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Find the *Neutrik Test Instruments RT-2M* at our website: *Click HERE*

Less noise • More sound

RT-2M

High-Speed Analog Audio Test System

Reference Manual

Refers to firmware revision 7.10 or higher

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V 2.2.2 / Dec. 2007 / MBe

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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-2M
Year of Construction	1999

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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Installation

Unpacking

RT-2M has been carefully packed by **NTI** to avoid damages during transportation. Should the box show severe damages, please immediately check the instrument inside for external impacts. In case of any visible damage, please do not send the instrument back but contact your local **NTI** dealer or the carrier to avoid loss of claims for replacement.

Rack Mount

RT-2M is designed to mount in a 19" Rack and occupies only one unit of height or rack space (1.75"). Please allow at least 2" additional depth at the back for all necessary connectors.
Make sure there is enough fresh air circulation through the cooling slots and around the unit, and do not place *RT-2M* besides high temperature devices such as power amplifiers to avoid overheating. The specified temperature range is 5° C – 45° C (40° F – 110° F), whereby the humidity must not exceed 90 % R.H. non-condensing.

AC Power Connection

Before connecting the instrument to mains power make sure that the selected voltage matches the one of your area. *RT-2M* can operate from 100 VAC, 120 VAC and 230 VAC sources.

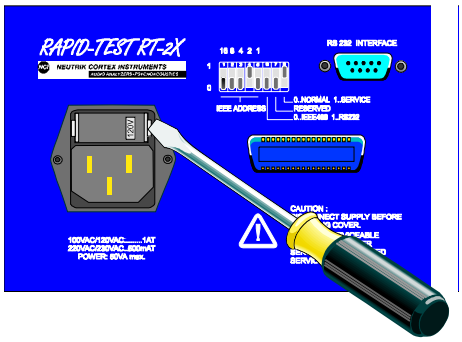


Fig 1 Voltage Selector

To change the mains voltage of *RT-2M*, remove the power cable and open the flap of the fuse holder at the rear side of *RT-2M*. Press a small screwdriver into the slot to open the flap as shown in ***Fig 1*** or ruin your fingernails.
Take out the drum and insert it in the new position, so that the proper voltage indicator points towards you. At the same time, replace the mains fuse with the proper current rating:

- 1 A slow for 100 / 120 VAC
- 500 mA slow for 230 VAC

After selection of the correct mains voltage, close the flap and insert the power cable.



***RT-2M* is connected with earth through the ground wire of the mains power cable. This connection is essential for safe operation and must not be interrupted.**

Mains Power Cable

The mains power cable that is included to the unit has an unconnected end with three colored leads. Connect these leads to an appropriate mains plug as follows:

- Brown → Live (AC)
- Blue → Ground
- Yellow-Green → Earth

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Warranty

Limited Warranty

NTI guarantees the *RT-2M* 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 damage, pack your *RT-2M* 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 *Installation* (p. *3*) 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.

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Block Diagrams

Generator

RT-2M contains a completely independent two-channel arbitrary generator. The digital section has its own high level microprocessor enabling the system to react flexibly to external events, communicate with various interfaces and reprogram the sample counter for the arbitrary generator

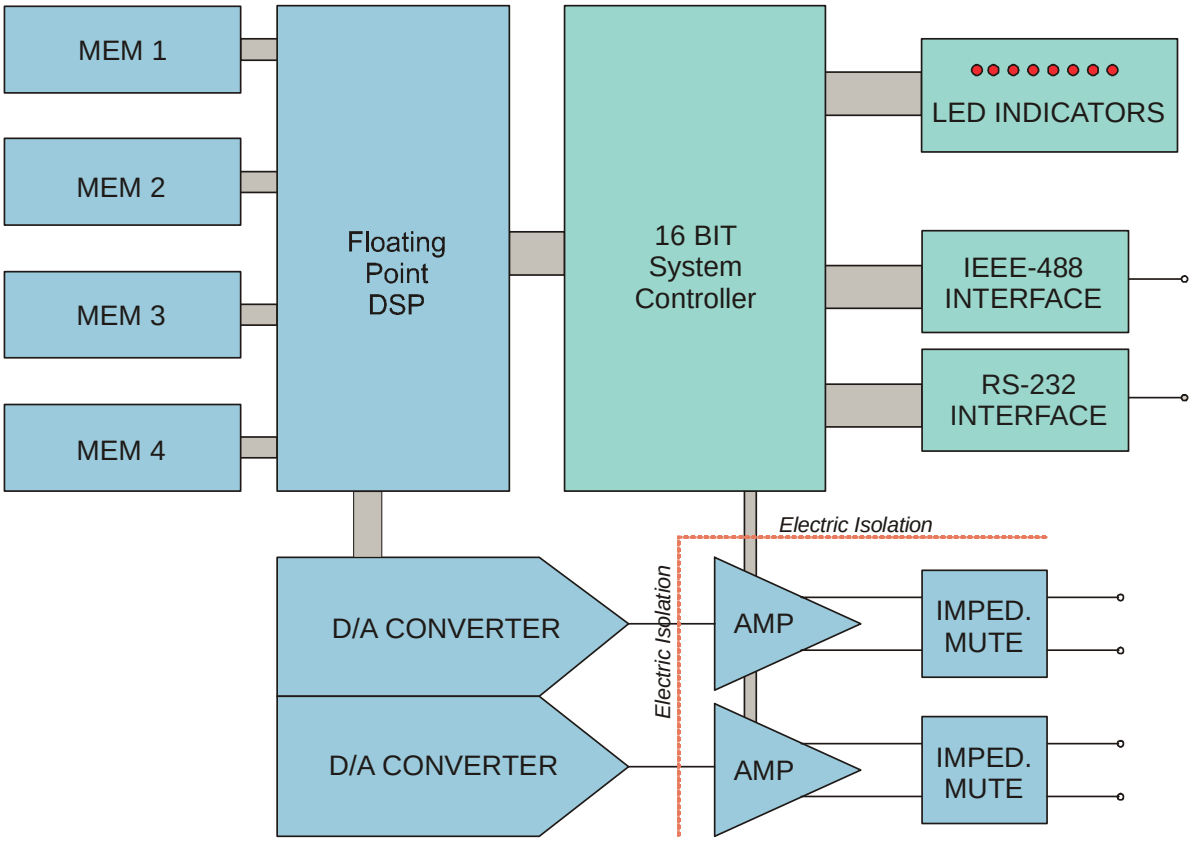


Fig 2 Block Diagram Generator

Digital Section

The CPU reads the samples out of a non-volatile memory. The memory block provides capacity for eight independent test signals, each with 16 bit resolution and any length as defined in ***Table 12***. Space is also provided for the header of each signal. The master clock is derived from a high precision crystal.

Analog Section

The two-channel analog output signal after the D/A converters is fed into a reconstruction filter, cutting off all frequencies above 20 kHz. On its way the signal also passes through an electrical isolation to keep the complete analog output section floating. The programmable output amplifier offers a balanced signal with 150 Ω output impedance (unbalanced 75 Ω) at any level in steps of 0.1 dB between –60 dBVp to +29 dBVp.

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Analyzer

The RT-2M analyzer consists of a two channel analog input stage that converts the input signals into digital data. Next, the DSP calculates a FFT with twice the blocklength of the defined multitone signal and provides the required test result according to the individual demands of the user.
The analyzer also allows weighting the measurement results according to different standards.

