the device under test (DUT) according to the specific application as shown on he pictures below.

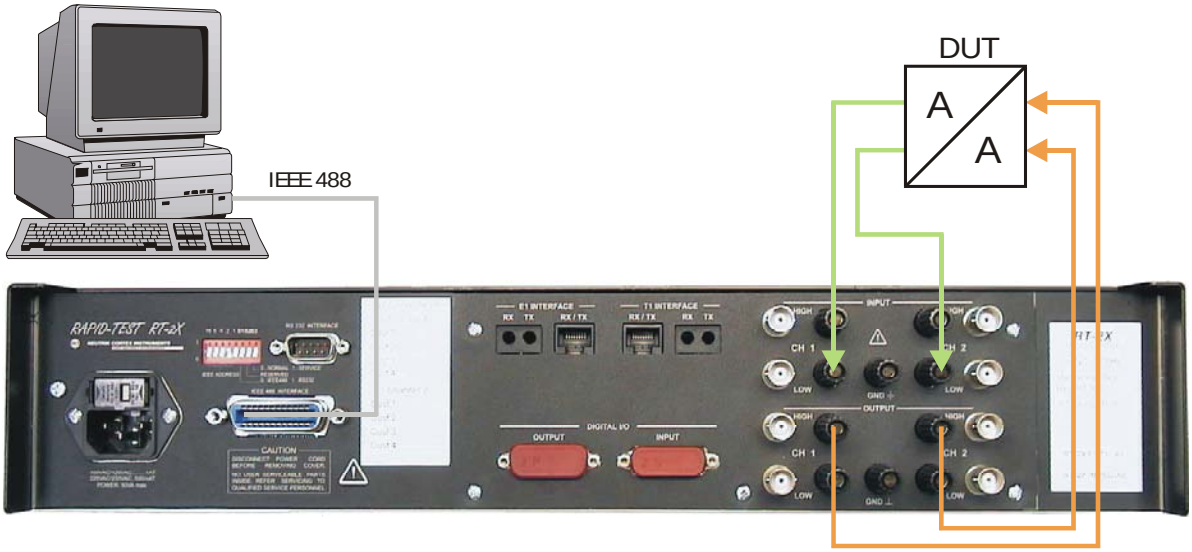

Fig 10 A-A setup

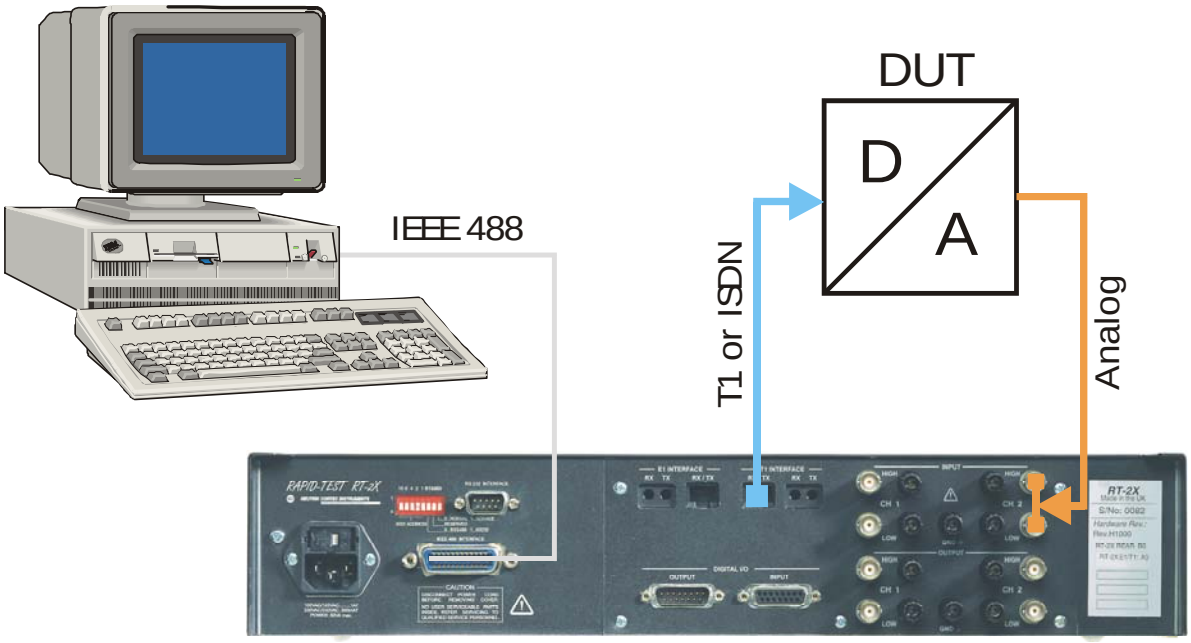

Fig 11 D-A setup

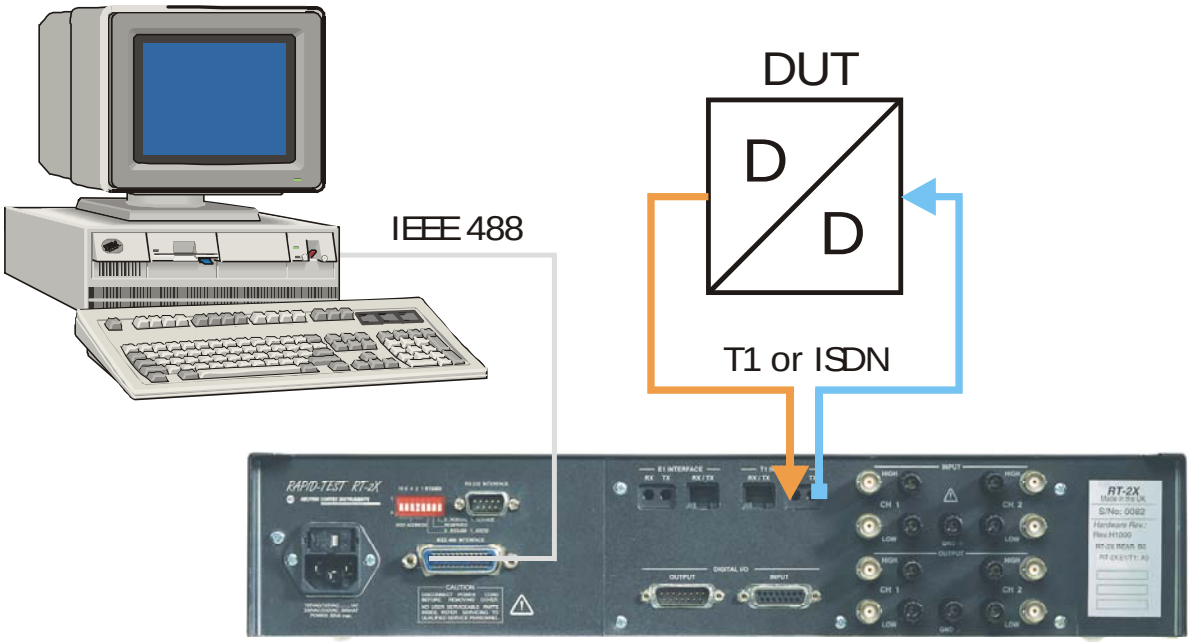

Fig 12 D-D setup

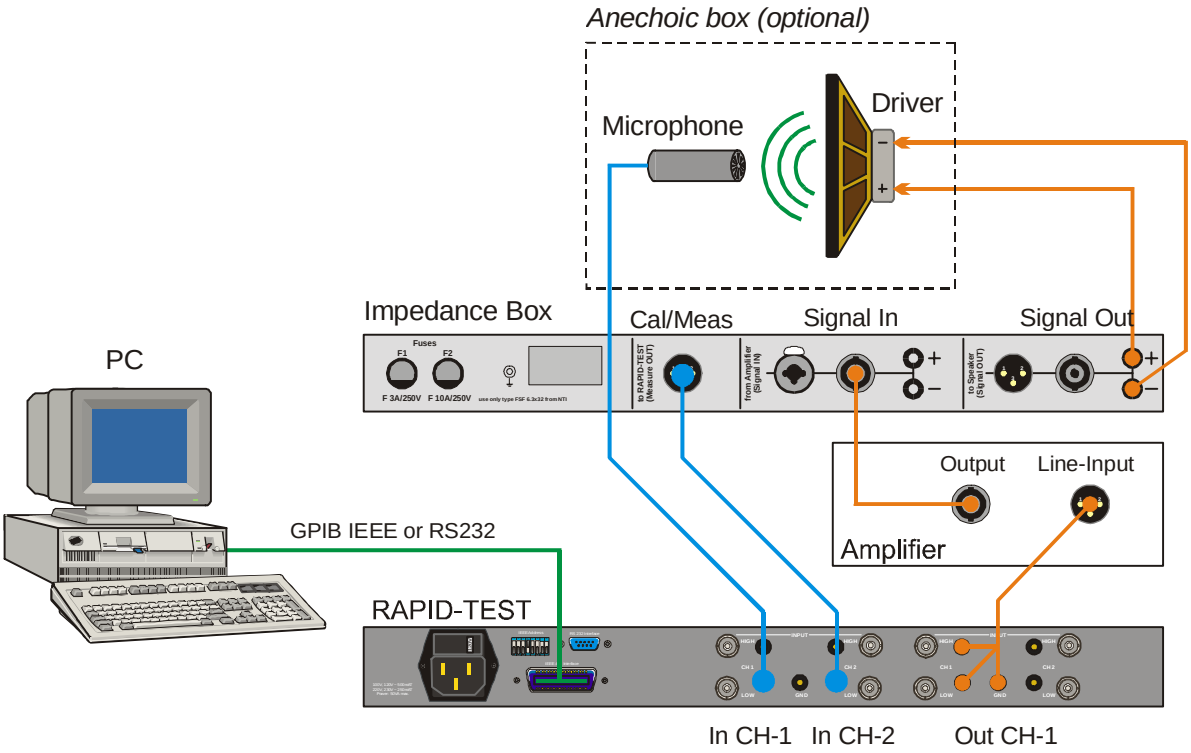

Fig 13 Rub & Buzz test setup

Please refer to the ***RT-2X Reference Manual*** for further details, e.g.:

- Balanced, unbalanced connections.
- Output & input impedance.
- Digital connector pins.
- LCL, LCTL measurements.
- RL, ERL, SRL measurements.

Test signal Selection & Defintion

1. Evaluate the required test signal(s) for the DUT (refer to chapter ***2.1 Internal Signal Analysis***, p. ***9*** for further information). Keep in mind that you can define a sequential test procedure that comprises of one, two or all three test signals.

2. Follow the instructions of the corresponding chapters to define the signal parameters of a multitone burst, stepped sweep or gliding sweep.

Multitone Burst

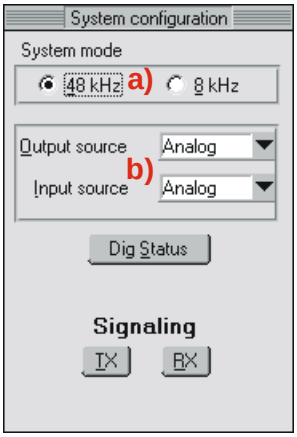

Fig 14 RT-Eval "System configuration" panel

System Mode

a) Adjust the system mode to 48 kHz or 8 kHz (i.e. internal sampling rate). 48 kHz is the best choice for A-A operation. If an ISDN or T1 option is installed, the 8 kHz system mode must be selected for A-D, D-A and D-D operation.

b) Select the generator and analyzer operation: "Analog" or "ISDN / T1".

NOTE **Refer to the *RT-2X Reference Manual* for further details about ISDN and T1 operation.**

Signal Definition

Click on the  button in the RT-Eval main panel to open the "Signal Editor" panel.