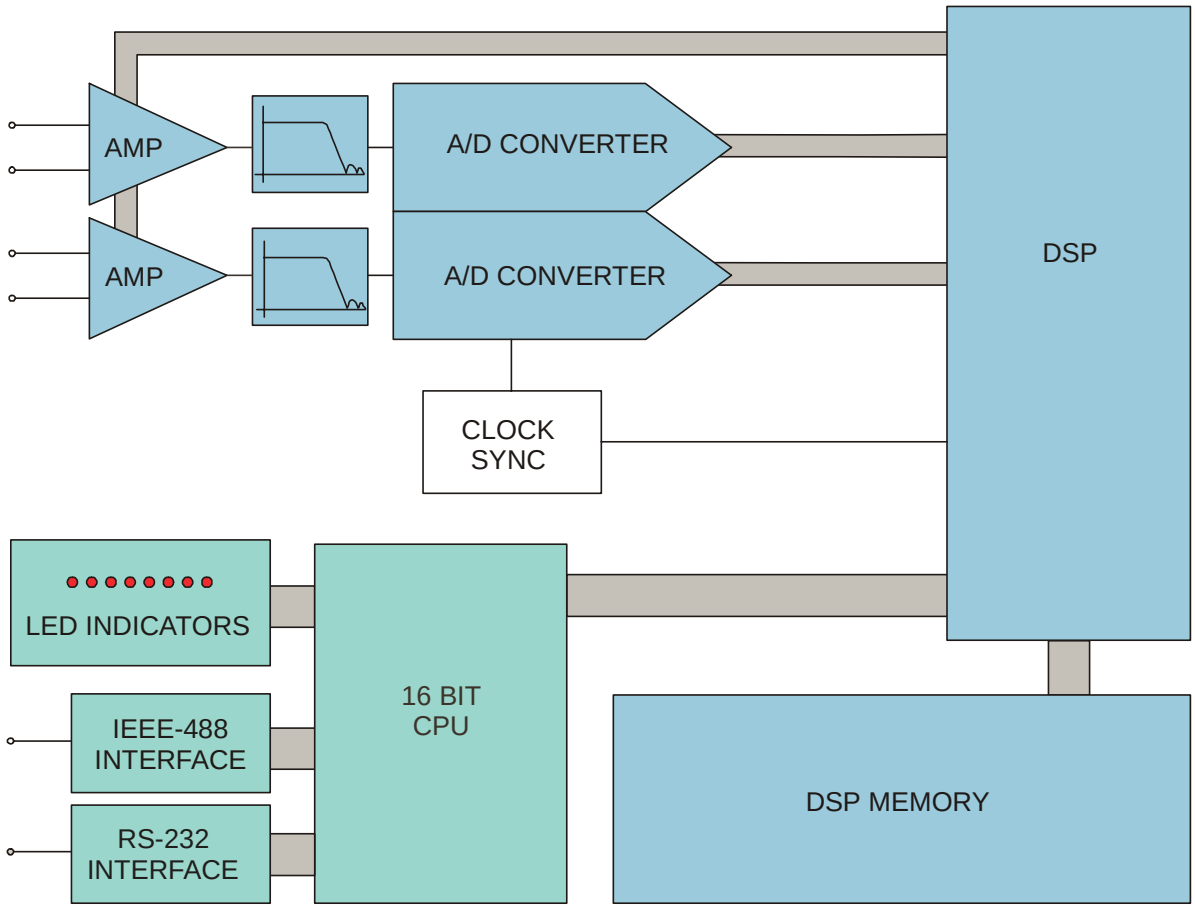


Fig 3 Block Diagram Analyzer

Digital Section

The digital section mainly consists of the DSP and a logic circuitry programmed into a FPGA. A demultiplexer, controlled by the CPU, either directs the A/D converted analog input signal to the DSP. The DSP is used for all calculations - especially the FFT - and to control the range setting of the analog input amplifiers. The DSP is connected via a bus to the central processing unit, which manages all communication to the PC and controls the system bus.

Analog Section

RT-2M features two independent analog input stages with completely independent ranging facilities. At the rear panel, balanced 4 mm 'banana' and BNC connectors provide access to the input section with input impedance of 100 kΩ. Levels can be handled from –60 dBVp to +40 dBVp with full dynamic range.

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Commands

Command Structure

To control *RT-2M*, send the commands to the unit in ASCII format, either through the IEEE-488 or RS232 interface (verify the DIP-switch setting as shown on p. ***119***, ***163***).

Under RS232 control, every command transmission from the PC to *RT-2M* has to be terminated with a "CR LF" (Carriage Return Line Feed), whereby the answers of *RT-2M* are terminated with "LF" (Line Feed).

The full IEEE-488.1 function set is implemented, but not all IEEE-488.2 commands.

Function	*Implemented*	*Note*
Source handshake	SH1	Complete capability
Acceptor handshake	AH1	Complete capability
Talker	T6	No talk-only mode
Talker (extended)	TE0	No capability
Listener	L4	No listen-only mode
Listener (extended)	LE0	No capability
Service request	SR1	Complete capability
Remote local	RL0	Only local lockout
Parallel poll	PP0	No capability
Device clear	DC1	Complete capability
Device trigger	DT0	No capability
Controller	C0	No capability

Table 1 IEEE 488.1 Compatibility

The control commands are divided into six groups (i.e. "subsystems").

Subsystem	*Function*
SYSTem	System status commands
INOUT	Interface & operation mode status
OUTPut	Generator control commands
INPut	Analyzer control commands
MEASurement	Measurement result query commands
*	Device status commands

Table 2 Subsystem Definition

- *RT-2M* accepts only the *short* or the *exact full* form of the commands. Sending a command in another form will generate an error.
- In the command list, the CAPITAL letters indicate the *short* form. However, *RT-2M* accepts either lowercase *and* UPPERCASE letters, i.e. it is not case sensitive.
- If several commands shall be transmitted to the unit together, they must be separated by semi-colons (";")

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Command Notation & Descriptive Symbols

The *RT-2M* command descriptions use headings to divide the syntax information into easily readable parts. These headings and their meaning are listed below. If a heading does not apply to a command, it does not appear in the command syntax description.

Usage	What the command does.
Availability	The mode and system settings that must be active to execute the command.
Parameter	The parameters to be set and their types.
Answer	The possible answer(s) to a query command.
Default	The default value(s) of the parameter(s) that will be applied after a system RESET.
Unit	The available units of the parameters.
Query	The query instruction that returns the parameter value(s) of the corresponding command.
Examples	Command examples are provided here. Short form and lowercase characters randomly to remind the reader that both forms are allowed.
Explanation	Additional explanations, hints and note.

Table 3 Command Headings

The subsequent table lists the symbols that are used for the command description.

Symbol	***Description***
:	Colons separate elements of a RT-2M command.
[ ]	Square brackets enclose the *list of available parameters*, out of which 1 parameter must be selected.
¦	A vertical line reads as an "OR", i.e. this sign separates *alternative* parameters.
< >	Triangle brackets enclose the *variable parameters* that must be set to a user-defined value.
{ }	Braces have the same meaning as triangle brackets ("< >"), except that the enclosed parameters can be included *several* times.
,	Commas separate arguments in an arguments list.
?	The question mark indicates a *query* command.
;	Semi-colons must be used to separate commands in a command list.
( )	Round brackets enclose comments.
💻 →	The string is sent from the PC to RT-2M.
→ 💻	The string is returned from RT-2M to the PC.

Table 4 Descriptive Symbols

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SYSTem Subsystem

SYSTem:ERRors?

Usage Queries the error message numbers that occured since the last query, PowerUp or RESET.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `{Error_No},` *integer*

Command errors:

100 No subsystem separator found (':')
101 No subsystem found
102 No command separator found (':')
110 No SYSTem command found (e.g. RESET)
120 No INPut command found (e.g. LINK)
121 No INPut[1¦2] command found (e.g. RANGE)
130 No OUTPut command found (e.g. FLOAT)
131 No OUTPut[1¦2] command found (e.g. LEVEL)
132 No MTONe command found (e.g. STARt)
133 No TRIGger command found (e.g. ARMed)
134 No THReshold command found (e.g. DELAY)
140 No MEASurement command found (e.g. LEVEL)
141 No MEASurement[1¦2] command found (e.g. DIST)
142 No NOISe command found (e.g. UNIT)
143 No FREQuency command found (e.g. SELective)
144 No WINDows command found (e.g. SELective)
145 No device status command found (e.g. *OPC)
149 Trigger configuration parameter expected (e.g. LOOSE)
150 No parameter expected
151 Float parameter expected
152 Float parameter out of range (e.g. INP:RANG –5E3)
153 Integer parameter expected
154 Integer parameter out of range (e.g. OUTP:MTON:START 0)
155 String parameter expected (e.g. "ON")
156 "ON" or "OFF" string expected
157 Filter parameter expected (e.g. "CCIT")
158 Location parameter expected (e.g. "FRONT")
159 Sync parameter expected (e.g. "EXTERNAL")
160 String too long
161 Wrong number of samples (512, 1024, 2048, 4096, 8192)
162 Corresponding frequency or binnumber out of range
163 Phase value out of range
164 Wrong number of multitone parameters
165 IEEE bus error
166 Output Buffer overflow
167 Bins must be in increasing order
168 Too many parameters
169 Integer parameter must be in increasing order
170 Illegal unit
171 Binlevel weighting parameter out of range (–60 dB to 0 dB)
172 Missing BinLevel reference: minimum 1 weighting factor per chn. must be set to 0 dB
173 No valid signal identifier (e.g. "OUTPUT:MTONE:ACTIVE 5" in 48 kHz mode)
174 No channel selection allowed (e.g. "INPUT:TRIGGER:TIMEOUT ")
175 No valid string – or float & unit – parameter (e.g. MEAS:PURE:STE:REF:LIMIT1 10)
176 No valid string or float+integer parameter (e.g. OUTPut:ARBSIN 1000.0,350.0)
180 Option not installed
182 Command not executable after command INPut:TRIGger:ARMed
185 Command not executable, change to OFF mode first

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187 Command not executable while unit is generating an arbitrary sine signal
190 Not available with this HW Version
191 Not available with this SW Version
192 Not available with RS232 interface
193 Command not available
194 Stepped Sweep license required – please contact NTI
199 Unexpected error occurred – please report to NTI

Device errors:
203 No trigger detected.
204 No stereo trigger detected. (e.g. phase measurement)
205 Measurement function needs ≥ 1 same bin on both channels
206 Measurement function needs ≥ 1 different bin on both channels
207 Measurement function needs same set bins on both channels
208 No signal exceeded threshold
209 No signal sampled
210 Analyzer overload
211 The queried measurement doesn't support filtering – turn off active input filter
212 Measurement function needs same weighting factors on both channels
213 Measurement function needs same phase values on both channels
214 Wrong stepped sweep acquisition mode – activate mode DISTORTION
215 Measurement function needs valid steepness reference – active reference is not valid
216 Measurement function needs same reference signal length & measurement signal length
217 Acquired stepped sweep signal is not compatible with measurement function
218 Acquired multitone signal is not compatible with measurement function
219 Acquired steepness signal is not compatible with measurement function
220 Replace backup-battery
230 Hardware and software version do not match
240 Minimum one external measurement required (e.g. SYNC EXTNoheader)
245 No valid frequency within selected bandwitdth
246 Measurement not possible – signal bins defined too close to each other (choose higher blocklength or change signal bins)
250 DTMF receive buffer overflow
255 RS232/GPIB interface output buffer overflow
256 RS232/GPIB interface input buffer overflow
265 Measurement function requests same range setting on both channels
266 Measurement function requests same output level setting on both channels
267 No filter allowed with this measurement
268 Wrong external balanced connection – swap HI and LO input of active channel
269 Overtemperature detected – disconnect external voltage source
280 Entered license code not accepted
281 No valid license installed

System errors:
400 RS232 parity error
401 RS232 overrun error – character in input buffer overwritten
402 RS232 framing error – no valid stop bit detected (e.g. wrong Baudrate, no stopbit...)
410 RS232 transmitting timeout /* OUT OF ORDER */
420 IEEE bus error
430 Analog output & input calibration values lost – recalibrate device
438 Steepness reference values lost – please report to NTI
439 Amplitude shaping values lost – please report to NTI
440 All installed licenses lost – please report to NTI
450 Unexpected interrupt occurred – please report to NTI
451 Unexpected command occurred – please report to NTI
452 DSP memory failure – please report to NTI
460 RT-1M command that can not be executed with RT-2M

PureSound errors:
501 No valid chirp parameter (e.g. FSTART)
502 No valid PureSound™ command

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503 No valid STEepness command
504 No valid REFerence command
505 Illegal reference selection (A or B)
506 Correlation steepness reference not valid
507 No valid clicks command
508 No valid varlimit Command
510 No valid PureSound™ mode
515 Not valid in PureSound™ mode RNB or CORRelation
516 Not valid in PureSound™ mode RNB
517 Not valid in PureSound™ mode CORRelation
518 Not valid in PureSound™ mode OFF
520 Not valid in PureSound™ mode RNB or CORRelation – specific channel required (e.g. INPut[1¦2]:TRIGger:ARMed)
521 Not valid in PureSound™ mode OFF – specific channel not allowed (e.g. INPut[1¦2]:TRIGger:ARMed)
530 Number of reference values does not match with previous band
531 Transmitted bands are not consecutive
532 Parsing error in reference values
533 Number of reference values does not match with set length
535 Chirp start- or stop-frequency too high
536 "EXTENDED" or "NORMAL" string parameter expected
540 No valid steepness varlimit parameter (e.g. ENABLE)
541 xValues for variable steepness limits must be in an increasing order
542 Wrong number of variable steepness limits
543 Not valid with variable steepness limits set – disable variable steepness limit of this band first
544 Not valid with constant steepness limits set – disable constant steepness limit of this band first

Stepped sweep command errors:
550 No valid STEPpedsweep command (e.g. RMSLEVEL)
551 No valid settling command (e.g. ACTIVE)
552 No valid RMS level command found (e.g. UNIT)
553 No valid PHASe command found (e.g. UNIT)
555 Stepped sweep start/stop frequencies too close
556 No valid smoothing command (e.g. RESOLUTION)
557 No valid distortion command (e.g. HARMONIC?)
558 No valid THDN / HARMONIC command (e.g. UNIT)
562 Wrong number of stepped sweep parameters
563 No valid acquisition mode parameter (e.g. RMSLEVEL)
565 No valid settling mode parameter (e.g. NORMAL)
566 No valid settling active parameter (e.g. CHANNEL1)
567 No valid settling algorithm parameter (e.g. EXPONENTIAL)
568 No valid settling type parameter (e.g. RMSLEVEL)
569 Settling type not valid in acquisition mode RMSLEVEL
570 No valid amplitude shape paramter (e.g. ENABLE)
571 Amplitude shaping parameters are not valid for the actual system settings (e.g. wrong number of #Steps)

Loudness command errors:
580 No valid Loudness command (e.g. SLR, RLR)

Internal errors:
600..799 Service required – please report to NTI

Example

💻 → `System:Errors?`
→ 💻 `130,203,204`

Explanation If no error(s) have occurred, a "0" is returned. In any other case, the buffered list of error numbers is returned. The error buffer is cleared after each query.

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SYSTem:INFormation?

Usage Queries the manufacturer, hardware version, serial number and firmware revision of the system. Compatible with SCPI <*IDN?> command.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`NEUTRIK,`	*string*	(manufacturer)
`RT2M,`	*string*	(instrument type)
`<S_No>,`	*integer*	(serial number)
`<FW_Rev>`	*float*	(firmware revision)

Example

💻 → `System:Information?`
→ 💻 `NEUTRIK,RT2M,0123,6.11`

SYSTem:LICense?

Usage Queries the type of license and its status on RT-2M.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `PURESOUND [n DAYS¦PERMANENT]` *string [integer&string ¦ string]* (n = 1 – 8190)

Examples

💻 → `System:License?`
→ 💻 `PURESOUND 30 DAYS`

💻 → `SYST:LIC?`
→ 💻 `PURESOUND PERMANENT`

Explanation From firmware version 5.10 onwards, all RT-2M are prepared for the PureSound™ option that has to be activated with a key code for a restricted number of days or permanently.

SYSTem:RESet

Usage Executes a system RESET. All previously changed command parameters are re-set to their default values. Error queue is cleared.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Examples

💻 → `SYST:RES`

💻 → `SYSTEM:RESET`

Explanation The RESET command initializes the complete instrument including the IEEE interface. Commands that are in the command buffer, or those that are entered shortly after the RESET can be deleted by the RESET command and are therefore not executed.

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INOUT Subsystem

INOUT:PUResound:MODE [OFF¦RNB¦CORRelation]

Usage Activates the PureSound™ mode.

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the sampling rate must be switched to 48 kHz (***SYSTem:MODE 48Ksamplingrate***).

Parameter `[OFF¦RNB¦CORRELATION]` *string* (inactive ¦ steepness measurement ¦ correlation analysis)

Default `OFF`

Query ***INOUT:PUResound:MODE?***

Examples

💻 → `INOUT:PUResound:MODE RNB`

💻 → `INOUT:PUResound:MODE CORRelation`

Explanation ***INOUT:PUResound:MODE RNB*** enables the Rub & Buzz measurement functions.

INOUT:PUResound:MODE CORRELATION allows measuring the sound correlation.

NOTE	**To enable the PureSound™ license please contact NTI.**

INOUT:PUResound:MODE?

Usage Queries the PureSound™ status.

Availability Normal and PureSound™ mode (also if the analyzer is armed), whereby the PureSound™ license must be enabled.

Answer `[OFF¦RNB¦CORRELATION]` *string* (inactive ¦ steepness measurement ¦ correlation analysis)

Example

💻 → `INOUT:PUResound:MODE?`

→ 💻 `RNB`

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OUTPut Subsystem

OUTPut:ARBitrarysine [<Frequency>,<Time>¦BREAK]

OUTPut:ARBSIN [<Frequency>,<Time>¦BREAK]

Usage Generates a sine signal with user-defined frequency & duration (p. ***173***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[<Frequency>,`	*float*	1.00 to 22000.00	(frequency in Hz, resolution = 0.01)
`<Time>¦`	*integer*	0 to 30000	(time expressed in ms, resolution = 1)
`BREAK]`	*string*	(immediately stops the arbitrary sine ouput signal)	

Examples

💻 → `Outp:Arb 1.23456E+02,500` (123.456 Hz, 500 ms)

💻 → `OUTPUT:ARBSIN 2.150E+03,1200` (2150 Hz, 1200 ms)

💻 → `OUTP:ARB BREAK` (stop the current signal generation)

Explanation The command allows using RT-2M as an arbitrary sine wave generator, whereby the output level is defined by command ***OUTPut[1¦2]:LEVel …*** or ***OUTPut[1¦2]:SINelevel …***.

Re-send the ***OUTP:ARB*** … command with a new frequency or duration parameter to amend the signal generation without interruption.