a) Select a memory location and enter a name for the new multitone signal. *RT-2X* can store four multitone signals in its nonvolatile memory.

b) Adjust the blocklength (i.e. the number of samples for the multitone signal) if required. The lower the blocklength, the shorter the duration and the lower the frequency resolution of the multitone signal.

c) Delete the obsolete frequencies of the multitone signal that had been stored in the selected memory.

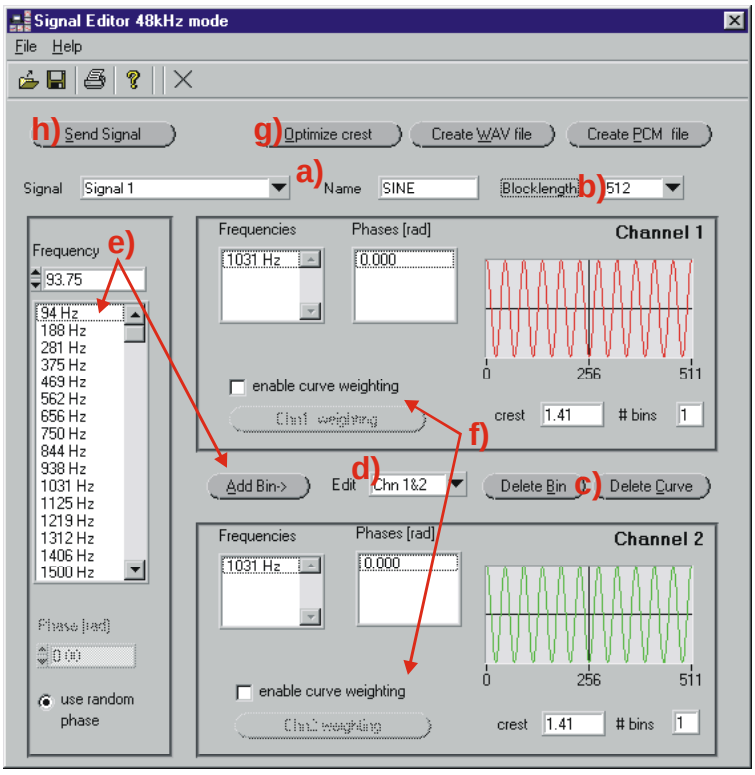

Fig 15 RT-Eval "Signal Editor" panel

d) Some applications (e.g. Crosstalk measurements) require that the multitone burst comprises of two different multitone signals, one in each channel. Therefore, the corresponding channel(s) must be activated before adding signal bins (i.e. frequencies) to the multitone signal as described in step ***e)***.

e) Select the frequencies ("signal bins") that shall build the multitone signal and add them one after the other to the signal. The maximum possible number of signal bins is 31. In case of an individual multitone signal definition for channel 1 and 2, repeat steps ***d)*** and ***e)*** for the alternate channel.

f) If required, define an individual binlevel weighting for the two channels. Please refer to the *RT-2X* ***Reference Manual*** for further details.

g) Open the "Optimize crest factor" panel and click on the "Start" button. As soon as the optimization procedure has stabilized, click to the "Stop" and the "OK" button.

h) Click to the "Send Signal" button to download the new multitone signal from the PC and store it in the non-volatile memory of *RT-2X*.