NOTE **The actual output level is attenuated below 20 Hz and above 20 kHz as follows (refer to p. *173*):**
- **–4 dB to 0 dB from 1 Hz to 20 Hz**
- **0 dB to –0.5 dB from 20 kHz to 22 kHz.**

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OUTPut[1¦2]:BINlevel <BinLevel> [V¦VP¦DBV¦DBVP¦DBM]

Usage Defines the BinLevel of the active multitone signal, i.e. its (reference) signal bin level.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

[0 to xxV¦	*float & string*	($Volt_{RMS}$)
0.001 to xx VP¦		(Volt Peak)
+0.001 to xx DBV¦		(Decibel $Volt_{RMS}$)
–60.00 to xx DBVP¦		(Decibel Volt Peak)
xx DBM]		(Analog RMS level, p. ***199***)

Default `0 DBVP`

Query ***OUTPut[1¦2]:BINlevel? [V¦VP¦DBV¦DBVP¦DBM]***

Examples

💻 → `Outp1:Binlevel -0.62E+01 dBVp`

💻 → `OUTPUT2:BINLEVEL 1.00E-01 V`

💻 → `outp2:bin 0.96e+02 %fs`

Explanation The command defines the actually generated signal bin level of the active multitone signal.

- If no BinLevel weighting is active, the **<*BinLevel*>** applies for all signal bins.
- Alternatively, i.e. if the BinLevels of the multitone signal bins are weighted individually with command ***OUTPut:MTONe:PARameter …***, **<*BinLevel*>** defines only the BinLevel of the reference signal bin, i.e. the unweighted signal bin (refer to p. ***160***).

The maximum possible BinLevel depends on the Crest factor of the test signal.

NOTE	**REFER TO CHAPTER *Output Level* (p. *158*) FOR DETAILS ABOUT THE CORRELATION BETWEEN BINLEVEL, MT LEVEL AND SINELEVEL.** **Using command *OUTPut[1¦2]:BINlevel <Level>* ... is only recommended for advanced customers. Better apply *OUTPut[1¦2]:LEVel <Level>* ... to adjust the output level (i.e. MT Level) of a multitone signal.** **[dBm] is a power unit that refers to 600 Ω output impedance. Thus, if another output impedance is selected, the actual RMS output level changes.**

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OUTPut[1¦2]:BINlevel? [V¦VP¦DBV¦DBVP¦DBM]

Usage Queries the (reference) BinLevel of the active test signal, expressed in the selected unit.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[V¦`		($Volt_{RMS}$)
`VP¦`		(Volt Peak)
`DBV¦`	*string*	(Decibel $Volt_{RMS}$)
`DBVP¦`		(Decibel Volt Peak)
`DBM]`		(RMS level, p. ***199***)

Answer `<BinLevel> [V¦VP¦DBV¦DBVP¦DBM]` *float & string*

Example

```
💻 →   Output2:Binlevel? Vp
→ 💻   -1.23456E-01 VP
```

Explanation The reference BinLevel represents the level of the unweighted signals bin(s). Refer to chapter ***Multitone Binlevel Weighting (Individual Binlevel)*** for further details (p. ***160***).

The command is very helpful for the conversion of the BinLevel into different units. For instance, if the BinLevel has been defined in V, it can be queried directly in another unit.

Even if the generator level has been defined with command ***OUTPut[1¦2]:LEVel …*** or ***OUTPut[1¦2]:SINlevel …*** the query returns directly the BinLevel.

NOTE	**REFER TO CHAPTER *Output Level* (p. *158*) FOR DETAILS ABOUT THE CORRELATION BETWEEN SINELEVEL, MT LEVEL AND BINLEVEL.** **[dBm] is a power unit that refers to 600 Ω output impedance. Thus, if another output impedance is selected, the actual RMS output level changes.**

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OUTPut:DTMF [1¦2¦3¦4],[1¦2¦3¦4],<Time>,<RowFrqDev>,<ColFrqDev>,<AmpRatio>

Usage

Generates a DTMF tone, whereby the user must define the key-number, signal duration, frequency deviation and amplitude ratio of the two signal components (p. ***114***).

Availability

Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[1¦2¦3¦4],`	*integer*	(x-coordinate of the 4x4 keypad)
`[1¦2¦3¦4],`	*integer*	(y-coordinate of the 4x4 keypad)
`1 to 5000,`	*integer*	(DTMF signal duration in milliseconds; resolution = 1)
`-5.00 to +5.00,`	*float*	(row-frequency deviation in %; resolution = 0.01)
`-5.00 to +5.00,`	*float*	(column-frequency deviation in %; resolution = 0.01)
`0.10 to 10.00`	*float*	(amplitude ratio LowFreq : HighFreq; resolution = 0.01)

Examples

💻 → `OUTP:DTMF 2,3,100,0,0,1` (standard DTMF tone of key #6)

💻 → `outp:dtmf 1,1,50,0.50E00, -0.50E00,3.00E00` (key 1, 50 ms, frequencies de-tuned to 700.5 / 1203.0 Hz, amplitude ratio 3:1)

Explanation

The standard 4x4 keypad coding is:
(the meaning of the characters a, b, c, d is user-defined)

↓*row* \ *1* → *column*	*1*	*2*	*3*	*4*
1	1	2	3	a
2	4	5	6	b
3	7	8	9	c
4	*	0	#	d

The frequencies associated to the rows and columns are:

row	*frequency*	*column*	*frequency*
1	697	*1*	1209
2	770	*2*	1336
3	852	*3*	1477
4	941	*4*	1633

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OUTPut:FLOAT [OFF¦ON]

Usage Switches the generator output connectors to grounded (OFF) or floating (ON).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Range `[OFF¦ON]` *string*

Default `OFF`

Query ***OUTPut[1¦2]:STATus?***

Example 💻 → `Output:Float ON`

Explanation Please refer to chapters ***Ground Connections*** and ***Analog Output Connections***, (p. ***118, 204***) for application details.

OUTPut[1¦2]:IMPedance [150¦600]

Usage Activates the impedance of the generator output (p. ***123***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Range `[150¦600]` *integer¦string*

Default `150` (Ohm)

Query ***OUTPut[1¦2]:STATus?***

Examples 💻 → `Output:Imp 150` (output impedance of both channels = 150 Ω)

💻 → `OUTP1:IMPED 600` (output impedance of channel 1 = 600 Ω)

Explanation The RT-2M output impedance is only active in status ***INPut[1¦2]:LINK OFF***.

NOTE	**If no channel-number is indicated, the *OUTPut[1¦2]:IMPedance* ... command applies on *both* channels simultaneously.**

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OUTPut[1¦2]:LEVel <Level> [V¦VP¦DBV¦DBVP¦DBM]

Usage Defines the MT Level, i.e. the overall output level of the active test signal (refer to p. ***158***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[xx V¦`		(Volt$_{RMS}$)
`0.001 to 28.20 VP¦`		(Volt Peak)
`xx DBV¦`		(Decibel Volt$_{RMS}$)
`-60.00 to +29.00 DBVP¦`	*float & string*	(Decibel Volt Peak)
`xx DBM]`		(RMS level, p. ***199***)

Default `0 DBVP`

Query ***OUTPut[1¦2]:LEVel? [V¦VP¦DBV¦DBVP¦DBM***

Examples

💻 → `output2:level 0.50E-01 dbm`

💻 → `Outp1:Level -6.2 dBVp`

💻 → `OUTPUT2:LEVEL 0.35e2 V`

Explanation The MT Level represents the actual RMS level of the complete multitone signal, regardless whether some of its signal bins are weighted or not.

The absolute maximum MT Level is +29 dBVp. If the MT Level is expressed in dBV, V or dBm its range depends on the Crest factor of the test signal.

Command ***OUTPut:MTONe:PARameter …*** allows individually weighting the multitone signal bins (chapter ***Multitone Binlevel Weighting (Individual Binlevel)***, p. ***160***).

NOTE	**REFER TO CHAPTER *Output Level* (p. *158*) FOR DETAILS ABOUT THE CORRELATION BETWEEN MT LEVEL, BINLEVEL AND SINELEVEL.** **[dBm] is a power unit that refers to 600 Ω output impedance. Thus, if another output impedance is selected, the actual RMS output level changes.**

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OUTPut[1¦2]:LEVel? [V¦VP¦DBV¦DBVP¦DBM]

Usage Queries the MT Level of the active test signal, expressed in the indicated unit.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[V¦`		($Volt_{RMS}$)
`VP¦`		(Volt Peak)
`DBV¦`	*string*	(Decibel $Volt_{RMS}$)
`DBVP¦`		(Decibel Volt Peak)
`DBM]`		(RMS level, p. ***199***)

Answer `<MTLevel> [DBVP¦VP¦DBV¦V¦DBM]` *float & string*

Example

💻 → `Output1:Level? dBVp`
→ 💻 `6.80888E+00 DBVP`

Explanation The MT Level represents the actual RMS level of the complete multitone signal, regardless whether some of its signal bins are weighted or not.

The command is very helpful for the conversion of the MT Level into different units. For instance, if the MT Level has been defined in V, it can be queried directly in another unit.

Even if the generator level has been defined with command ***OUTPut[1¦2]:BINlevel …*** or ***OUTPut[1¦2]:SINlevel …*** the query returns directly the MT Level.