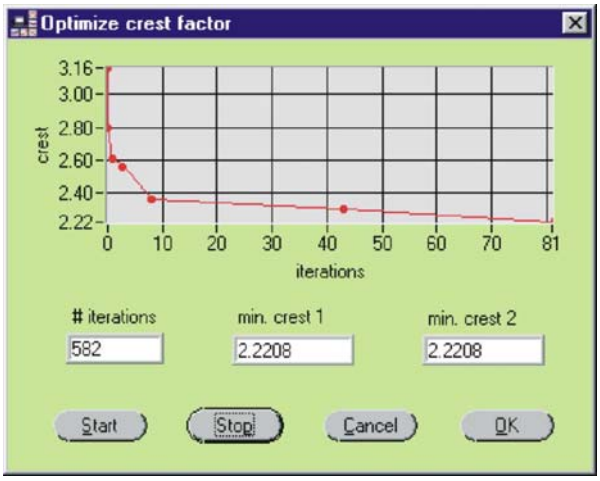

Fig 16 RT-Eval "Optimize crest factor" panel

→ ***Reference Manual***

- Chapter ***Output Level***
- Chapter ***Multitone Signal Definition***
- Command ***SYSTem:MODE [8Ksamplingrate¦48Ksamplingrate]***
- Command ***OUTPut:SOURce [ANALog¦ISDn¦T1]***
- Command ***OUTPut:MTONe:PARameter …***

Stepped Sweep

Make sure that the system mode is set to 48 kHz (see p. ***17***) and click on the button in the RT-Eval main panel to open the "Sweep Setup" panel.

a) Enter the start & stop frequency in the range from 20 Hz to 20 kHz. Note that the first may also be higher than the latter (e.g. f_{Start} = 15 kHz → f_{Stop} = 300 Hz).

b) Enter the number of steps (i.e. frequencies) of the sweep. The minimum number is 2, maximum is 500.

c) Enable the noise immunity feature (i.e. a narrow-band filter that rejects ambient noise) if the test setup is located in a noisy environment. Disabling this feature results in a faster test cycle time at the cost of lower noise immunity.

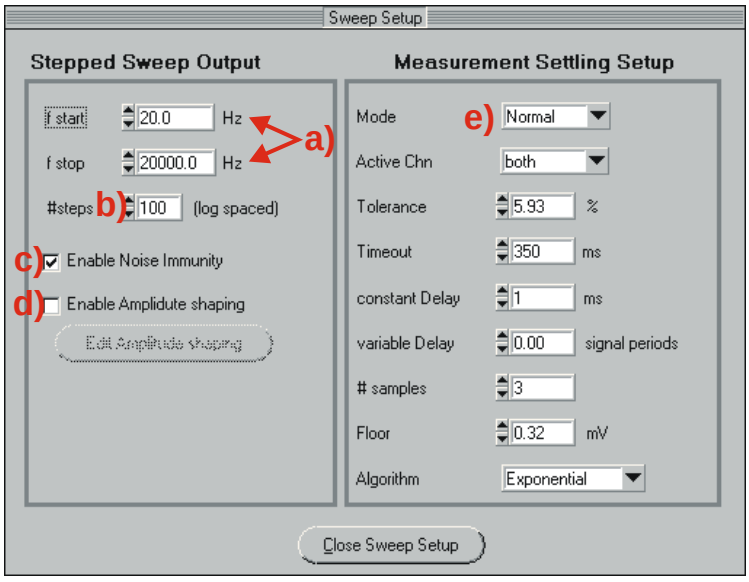

Fig 17 RT-Eval "Sweep Setup" panel

d) If required, define an individual amplitude shaping for the sweep signal. Please refer to the ***RT-2X Reference Manual*** for further details

e) Adjust the settling mode to "Normal" to get absolutely accurate measurement results. If you switch the settling "Off", the stepped sweep test will be speeded up. However, in this case the acquired measurement results have a reduced significance, i.e. they only provide a relative characterization of the DUT.

→ ***Reference Manual***

- Chapter ***Output Level***
- Chapter ***Stepped Sweep Transmission & Measurements***
- Command ***SYSTem:MODE 48Ksamplingrate***
- Command ***OUTPut:STEPpedsweep:FSTArt <Frequency>…***
- Command ***OUTPut:STEPpedsweep:FSTOp <Frequency>***
- Command ***OUTPut: STEPpedsweep:NSTeps <steps>***
- Command ***OUTPut:STEPppedsweep:AMPLitudeshape [DISABLE¦<shape1,shape2,….>]***
- Command ***MEASurement:STEPpedsweep:NOISeimmunity [OFF¦ON]***
- Command ***MEASurement:STEPpedsweep:SETTling:MODE [OFF¦NORMAL]***

Gliding Sweep

Make sure that the system mode is set to 48 kHz (see p. ***17***) and click on the button in the RT-Eval main panel to open the "R&B Setup" panel:

a) The box "Use Generator Chirp" must be ticked if the gliding sweep (i.e. chirp) shall be generated by *RT-2X*.

b) Select the active channel. Note that this setting applies on both the output & input.

c) Enter the start & stop frequency in the range from 20 Hz to 1'500 kHz. Note that the first may be higher than the latter (e.g. f_{Start} = 1 kHz → f_{Stop} = 50 Hz).

d) Adjust the sweep duration ("Length", 100 ms – 10'000 ms), the "Settling" time (0 – 1'000 ms) and the "Fade In" time (0 – 1'000 ms). ***Fig 19*** and ***Table 5*** explain the backgrounds of these parameters.

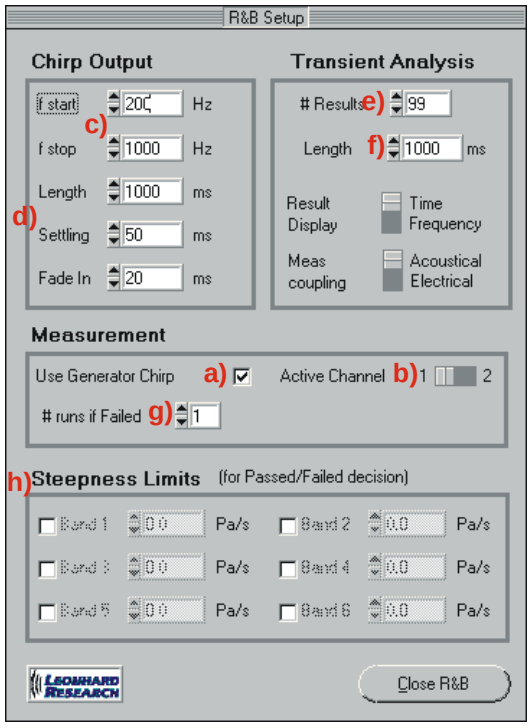

Fig 18 RT-Eval "R&B Setup" panel

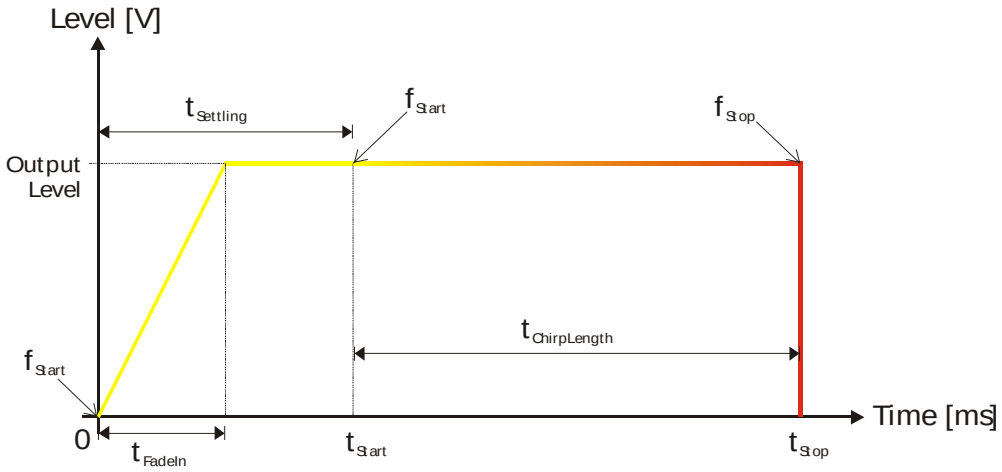

Fig 19 Gliding sweep parameters

- f_{Start} is the frequency, at which the gliding sweep starts.
- f_{Stop} is the frequency, at which the gliding sweep stops.
- $t_{Settling}$ represents the time, during which a sine signal with f_{Start} is generated before the chirp starts. This allows the DUT settling to the stimulus.
- t_{FadeIn} represents the time, during which the *RT-2X* output voltage is raised continuously from 0 V to the *RT-2X* output level. A fade-in may be required to reduce initial transients. Normally, t_{FadeIn} is below or equal to $t_{Settling}$.
- *Chirp Length* equals the duration of the core sweep i.e. the time from t_{Start} to t_{Stop}. The overall chirp duration $t_{Total} = t_{Settling} + t_{ChirpLength}$.

Table 5 Gliding sweep parameters

e) Enter the number of steepness values that build the result (i.e. the resolution of the steepness graph). *RT-2X* divides the time period "$t_{ChirpLength}$" in the corresponding number of intervals and returns the maximum steepness of each interval as result.

f) Adjust the duration of the transient analysis ("Length", 100 ms – 10 s).
   - If the continous sweep is generated by *RT-2X*, this value should be equal to the "Chirp Output Length" as defined in step ***d)***.
   - If an external device generates the chirp, the "Transient Analysis Length" must be adjusted to the corresponding duration.

g) If the system is operated in a noisy environment, activate the noise cancellation by adjusting the "# runs if failed" to 2 or 3. Consequently, *RT-2X* will repeat a measurement 2 – 3 times if the Pass/Fail limits are exceeded to find out whether the cause has been a systematic error of the DUT or ambient noise.

→ ***Reference Manual***

- Chapter ***Output Level***
- Chapter ***PureSound™ Mode***
- Chapter ***PureSound™ Chirp (Gliding Sweep) Parameters***
- Command ***SYSTem:MODE 48Ksamplingrate***
- Command ***OUTPut:PUResound:CHIRp:FSTArt <Frequency>***
- Command ***OUTPut:PUResound:CHIRp:FSTOp <Frequency>***
- Command ***OUTPut:PUResound:CHIRp:LENGth <Duration>***
- Command ***OUTPut:PUResound:CHIRp:MAXRuns <Runs>***
- Command ***OUTPut:PUResound:CHIRp:SETTling <Duration>***
- Command ***OUTPut:PUResound:CHIRp:FADEin <Duration>***

Generator Output Settings

Analog Generator Operation (A-A, A-D)

Before you start with the analog generator settings, execute the following steps:

- Adjust the system mode to 48 kHz (recommended) or 8 kHz (only required for A-D operation) and the output source to "Analog" (see p. ***17***).
- Select the required multitone signal in the "Multitone" panel (this is only necessary if the test cycle comprises of a multitone burst).

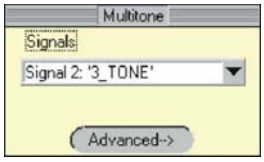

Fig 20 RT-Eval "Multitone" panel

Next, click on the "Advanced" button in the "Generator" panel to provide access to all output settings.

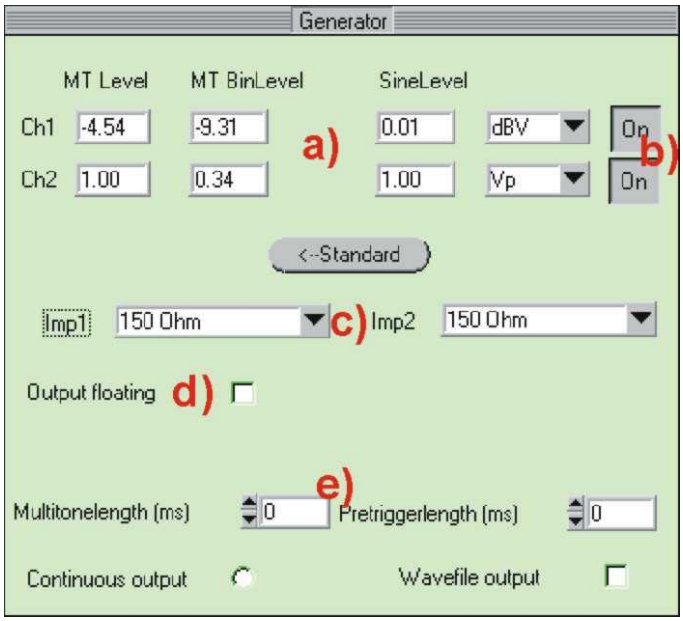

Fig 21 RT-Eval "Generator" panel (analog operation)

a) Adjust the level unit(s) and the output level of channel 1 & 2. Please note the correlation between the "MT Level", the "MT BinLevel" and the "SineLevel":
   - MT Level → The level of the multitone signal. This value corresponds to the actual output level of ***RT-2X***.
   - MT BinLevel → The level of the signal bins that build the multitone signal. This value is always equal or smaller than the MT Level. Therefore, be careful with the direct adjustment of the MT BinLevel and always watch the MT Level to avoid overloading.
   - SineLevel → The level of a pure sine wave that corresponds to the peak level of the active multitone signal. Consequently, if the MT Level is expressed in a peak unit, i.e. [Vp] or [dBVp], it is always identical to the SineLevel.