NOTE	**REFER TO CHAPTER *Output Level* (p. *158*) FOR DETAILS ABOUT THE CORRELATION BETWEEN SINELEVEL, MT LEVEL AND BINLEVEL.** **[dBm] is a power unit that refers to 600 Ω output impedance. Thus, if another output impedance is selected, the actual RMS output level changes.**

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OUTPut:MTONe:ACTive [1¦2¦3¦4¦LOUDNESS]

Usage Selects the active multitone signal for the next signal transmission. All commands with no signal number refer by default to this selection.

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[1¦2¦3¦4¦LOUDNESS]` *integer¦string*

Query ***OUTPut[1¦2]:STATus?***

Examples

💻 → `OUTP:MTON:ACT 2`

💻 → `output:mtone:active loudness`

Explanation

- Signals No. 1 – 4 can be user-defined.
- Signal "LOUDNESS" is for SLR, RLR and STMR measurements (p. ***140***).

OUTPut:MTONe:BLOCklength?

Usage Queries the blocklength (i.e. number of samples) of the active multitone signal (p. ***129***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `[512¦1024¦2048¦4096¦8192]` *integer*

Example

💻 → `OUTput:MTONe:BLOCklength`
→ 💻 `2048`

OUTPut:MTONe:CLEarweightings

Usage Clears the individual BinLevel weighting of the active multitone signal.

Availability Normal mode (not available if the analyzer is armed).

Example 💻 → `OUTP:MTONE:CLEAR`

Explanation Refer to commands ***OUTPut:MTONe:PARameter …*** and ***OUTPut[1¦2]:MTONe:EQUalize*** as well as to the chapter ***Multitone Binlevel Weighting (Individual Binlevel)*** (p. ***160***).

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OUTPut:MTONe:CONtinuous

Usage Starts RT-2M to continuously generate the active multitone signal.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Example 💻 → `OUTP:MTONE:CON`

Explanation The multitone signal is sent out in a continuous loop without header.

Stop the continuous multitone signal generation by sending any command to RT-2M.

NOTE	**No measurement can be executed in this status.**

OUTPut[1¦2]:MTONe:CRESt?

Usage Queries the Crest factor of the active multitone signal (p. ***131***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `<CrestFactor>` *float* (any positive number ≥√2)

Example 💻 → `OUTP1:MTONe:CREST?`
→ 💻 `2.33433E00`

Explanation The Crest factor can be used to calculate the correspondance between:

- RMS output level and peak level of a multitone signal (p. ***158***).
- MT Level, BinLevel and SineLevel (p. ***159***).

OUTPut[1¦2]:MTONe:EQUalize

Usage Equalizes the active multitone signal with the inverse transfer function of the last successful level measurement (p. ***160***).

Availability Normal mode (not available if the analyzer is armed).

Example 💻 → `Outp2:Mton:Equ`

Explanation The command amends the individual BinLevels of the active multitone signal so that the new weighting compensates the frequency response of the DUT.

NOTE	**Use command *OUTPut:MTONe:CLEarweightings* to reset an equalized BinLevel weighting.**

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OUTPut:MTONe:MTONelength <Length>

Usage Prolongs the multitone signal duration of the active multitone signal (p. ***133***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<Length>` *integer* 0 to 30000 (multitone length in ms; resolution = 1)

Default `0` (ms)

Example 💻 → `Outp:Mton:Mton 500`

Explanation The <Length> is rounded to the next possible integer multiple of 1 multitone block duration. 0 corresponds to the transmission of the minimum number of multitone blocks.

The command allows the DUT stabilizing to the multitone signal before analysis is started.

OUTPut:MTONe:NAME?

Usage Queries the name of the active multitone signal.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `<Name>` *string* (up to 8 characters)

Example
💻 → `Output:Mtone:Name?`
→ 💻 `23_BIN`

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OUTPut:MTONe:PARameter [1¦2¦3¦4¦LOUDNESS],<SignalName>, [512¦1024¦2048¦4096¦8192],[WTD,]<#SigBinsChn1>,<#SigBinsChn2>,{Bin_ID1},{Bin_ID2},{φ1},{φ2}{,Weighting1}{,Weighting2}

Usage Defines the mandatory and some optional parameters of a multitone signal.

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter

`[1¦2¦3¦4¦ LOUDNESS],`	*integer¦string*	(multitone signal number, p. ***153***)
`<SignalName>,`	*string*	(user-defined name, ≤ 8 characters, no spaces)
`[512¦1024¦2048¦ 4096¦8192],`	*integer*	(blocklength, p. ***129***)
`[¦WTD,]`	*string*	(string 'WTD' activates BinLevel weighting, p. ***160***)
`<#SigBinsChn1>,`	*integer*	1 to 31 (number of signal bins that are defined for
`<#SigBinsChn2>,`	*integer*	channel 1 and channel 2)
`{Bin_ID1},`	*integer*	Bin_Min to Bin_Max (individual signal bin Nos. of
`{Bin_ID2},`	*integer*	channel 1 and channel 2, p. ***152***)
`{φ1},`	*float*	–3.1416 to + 3.1416 (individual phases of chn. 1 &
`{φ2}`	*float*	chn. 2 signal bins in radiant, resolution = 0. 001)
`{,0 to –60}`	*float*	(individual BinLevel weightings of chn. 1, chn. 2 in
`{,0 to –60}`	*float*	dB, resolution = 0. 00001 [apply only if WTD])

Query ***OUTPut:MTONe:PARameter?***

Examples

💻 → `OUTP:MTON:PAR 3,'3TONEWTD, 512,WTD,3,3,3,7,32,5,9,36, -0.15254E+01,2.43579E+01, 3.04434E+01,-0.15254E+01, 2.43579E+01,3.04434E+01, 0.00,-0.60E+02,-1.20E+02, 0.00,0.00,0.00`

(signal # 3, signal name '3TONEWTD', blocklength 512, individual BinLevel weighting active, 3 signal bins different on chn.1: 3, 7, 32 and chn.2: 5, 9, 36 with identical phases: -1.5254, 2.43579, 3.04434, individual BinLevel weighting of chn.1 signal bins: 0, –6, –12 [dB])

💻 → `OUTP:MTON:PAR 1,'TELEFON', 2048,3,3,25,85,256,25,85, 256,0,1.5708E00,3.1416E00, 0,1.5708E00,3.1416E00`

(signal No. 1, signal name 'TELEFON', blocklength 2048, no individual binlevel weighting, 3 identical signal bins on both channels: 25, 85, 256 w/ identical phases: 0, π/2, π [= 0°, 90°, 180°])

Explanation The command parameters comprise all information that define a multitone signal, except of the generator level (refer to ***OUTPut[1¦2]:LEVel …*** and ***OUTPut[1¦2]:BINlevel …***).

- The parameters of the predefined signal "LOUDNESS" cannot be amended, except of the BinLevel weighting that can be equalized with ***OUTPut[1¦2]:MTONe:EQUalize*** and cleared with ***OUTPut:MTONe:CLEarweightings***.
- <#SigBins1¦2> equals the total number of signal bins for channel 1¦2.
- {BinID1¦2} indicates the bin numbers as calculated with ***Equation 13*** (p. ***152***).
- {φ1¦2} indicates the phases of the signal bins.
- {Weightg1¦2} defines the attenuation of the corresponding signal bin, expressed in dB (0 dB = no attenuation). At least one signal bin must be left unweighted (p. ***160***).
- Use command ***OUTPut[1¦2]:MTONe:EQUalize*** to let RT-2M automatically define a BinLevel weighting that compensates for the DUT's frequency response.
- Use command ***OUTPut:MTONe:CLEarweightings*** to clear the BinLevel weighting.

NOTE	**In case of BinLevel weighting, the reference bin has the highest BinLevel within the multitone signal, because it is not possible to apply a negative weighting (i.e. amplification).**

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OUTPut:MTONe:PARameter?

Usage Queries the parameters of the active multitone signal.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`[1¦2¦3¦4 LOUDNESS],`	*integer*¦*string*	(multitone signal number, p. ***153***)
`<SignalName>,`	*string*	(user-defined name)
`[512¦1024¦2048¦4096¦8192],`	*integer*	(blocklength, p. ***129***)
`[¦WTD,]`	*string*	('WTD' = BinLevel weighting active, p. ***160***)
`<#SigBinsChn1>,`	*integer*	1 to 31 (number of signal bins that of channel 1,
`<#SigBinsChn2>,`	*integer*	channel 2)
`{Bin_ID1},`	*integer*	Bin_Min to Bin_Max (individual signal bin Nos.
`{Bin_ID2},`	*integer*	of channel 1, channel 2, p. ***152***)
`{φ1},`	*float*	–3.1416 to + 3.1416 (individual phases of chn. 1,
`{φ2}`	*float*	chn. 2 signal bins in radiant)
`{,0 to –60}`	*float*	(individual BinLevel weightings of chn. 1, chn. 2
`{,0 to –60}`	*float*	in dB [only if WTD])

Examples

💻 → `OUTP:MTON:PAR?`

→ 💻
```
4,3TONE,512,WTD,3,3,3,11,32,
3,11,32,-0.352E00,2.435E00,
2.644E00,-0.352E00,2.435E00,
2.644E00,0.00E00,-0.60E+02,
-1.20E+02,0.00E00,0.00E00,
0.00E00
```
(signal No. 4, signal name '3TONE', blocklength 512, individual BinLevel weighting active, 3 identical signal bins on both channels.2: 3, 11, 32 with identical phases: -0.352, 2.435, 2.644, individual BinLevel weighting of chn.1 signal bins: 0, –6, –12 [dB])

💻 → `OUTP:MTON:PAR?`

→ 💻
```
2,TEST_1,512,4,4,1,32,48,64,
1,32,48,64,1.23E00,0.01E00,
-3.141E00,-1.65E00,0.98E00,
2.99E00,1.54E00,-0.55E00
```
(signal No. 2, signal name 'TEST_1', blocklength 512, no individual BinLevel weighting, 4 identical signal bins on both channels: 1, 32, 48, 64, phases chn.1: 1.23, 0.01, –3.14, –1.65, phases chn.2: 0.98, 2.99, 1.54, –0.55)

Explanation The format of the returned string complies with ***OUTPut:MTONe:PARameter ...***.