   For most cases it is recommended to adjust the MT Level. Only few applications require the direct adjustment of the MT BinLevel, whereby the SineLevel is only used for specific telecom applications.

b) The two output channels can be muted individually if required. In this case, the output plugs are disconnected from the generator, but not from the output impedance module (see next step).

c) Adjust the output impedance of channel 1 & 2. A proper selection is especially important if the output level is expressed in the unit [dBm].

d) Tick the box "Output floating" if the *RT-2X* generator shall not be connected to ground.

e) The "Pretriggerlength" and "Multitonelength" artificailly prolong the header of the multitone signal and the multitone signal itself. This may be necessary if the DUT needs some time to settle to the transmitted signal, e.g if it comprises of an automated gain control (AGC).

→ ***Reference Manual***

- Chapter ***Output Level***
- Command ***SYSTem:MODE [8Ksamplingrate¦48Ksamplingrate]***
- Command ***OUTPut:SOURce ANALog***
- Command ***OUTPut[1¦2]:LEVel …***
- Command ***OUTPut[1¦2]:BINlevel …***
- Command ***OUTPut[1¦2]:SINlevel …***
- Command ***OUTPut[1¦2]:MUTe [OFF¦ON]***
- Command ***OUTPut[1¦2]:IMPedance …***
- Command ***OUTPut:FLOAT [OFF¦ON]***
- Command ***OUTPut:MTONe:PRETriggerlength <Length>***
- Command ***OUTPut:MTONe:MTONelength <Length>***

Digital Generator Operation (D-A, D-D)

NOTES **The digital generator functions are only available if RT-2X is equipped with an ISDN or a T1 option.**
For ISDN operation, a NT (network terminator) must be connected to the test circuit.

Before you start with the digital generator settings, execute the following steps:

- Adjust the system mode to 8 kHz and the output source to "Analog" (see p. ***17***).
- Select the required multitone signal in the "Multitone" panel (see p. ***22***).

Next, click on the "Advanced" button in the "Generator" panel to provide access to all output settings.

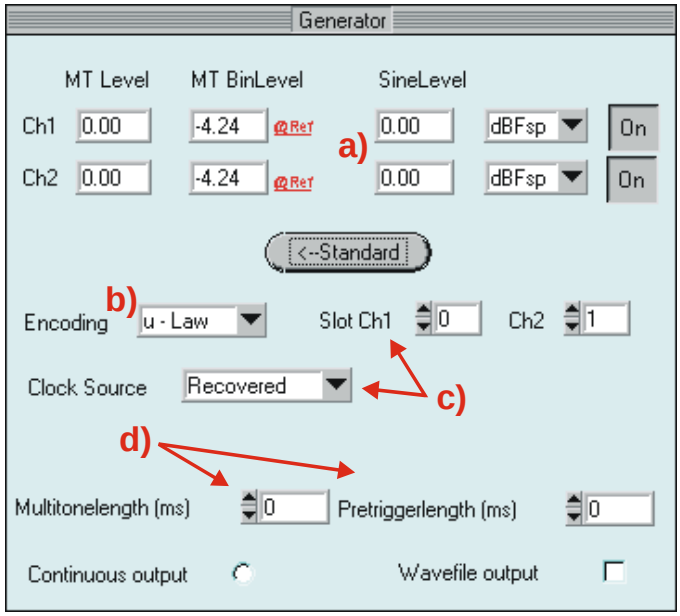

Fig 22 RT-Eval "Generator" panel (digital operation)

a) Adjust the level unit(s) and the output level of channel 1 & 2. Please note the correlation between the "MT Level", the "MT BinLevel" and the "SineLevel":
   - MT Level → The level of the multitone signal. This value corresponds to the actual output level of RT-2X.
   - MT BinLevel → The level of the signal bins that build the multitone signal. This value is always equal or smaller than the MT Level. Therefore, be careful with the direct adjustment of the MT BinLevel and always watch the MT Level to avoid overloading.
   - SineLevel → The level of a pure sine wave that corresponds to the peak level of the active multitone signal. Consequently, if the MT Level is expressed in a peak unit, i.e. [Vp] or [dBVp], it is always identical to the SineLevel.

   For most cases it is recommended to adjust the MT Level. Only few applications require the direct adjustment of the MT BinLevel, whereby the SineLevel is only used for specific telecom applications.

b) Select the "Encoding" of the generated signal.

c) If the RT-2X unit is equipped with a T1 interface, adjust the "Slot #" of the output channels and the "Clock Source" according to your demands (further details are filed in the ***RT-2X Reference Manual***).

d) The "Pretriggerlength" and "Multitonelength" artificailly prolong the header of the multitone signal and the multitone signal itself. This may be necessary if the DUT needs some time to settle to the transmitted signal, e.g if it comprises of an automated gain control (AGC).

→ ***Reference Manual***

- Chapter ***Output Level***
- Chapter ***Digital Circuits***
- Chapter ***ISDN Interface***
- Chapter ***T1 Interface***
- Command ***SYSTem:MODE 8Ksamplingrate***
- Command ***OUTPut:SOURce [ISDn¦T1]***
- Command ***OUTPut[1¦2]:LEVel …***
- Command ***OUTPut[1¦2]:BINlevel …***
- Command ***OUTPut[1¦2]:SINlevel …***
- Command ***OUTPut[1¦2]:MUTe [OFF¦ON]***
- Command ***OUTPut:MTONe:PRETriggerlength <Length>***
- Command ***OUTPut:MTONe:MTONelength <Length>***

Analyzer Input Settings

Analog Analyzer Operation (A-A, D-A)

Before you start with the analog analyzer settings, execute the following steps:

- Adjust the system mode to 48 kHz (recommended) or 8 kHz (only required for D-A operation) and the input source to "Analog" (see p. ***17***).
- Select the required multitone signal in the "Multitone" panel (this is only necessary if the test cycle comprises of a multitone burst).

Next, click on the "Advanced" button in the "Analyzer" panel to provide access to all input settings.

a) Adjust the level unit(s) and the input range(s) of channel 1 & 2. If you are uncertain about the proper value, click on the "Opt." button to open the "Range optimizer" panel.
   - Tick the boxes of the active channels. Parallel optimization of the input range is supported.
   - The "User headroom" defines the difference between the maximum recorded input level and the input range It is by default +6 dB and can be adjusted by the user.
   - Click on the "Find Range" button to start the procedure.
   - Watch the results and click on the "Copy ranges" button if they make sense.

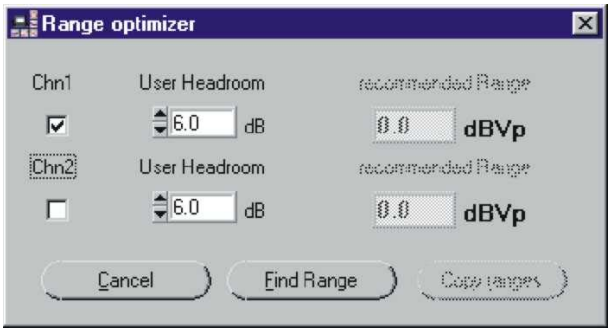

Fig 24 RT-Eval "Range optimizer" panel

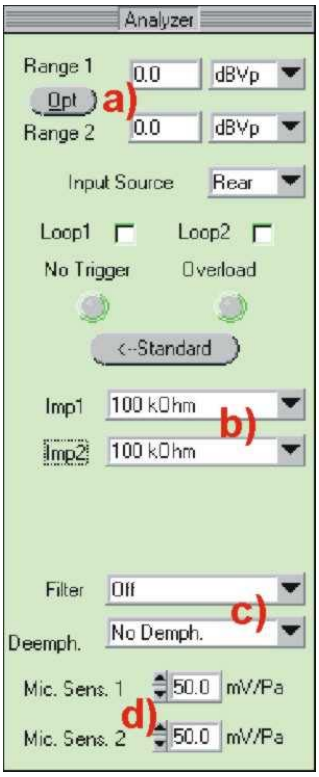

Fig 23 RT-Eval "Analyzer" panel (analog operation)

b) Adjust the input impedance of channel 1 & 2. If a microphone is connected to the ***RT-2X*** inputs, activate the internal "Phantom" microphone power supply (15 V or 48 V).

c) Activate an input filter (A-weighting, C-weighting or CCITT psophometric) or the deemphasis (750 µs) if required.

d) For sound pressure level (SPL) measurements it is necessary to enter the sensitivity of the used microphone im [mV/Pa], i.e. millivpolt per Pascal.

→ ***Reference Manual***

- Chapter ***Input Range***
- Command ***SYSTem:MODE [8Ksamplingrate¦48Ksamplingrate]***
- Command ***INPut:SOURce ANALog***
- Command ***INPut[1¦2]:RANGe …***
- Command ***MEASurement[1¦2]:HEADroom?***

- Command ***INPut[1¦2]:IMPedance …***
- Command ***INPut:SWFilter …***
- Command ***INPut:DEEMphasis [OFF¦ON]***
- Command ***INPut[1¦2]:MICSensitivity <Sensitivity>***

Digital Analyzer Operation (A-D, D-D)

NOTES **The digital analyzer functions are only available if RT-2X is equipped with an ISDN or a T1 option.**
For ISDN operation, a NT (network terminator) must be connected to the test circuit.

Before you start with the analog analyzer settings, execute the following steps:

- Adjust the system mode to 8 kHz and the input source to "Analog" (see p. ***17***).
- Select the required multitone signal in the "Multitone" panel (p. ***22***).

Next, click on the "Advanced" button in the "Analyzer" panel to provide access to all input settings.

a) Select the required "Decoding" (OFF, A-Law or µ-Law).

b) If the RT-2X unit is equipped with a T1 interface, adjust the "Slot #" for the input channels according to your demands (please refer to the ***RT-2X Reference Manual*** for further details).

c) Activate an input filter (A-weighting, C-weighting or CCITT psophometric) or the deemphasis (750 µs) if required.

→ ***Reference Manual***

- Chapter ***Digital Circuits***
- Chapter ***ISDN Interface***
- Chapter ***T1 Interface***
- Command ***SYSTem:MODE 8Ksamplingrate***
- Command ***INPut:SOURce [ISDn¦T1]***
- Command ***INPut:SWFilter …***
- Command ***INPut:DEEMphasis [OFF¦ON]***

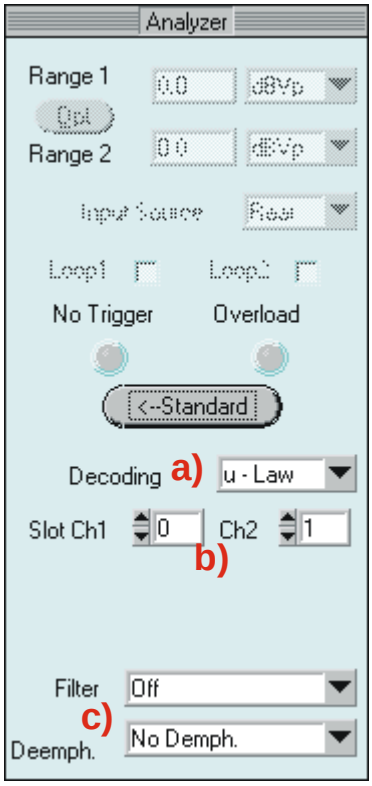

Fig 25 RT-Eval "Analyer" panel (digital operation)

Trigger Modes & Analyzer Synchronization

Depending on the test signal, the *RT-2X* unit must be prepared properly to let the analyzer trigger to the incoming signal and to ensure a correct synchronization of the analyzer.

Click on the "Advanced" button in the "Sync mode" panel to provide access to all trigger modes & settings.

a) Select the trigger mode depending on the test signal and the specific restrictions of the setup. Please refer to the subsequent chapters for further details (***Multitone Trigger Modes***, ***Stepped Sweep Trigger Mode*** and ***Gliding Sweep (Chirp) Trigger Modes***, p. ***29*** - ***30***).

b) If you have selected the THReshold mode, adjust the "Trigger Level", the "Pre Meas Delay" and the "Post Meas Delay" (refer to the ***RT-2X Reference Manual***).

c) Adjust the trigger timeout in case that there is a delay > 500 ms on the signal path. If the delay is > 10 sec, proceed as described in the ***RT-2X Reference Manual***.

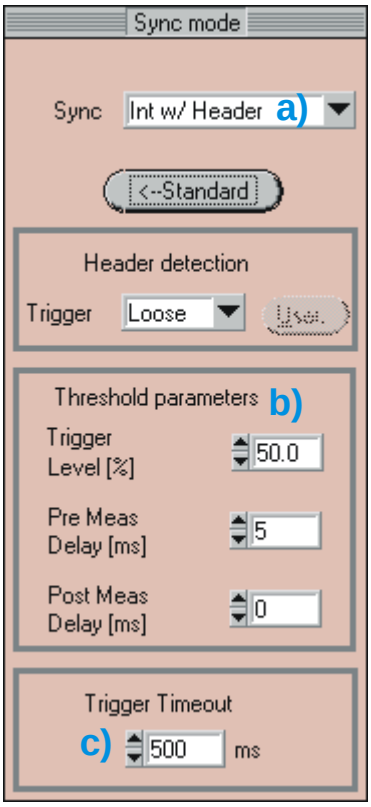

Fig 26 RT-Eval "Sync mode" panel

→ ***Reference Manual***

- Chapter ***Triggering & Signal Acquisition***
- Chapter ***Input Range***
- Command ***INPut:SYNC [INTernal¦INTNoheader¦EXTernal¦EXTNoheader¦THReshold]***

Multitone Trigger Modes

The user has the choice between three trigger modes:

1. *Internal with header* (INTernal).
   - The start command forces the *RT-2X* generator to send out the active multitone signal, preceded by the proprietary header.
   - After the start command, the analyzer waits for a proprietary trigger during maximum 10 seconds. If it detects a multitone burst during this period, it samples the signal. Otherwise, the analyzer returns an error message.
   - The internal *RT-2X* clock drives the generator & analyzer.
2. *Internal without header* (INTNoheader).
   - The start command forces the *RT-2X* generator to send out the active multitone signal without proprietary header, whereby the analyzer starts sampling simultaneously.
   - The internal *RT-2X* clock drives the generator & analyzer.
3. *External with header* (EXTernal).
   - The start command forces the *RT-2X* generator to send out the active multitone signal, preceded by the proprietary header.
   - After the start command, the analyzer waits for a proprietary trigger during maximum 10 seconds. If it detects a multitone burst during this period, it samples the signal. Otherwise, the analyzer returns an error message.
   - The analyzer synchronizes its clock frequency to the "Clock Sync." block of the incoming proprietary header.