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OUTPut:MTONe:PRETriggerlength <Length>

Usage Prolongs the duration of the multitone pretrigger for the active signal (p. ***150***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<Length>` *integer* 0 to 30000 (pretrigger duration expressed in ms; resolution = 1)

Default `0` (ms)

Example 💻 → `Output:Mtone:Pret 12345`

Explanation <Length> does not include the duration of the trigger, which always occupies some 42 ms.
<Length> = 0 defines the shortest possible pretrigger length = 0 ms.

This command allows the DUT stabilizing before the trigger signal is transmitted.

OUTPut:MTONe:STARt

Usage Starts the transmission (i.e. generation and/or analysis) of the active multitone signal.

Availability Normal mode (not available if the analyzer is armed).

Example 💻 → `OUTP:MTONE:START`

Explanation Send this command to RT-2M to
- generate and analyze a multitone burst *or*
- only generate a multitone burst *or*
- only analyze a multitone burst.

Refer to command ***INPut:SYNC …*** and chapter ***Test Setups*** (p. ***182***) for further information about the generation and analysis of multitone signals as well as test setup parameters

OUTPut[1¦2]:MUTe [OFF¦ON]

Usage Mutes the generator output.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `[OFF¦ON]` *string*

Default `OFF`

Query ***OUTPut[1¦2]:STATus?***

Example 💻 → `Output1:Mute ON`

Explanation In the ***MUTe*** state, the *output connectors* are not disconnected from the internal output impedance circuit, whereby the *generator circuit* is internally disconnected.

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OUTPut:PUResound:CHIRp:AMPLitudeshape <Frequency>,<Attenuation>

Usage Attenuates the chirp output level above an user-defined transition frequency (p. ***163***).

Availability Normal and PureSound™ mode (not if the analyzer is armed).

Parameter

`<Frequency>,`	*float*	5.0 – 750.0	(transition frequency in Hz; resolution = 0.01)
`<Attenuation>`	*float*	0.0 to –40.0	(attenuation in dB; resolution = 0.1)

Default `500,0` (Hz, dB)

Query ***OUTPut:PUResound:CHIRp:AMPLitudeshape?***

Example 💻 → `outp:pur:chirp:ampl 100,-20` (transition frequency = 100 Hz, attenuation = –20 dB)

Explanation The command is mainly intended for woofer testing. This application typically requires:

- a very high test signal level at low frequencies to detect all Rub&Buzz defects,
- a lower test signal level at higher frequencies to protect the operator's ears.

The amplitude shape has no impact on the continuous frequency change nor the chirp duration. The transition time is fixed to 10.2 ms.

OUTPut:PUResound:CHIRp:AMPLitudeshape?

Usage Queries the chirp level attenuation and the transition frequency (p. ***163***).

Availability Normal and PureSound™ mode (not if the analyzer is armed).

Answer

`<Frequency>,`	*float*	5.0 – 750.0	(transition frequency in Hz; resolution = 0.01)
`<Attenuation>`	*float*	0.0 to –40.0	(attenuation in dB; resolution = 0.1)

Default `500,0` (Hz, dB)

Example 💻 → `outp:pur:chirp:ampl?`

→ 💻 `50,-15` (transition frequency = 50 Hz, attenuation = –15 dB)

OUTPut:PUResound:CHIRp:FADEin <Duration>

Usage Defines the fade-in duration of the chirp (= gliding sweep, p. ***163***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `<Duration>` *integer* 0 to 1000 (fade-in duration expressed in ms; resolution = 1)

Default `20` (ms)

Example 💻 → `outp:pur:chirp:fade 0.30E+02`

Explanation During fade-in, RT-2M linearly increases the amplitude of the start frequency from 0 to the defined output level. This prevents an initial transient at the beginning of the chirp.

Most applications require a fade-in that is shorter than the settling (refer to the command ***OUTPut:PUResound:CHIRp:SETTling <Duration>***, p. ***44***).

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OUTPut:PUResound:CHIRp:FRANge [NORMal¦EXTended]

Usage Determines the frequency range (i.e. bandwidth) of the chirp (= gliding sweep, p. ***163***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed)

Parameter `[NORMal¦EXTended]` *string* (NORMal = 20–1500 Hz ¦ EXTended = 5–6000 Hz)

Default `NORMal`

Example 💻 → `OUTPut:PUR:CHIRp:FRANGe EXT`

Explanation Most drivers, speakers etc. can tested properly in the NORMal range (20 – 1'500 Hz). Only few woofers or tweeters need a stimulus 5–20 Hz or 1.5–6.0 kHz (EXTended).

> **NOTE** **The generated chirp level is attenuated in the range 5–20 Hz as follows:**
> **0 dB @ 20 Hz → –0.6 dB @ 10 Hz → –1.3 dB @ 5 Hz**

OUTPut:PUResound:CHIRp:FSTArt <Frequency>

Usage Defines the start frequency of the chirp (= gliding sweep, p. ***163***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `<Frequency>` *float* 20.0 to 1500.0 ¦ 6000.0 (start frequency in Hz, resolution = 0.1; > 1500.0 Hz only with extended range)

Default `200.0` (Hz)

Example 💻 → `outp:pur:chirp:fsta 1.00E+03`

Explanation Adjust the start frequency if RT-2M generates the chirp before transmitting the latter with the command ***OUTPut[1¦2]:PUResound:CHIRp:STARt***.

> **NOTE** **The generated chirp level is attenuated in the range 5–20 Hz as follows:**
> **0 dB @ 20 Hz → –0.6 dB @ 10 Hz → –1.3 dB @ 5 Hz**

OUTPut:PUResound:CHIRp:FSTOp <Frequency>

Usage Defines the stop frequency of the chirp (= gliding sweep, p. ***163***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `<Frequency>` *float* 20.0 to 1500.0 ¦ 6000.0 (start frequency in Hz, resolution = 0.1; > 1500.0 Hz only with extended range)

Default `1000.0` (Hz)

Example 💻 → `outp:pur:chirp:fsto 0.25E+04`

Explanation Adjust the stop frequency if RT-2M generates the chirp before transmitting the latter with the command ***OUTPut[1¦2]:PUResound:CHIRp:STARt***.

> **NOTE** **The generated chirp level is attenuated in the range 5–20 Hz as follows:**
> **0 dB @ 20 Hz → –0.6 dB @ 10 Hz → –1.3 dB @ 5 Hz**

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OUTPut:PUResound:CHIRp:LENGth <Duration>

Usage Sets the duration of the chirp (= gliding sweep, p. ***163***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `<Duration>` *integer* 100 to 10000 (chirp duration expressed in ms; resolution = 1)

Default `1000` (ms)

Example 💻 → `outp:pur:chirp:leng 1.5E+03`

Explanation Adjust the stop frequency if RT-2M generates the chirp before transmitting the latter with the command ***OUTPut[1¦2]:PUResound:STARt***.

NOTE	**The chirp duration must always be higher or identical to the acquisition length defined by *MEASurement:PUResound:LENGth*.**

OUTPut:PUResound:CHIRp:MAXRuns <Runs>

Usage Defines the number of cycles (i.e. repeated measurements) that are executed if the acquired steepness results exceed the user-defined individual limits. Thus, RT-2M can separate random noise from systematic DUT defects (p. ***171***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<Runs>` *integer* 1 to 20 (maximum number of runs; resolution = 1)

Default `1` (one RNB test per DUT)

Example 💻 → `outp:pur:chirp:maxr 5`

Explanation In a noisy environment, adjust <***Runs***> to ≥ 2. Thus RT-2M re-measures every DUT that exceeds the given steepness limits and determines, whether the recorded transients are caused by a Rub & Buzz defect or random noise.

OUTPut:PUResound:CHIRp:SETTling <Duration>

Usage Defines the settling duration of the RNB chirp (refer to p. ***163***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<Duration>` *integer* 0 to 1000 (settling duration expressed in ms; resolution = 1)

Default `50` (ms)

Example 💻 → `outp:pur:chirp:settling 1.0E+02`

Explanation Settling represents the time during which RT-2M generates the start frequency before it actually starts the chirp. This allows the test stand settling to the chirp's start frequency.

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OUTPut[1¦2]:PUResound:CHIRp:STARt

Usage Starts the RNB chirp generation and analysis.

Availability PureSound™ mode in status ***INOUT:PUResound:MODE RNB*** (not available if the analyzer is armed).

Example 💻 → `Outp1:pur:chirp:star`

Explanation The command not only starts the chirp transmission but also the RNB analysis of the incoming signal (refer to chapter ***Test Setups***, p. ***182***).

Alternatively, it is possible to execute a RNB analysis on an externally generated signal with command ***MEASurement[1¦2]:PUResound:STARt***.

OUTPut:PUResound:STATus?

Usage Queries the status of the PureSound™ RNB chirp.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`FRANGE [NORMAL¦EXTENDED],`	*string*	(1500 Hz ¦ 6000 Hz)
`FSTART [20.0 to 6000.0],`	*string & float*	(start frequency in Hz)
`FSTOP [20.0 to 6000.0],`	*string & float*	(stop frequency in Hz)
`LENGTH [100 to 10000],`	*string & integer*	(chirp duration in ms)
`SETTLING [0 to 1000],`	*string & integer*	(settling period in ms)
`FADEIN [0 to 1000],`	*string & integer*	(fade-in period in ms)
`MAXRUNS [1 to 20]`	*string & integer*	(# noise cancellation runs)

Example

💻 → `OUTPUT:PUR:STAT?`

→ 💻 `FRANGE NORMAL,FSTART 2.00E+02,FSTOP 1.00E+03,`
`LENGTH 1000,SETTLING 50,FADEIN 20,MAXRUNS 1`

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OUTPut[1¦2]:SINelevel <SineLevel> [DBVP¦VP¦DBV¦V¦DBM]

Usage Defines the SineLevel of the active test signal (refer to p. ***158ff***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[0.0007 to 20 V¦`		($Volt_{RMS}$)
`0.001 to 28.2 VP¦`		(Volt Peak)
`-63.00 to +26.00 DBV¦`	*float & string*	(Decibel $Volt_{RMS}$)
`-60.00 to +29.00 DBVP¦`		(Decibel Volt Peak)
`xx DBM]`		(RMS level, p. ***199***)

Default `0 DBVP`

Query ***OUTPut[1¦2]:SINelevel? [V¦VP¦DBV¦DBVP¦DBM]***

Examples

💻 → `Outp1:Sin 1.0E00 v`

💻 → `OUTPUT2:SINELEVEL 0.44E-02 DBV`

Explanation Similar to the MT Level, the SineLevel represents the RMS level of the test signal, regardless whether it is weighted (multitone) or shaped (stepped sweep).

The absolute maximum SineLevel is +29 dBVp. If the SineLevel is expressed in dBm, its range depends on the Crest factor of the test signal.

NOTE	**REFER TO CHAPTER *Output Level* (p. *158*) FOR DETAILS ABOUT THE CORRELATION BETWEEN SINELEVEL, MT LEVEL AND BINLEVEL.** **[dBm] is a <u>power</u> unit that refers to 600 Ω output impedance. Thus, if another output impedance is selected, the actual RMS output level changes.**

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OUTPut[1¦2]:SINelevel? [V¦VP¦DBV¦DBVP¦DBM]

Usage Queries the SineLevel of the active test signal, expressed in the indicated unit.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[V¦`		($Volt_{RMS}$)
`VP¦`		(Volt Peak)
`DBV¦`	*string*	(Decibel $Volt_{RMS}$)
`DBVP¦`		(Decibel Volt Peak)
`DBM]`		(RMS level, p. ***199***)

Answer `<MTLevel> [DBVP¦VP¦DBV¦V¦DBM]` *float & string*

Example

```
💻 →   Output1:sinelevel? dBVp
→ 💻   6.80888E+00 DBVP
```

Explanation Similar to the MT Level, the SineLevel represents the RMS level of the test signal, regardless whether it is weighted (multitone) or shaped (stepped sweep).

The command is very helpful for the conversion of the SineLevel into different units. For instance, if the SineLevel has been defined in V, it can be queried directly in another unit.

Even if the generator level has been defined with command ***OUTPut[1¦2]:LEVel …*** or ***OUTPut[1¦2]:BINlevel …***, the query returns directly the SineLevel.

NOTE	**REFER TO CHAPTER *Output Level* (p. *158*) FOR DETAILS ABOUT THE CORRELATION BETWEEN SINELEVEL, MT LEVEL AND BINLEVEL.** **[dBm] is a power unit that refers to 600 Ω output impedance. Thus, if another output impedance is selected, the actual RMS output level changes.**

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OUTPut[1¦2]:STATus?

Usage Queries the generator status.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`MODE 48KSAMPLINGRATE`	*string*
`SOURCE ANALOG`	*string*
`ACTIVE [1¦2¦3¦4¦LOUDNESS]`	*string* & *integer¦string*
`LEVEL [–60 to +29 dBVp¦0.001 to 28.3 Vp]`	*string* & *float* & *string*
`BINLEVEL [–60 to +29 dBVp¦0.001 to 28.3 Vp]`	*string* & *float* & *string*
`SINELEVEL [–60 to +29 dBVp¦0.001 to 28.3 Vp]`	*string* & *float* & *string*
`MUTE [OFF¦ON]`	*string*
`IMPEDANCE [150¦600]`	*string* & *integer¦string*
`FLOAT [OFF¦ON]`	*string*

Examples

💻 → `OUTPUT1:STATUS?`

→ 💻 `MODE 48KSAMPLINGRATE,SOURCE ANALOG,ACTIVE 2,LEVEL -4.59E+00 dBV,BINLEVEL -9.35E+00 dBV, SINELEVEL 0.00E00 dBV,MUTE OFF,IMPEDANCE 150,FLOAT OFF`

OUTPut:STEPpedsweep:AMPLitudeshape:SET <Shape$_1$>,<Shape$_2$>,…,<Shape$_{\#Steps+1}$>

Usage Defines the amplitude shape of the stepped sweep, i.e. the individual level attenuation of the sweep frequencies (p. ***161***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<Shape`$_n$`>,` *float* (attenuation of frequency #n, expressed in [dB])

Query ***OUTPut:STEPpedsweep:AMPLitudeshape:SET?***

Example 💻 → `OUTP:STEP:AMPL:SET -4.57,-8.05,-3.25,0`

Explanation The shaping (attenuation) becomes only effective if this feature is enabled (refer to command ***OUTPut:STEPpedsweep:AMPLitudeshape:ACTive [ENABle¦DISable]***).

"n", i.e. the number of <Shape$_n$> values must equal <#Steps+1> as defined with the command ***OUTPut:STEPpedsweep:NSTeps <#Steps>***.

> **NOTE** **At least one frequency must not be attenuated (<Shape$_x$> = 0) to act as reference for the output level definition.**

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OUTPut:STEPpedsweep:AMPLitudeshape:ACTive [ENABle¦DISable]

Usage Enables or disables the amplitude shaping of the stepped sweep (p. ***161***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[ENABle¦DISable]` *String*

Default `DISABLE`

Example 💻 → `OUTP:STEP:AMPL:ACT ENAB`

Explanation The amplitude shaping can only be enabled if the number of <Shape> values = <#Steps> + 1, whereby <Shape> and <#Steps> are defined by ***OUTPut:STEPpedsweep:AMPLitude:SET <Shape$_1$>,…,<Shape$_{\#Steps+1}$>*** and ***OUTPut:STEPpedsweep:NSTeps <#Steps>*** respectively.

OUTPut:STEPpedsweep:AMPLitudeshape:SET?

Usage Queries the amplitude shape values of the stepped sweep (p. ***161***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Answer `{Shape`$_n$`},` *float* (amplitude shape values of all sweep frequencies, expressed in dB)

Example 💻 → `OUTP:STEP:AMPL:SET?`
→ 💻 `-4.57E00,-8.05E00,-3.25E00,0`

Explanation The number of returned {Shape_n} values = <#Steps> + 1, whereby <#Steps> is defined with the command ***OUTPut:STEPpedsweep:NSTeps <#Steps>***.

OUTPut:STEPpedsweep:FSTArt <StartFrequency>

Usage Defines the start frequency of the stepped sweep (generator & analyzer, p. ***173***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<StartFrequency>` *float* 20.00 to 20000.00 (start freq. in Hz; resolution = 0.0001)

Default `20.00` (Hz)

Example 💻 → `outp:step:fsta 1.50037e2`

Explanation Define the start frequency before sending the command ***OUTPut:STEPpedsweep:STARt***.