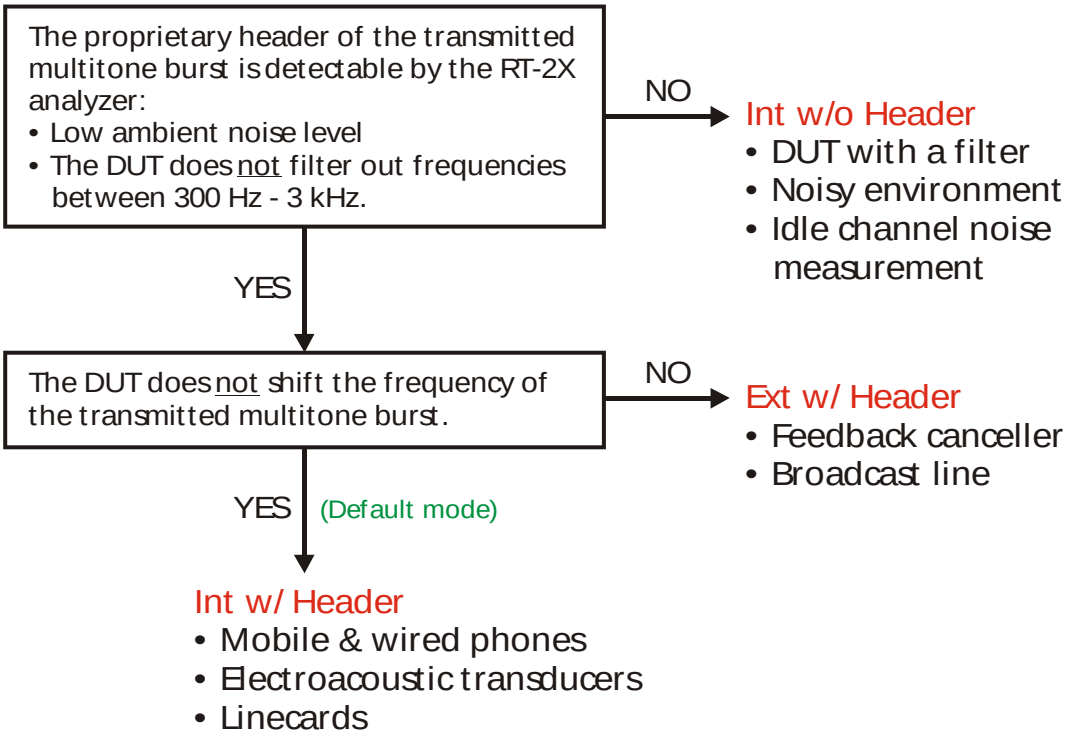

Fig 27 Multitone trigger mode selection

Stepped Sweep Trigger Mode

The stepped sweep operates with a fixed link between the RT-2X generator & analyzer, i.e. the user does not need to select a specific trigger mode.

Gliding Sweep (Chirp) Trigger Modes

The usere has the choice between two trigger modes:

1. *Internal without header* (INTNoheader).
   - The start command forces the RT-2X generator to transmit the chirp, whereby the analyzer starts sampling simultaneously.
   - The internal RT-2X clock drives the generator & analyzer.
2. *Threshold* (THReshold)
   - The start command forces the RT-2X generator to transmit the chirp.
   - The analyzer triggers as soon as the input signal level exceeds the user-defined limit and immediately starts sampling (NOTE: the incoming chirp may be generated by an external device as well).
   - The internal RT-2X clock drives the generator & analyzer.

Save Setup Data on PC

Click on the  button in the RT-Eval main panel to save the current settings in an "application file" (*.app) on the harddsik of your PC.

4.2 Test Procedure

Initialization

Before you enter the test execution, make sure that *RT-2X* unit is set up correctly. For this purpose, reload the corresponding application file (see chapter ***Save Setup Data on PC***, p. ***30***).

The "Measurement" menu provides access to the available measurement panels.

Multitone Measurements

Select the entry Add Panel to open a standard measurement panel. Up to eight of these panels may be opened in parallel.

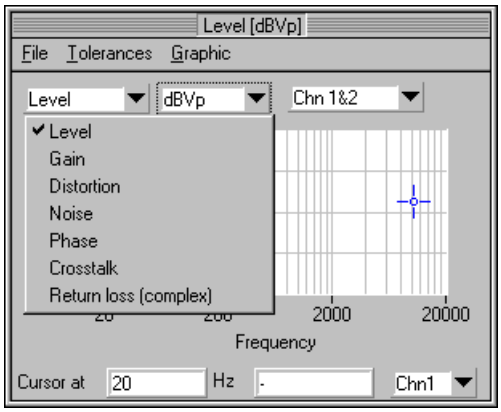

Fig 29 RT-Eval measurement panel

Fig 29 shows the list of available multitone measurement functions that can be activated. Select the required function within each panel and adjust the unit and input channel(s) according to your demands.

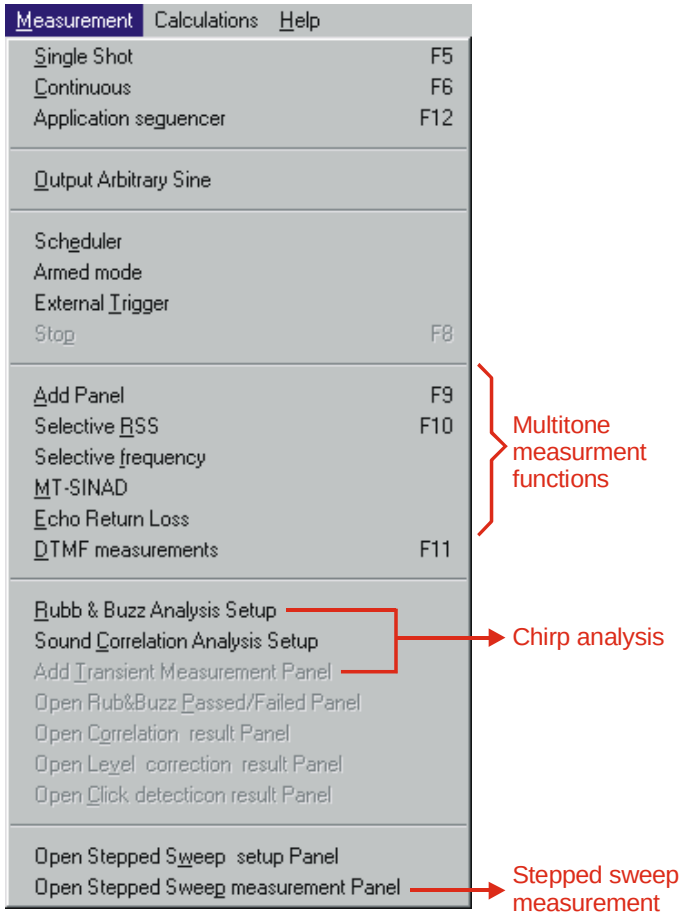

Fig 28 RT-Eval "Measurement" menu

The entries Selective RSS, Selective frequency and MT-SINAD open the corresponding panels. Within each of them, adjust the corresponding parameters (e.g. frequency range, input channel or unit) according to your demands.

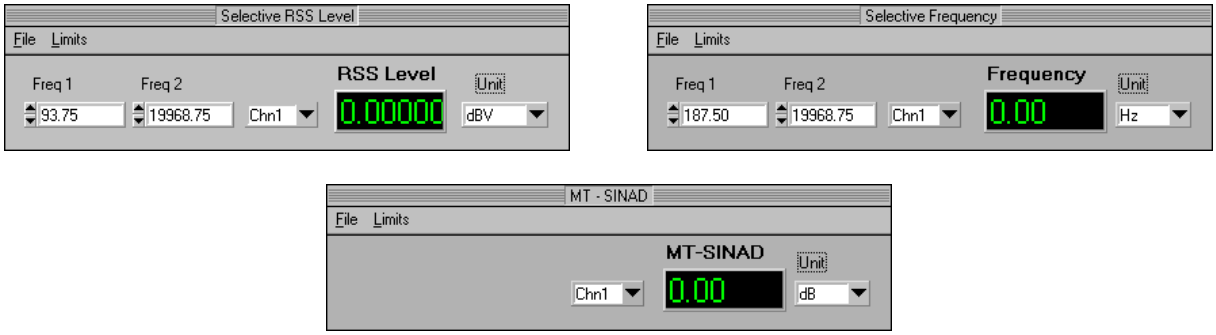

Fig 30 RT-Eval "Selective RSS level", "Selective Frequency" and "MT-SINAD" panels

Stepped Sweep Measurements

Select the entry Open Stepped Sweep measurement Panel. Consequently, the "Sweep Level" panel opens, wherein the frequency response of the transmitted stepped sweep will be displayed.

Select the result unit and the input channel(s) according to your demands.

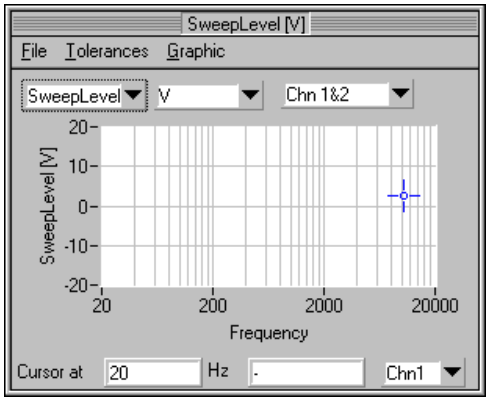

Fig 31 RT-Eval" Sweep Level" panel

Steepness Analysis with Gliding Sweep (Chirp)

To open a steepness result panel, first click on the entry Rub & Buzz Analysis Setup and then on the entry Add Transient Measurement Panel. Therein, the measured steepness values of the transmitted chirp will be displayed.

Select the result unit and the displayed bands as well as the user-defined steepness limits according to your demands.

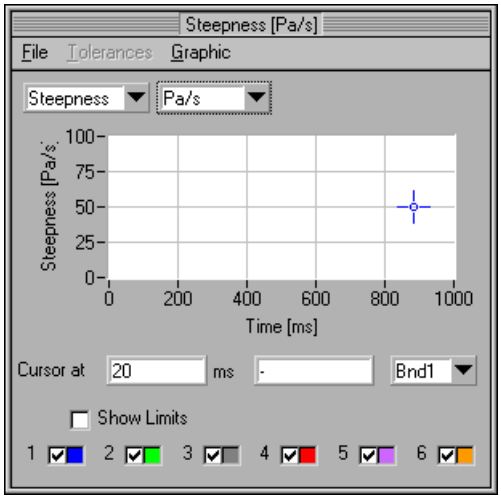

Fig 32 RT-Eval "Steepness" panel

→ ***Reference Manual***

- Chapter ***Multitone Measurements***
- Chapter ***Stepped Sweep Transmission & Measurements***
- Chapter ***PureSound™ Steepness Measurements***
- Commands ***MEASurement…***

Test Execution

Click on the GO button or press the F5 key to start the signal transmission. The measurement results of the selected functions will be displayed automatically in the corresponding panels.

→ ***Reference Manual***

- Command ***OUTPut:MTONe:STARt***
- Commands ***MEASurement…***

OPTIONS & ACCESSORIES

Order Code	*Description*	*Remarks*
RT2X RCIO	**Custom-defined input & output impedance**. The option consists of a user-defined input & output impedance (real or complex).	*Maximum 4 pcs RCIO options per impedance board.*
RT2X ISDN	**ISDN digital interface**. Provides 64 kbits/s ISDN S_0 Bus for multitone signal transmission through a digital Basic Rate Interface (BRI).	*Maximum 1 pc ISDN option per RT-2X unit. Cannot be installed together with the T1 option.*
RT2X T1	**T1 digital interface**. Plug-in board with 1.554 Mbits/s T1 interface, carrying 30 PCM channels. Includes basic signaling capabilities.	*Maximum 1 pc T1 option per RT-2X unit. Cannot be installed together with the ISDN option.*
RT2X LCL/RL	**LCL/RL option.** Plug-in board to measure LCL, LCTL, RL, ERL and SRL.	*Supports 1-channel measurements.*
RT2X LCL Compensation Box	**Reference box for LCL wiring compensation.** This device allows compensating the parasitic capacitance of a wiring between *RT-2X* and the DUT, thus optimizing the measuring accuracy.	
3382	**¼" measuring microphone**. Requires 15 V Phantom power supply and XLR connector.	*+15V Phantom power standard feature of RT-2X.*
3384	**½" measuring microphone**. Requires 48 V Phantom power supply and XLR connector.	*+48V Phantom power standard feature of RT-2X.*
XLR Adapter	**XLR-to-Banana adapter**. Allows connecting a measuring microphone with 3-pin XLR plug to the input Banana jacks of *RT-2X*.	*Maximum 2 adapters may be connected to the input section of RT-2X.*
PureSound™	**License code + RT-Speaker Software**. Patented method for Rub & Buzz detection and sound correlation measurements. Includes PC-software for Rub & Buzz testing on production lines.	*30 days free license available upon request.*
Imp Test Box	**Impedance Test Box**. Additional rack-mount box with switchable shunt resistors (0.1 and 1.0 Ω).	*Required for impedance measurements*

Table 6 Hardware Options & Accessories

Software Tools & Application Notes

Several PC-software packages & application notes are available free of charge from **NTI**. The software packages require a GPIB interface-board from National Instruments™ or a compatible PC-card if the unit is operated under IEEE control.

- RT-EVAL Evaluation Software.
- RT-License Software for License Key Activation (e.g. PureSound™).
- LabView® and LabWindows® CVI Driver Library.
- Comparison of Conventional vs. Multitone Testing.
- Multitone Testing.
- Mobile Phone Testing, Mobile Phone Test Setups.
- Loudness Rating Measurements.
- Rub & Buzz Detection with PureSound™.
- Sound Correlation Analysis with PureSound™.
- Vibration Analysis.
- DTMF Signal Analysis.
- Thiele-Small Parameters and Cpk, Ppk Process Control Analysis.