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OUTPut:STEPpedsweep:FSTOp <StopFrequency>

Usage Defines the stop frequency of the stepped sweep (generator & analyzer, p. ***173***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<StopFrequency>` *float* 20.00 to 20000.00 (stop freq. in Hz; resolution = 0.0001)

Default `20000.00` (Hz)

Example 💻 → `outp:step:fsto 1.20E+03`

Explanation Define the stop frequency before sending the command ***OUTPut:STEPpedsweep:STARt***.

OUTPut:STEPpedsweep:NSTeps <#Steps>

Usage Defines the number of steps for the stepped sweep (p. ***173***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<#Steps>` *integer* 1 to 500 (number of steps; resolution =1)

Default `100` (100 steps = 101 frequencies)

Example 💻 → `outp:step:nst 30`

Explanation A sweep with *n* steps comprises of *n+1* frequencies (if e.g. <#Steps> = 3, then the resultung stepped sweep comprises of 4 frequencies).

The frequencies are placed with equal intervals on the logarithmic frequency axis.

Define the number of steps before sending the command ***OUTPut:STEPpedsweep:STARt***.

OUTPut:STEPpedsweep:STARt

Usage Starts the stepped sweep generation & analysis (p. ***183***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Example 💻 → `Outp:steppedweep:start`

Explanation Command ***OUTPut:STEPpedsweep:STARt*** not only starts the stepped sweep generation but also the simultaneous acquisition of the transmitted signal.

The ***INPut:SNYC …*** command has no effect on the analyzer triggering.

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OUTPut:STEPpedsweep:STATus?

Usage Queries the stepped sweep generator status.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`FSTART [20.00 to 20000.00]`	*float*	(start frequency in Hz)
`FSTOP [20.00 to 20000.00]`	*float*	(stop frequency in Hz)
`NSTEPS [1 to 500]`	*integer*	(number of sweep steps)
`AMPLITUDESHAPE [ENABLE¦DISABLE]`	*string*	(status of amplitude shaping)

Example

💻 → `OUTPUT:STEPPEDSWEEP:STAT?`
→ 💻 `FSTART 2.20E+01,FSTOP 2.00E+04,NSTEPS 3,`
`AMPLITUDESHAPE ENABLE`

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INPut Subsystem

INPut:DEEMphasis [OFF¦ON]

Usage Activates the 750µs deemphasis, which applies on both channels.

Availability Normal mode (not available if the analyzer is armed).

Parameter `[OFF¦ON]` *string*

Default `OFF`

Query ***INPut[1¦2]:STATus?***

Example 💻 → `INP:DEEM ON`

Explanation The DEEMphasis is applied on both channels simultaneously and can also be activated after execution of the signal transmission, thus providing the weighted & unweighted results.
It can be activated independently of the status of other weightings (SWFilter, LAW).

INPut[1¦2]:IMPedance [100K¦600¦PHANTOM]

Usage Sets the input chn. impedance or activates the Phantom (i.e. microphone power) supply.

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[100K¦600¦PHANTOM]` *string*

Default `100k` (Ohm)

Query ***INPut[1¦2]:STATus?***

Examples

💻 →	`Input:Imp 100k`	(set the input imped. of chn. 1 & 2 to 100 kΩ)
💻 →	`Inp1:Impedance 600`	(set the input impedance of chn. 1 to 600 Ω)
💻 →	`INPUT: IMP PHANTOM`	(activate Phantom power on both inputs)

Explanation All input impedance as well as Phantom (i.e. microphone) power are available as standard in every RT-2M.

The Phantom voltage can be set to 15 V or 48 V (p. ***127***).

NOTE	**Make sure that Phantom power is never activated unless a microphone is connected to the inputs of RT-2M. Otherwise, the Phantom voltage could damage the connected device under test.** **If no channel-number is indicated, the command applies on *both* channels simultaneously.**

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INPut[1¦2]:LINK [OFF¦ON]

Usage Links internally the generator output to the analyzer input. The external input connectors of the selected channel are physically disconnected.

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[OFF¦ON]` *string*

Default `OFF` (no internal link)

Query ***INPut[1¦2]:STATus?***

Examples 💻 → `Input2:Link OFF`

💻 → `INP:LINK ON` (links both channels internally)

Explanation

NOTE	**If no channel-number is indicated, the command applies on both channels simultaneously.**

INPut[1¦2]:MICSensitivity <Sensitivity>

Usage Stores the entered microphone sensitivity in the non-volatile RT-2M memory (p. ***127***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<Sensitivity>` *float* 5.0 to 5000.0 (sensitivity in mV/Pa; resolution = 0.1)

Default `50` (mV/Pa)

Query ***INPut[1¦2]:STATus?***

Example 💻 → `INP1:MICS 45.2`

Explanation The command allows storing the sensitivity of the connected microphone on RT-2M. This is required for all measurements that are expressed in dBSPL as well as for the command ***MEASurement:PUResound:STEepness[1¦2¦3¦4¦5¦6]?***

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INPut[1¦2]:RANGe <InputRange> [DBVP¦VP]

Usage Defines the input range (sensitivity) & unit (p. ***125***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter

`<InputRange> [DBVP¦VP]`	*float & string*	(–60 to +40 DBVP, resolution = 0.1 ¦ 0.001 to 100 VP, resolution = 0.001)

Default `0 DBVP` (both channels)

Query ***INPut[1¦2]:STATus?***

Example 💻 → `INPut1:RANGe 3 VP`

Explanation Aadjust the input range properly to avoid clipping of the incoming signal, caused by the internal RT-2M attenuator.

Identify the available headroom with command ***MEASurement[1¦2]:HEADroom?***

INPut[1¦2]:STATus?

Usage Queries the actual input status of the unit.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`MODE 48KSAMPLINGRATE`	*string*
`SOURCE ANALOG`	*string*
`RANGE –60 to +40 dBVp¦0.001 to 100 Vp`	*string & float & string*
`IMPEDANCE [100k¦600¦PHANTOM]`	*string & integer¦string*
`SWFILTER [OFF¦CWE¦CCIT]`	*string*
`LINK [OFF¦ON]`	*string*
`SYNC [INT¦INTN¦EXT¦EXTN¦THR]`	*string*
`DEEMPHASIS [OFF¦ON]`	*string*
`TRIGGER:CONFIGURATION [TIGHT¦LOOSE¦USER]`	*string*
`MICSENSITIVITY [5.0 TO 5000.0]`	*string & float*
`VOLTAGEDIVIDERRATIO [1.0 TO 100.0]`	*string & float*

Examples

💻 → `Input2:Status?`

→ 💻 `MODE 48KSAMPLINGRATE,SOURCE ANALOG,RANGE 0.50E00 dBVp,IMPEDANCE 100K,SWFILTER CCIT,LINK OFF,SYNC EXTN,DEEMPHASIS ON,TRIGGER:CONFIGURATION TIGHT, MICSENSITIVITY 1.35E+01,VOLTAGEDIVIDERRATIO 1.00E+00`

Explanation The returned status format depends on the analyzer operation.

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INPut:SWFilter [OFF¦CWEighting¦CCITt¦AWEighting]

Usage Activates one of the software weighting filters (p. ***116***).

Availability Normal mode (not available if the analyzer is armed).

Parameter `[OFF¦CWEighting¦CCITt¦AWEighting]` *string*

Default `OFF`

Query ***INPut[1¦2]:STATus?***

Example 💻 → `INPUT:SWFILTER CWEIGHTING`

Explanation The SWFilter is applied on both channels simultaneously, and can also be activated *after* execution of the signal transmission, thus providing the weighted & unweighted results. It can be activated independently of the status of other weightings (DEEMphasis, LAW).

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INPut:SYNC [INTernal¦INTNoheader¦EXTernal¦EXTNoheader¦THReshold]

Usage Defines the trigger & synchronization mode (p. ***188ff***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).
- INT: Only for multitone signals
- INTN: Multitone signals or chirp; mandatory default for stepped sweep
- EXT: Only for multitone signals
- EXTN: Only for multitone signals
- THR: Multitone signals or chirp

Parameter **A)** A-A, A-D operation in Normal mode
`[INT¦INTN¦EXT¦EXTN¦THR]` *string*

B) PureSound™ mode
`[INTN¦THR]` *string*

`INT` The RT-2M generator and analyzer use the same sampling clock and the multitone signal is transmitted with the proprietary header.
- Command ***OUTPut:MTONe:STARt*** starts the signal transmission.
- The analyzer starts sampling as soon as it recognizes the proprietary header
- The maximum allowable time delay (timeout condition) between the start command and the detection of the proprietary header can be defined with command ***INPut:TRIGger:TIMEout*** <***Timeout***> (default = 500 ms).
- If command ***INPut:TRIGger:ARMed*** has been sent to RT-2M prior to the start command, no timeout condition is applied, i.e. the analyzer waits until it detects the proprietary header or until it is interrupted with ***INPut:TRIGger:BREak***.

`INTN` The RT-2M generator and analyzer use the same sampling clock. The generator sends out the test signal without the proprietary header.
- Command ***OUTPut:MTONe:STARt***, ***OUTPut[1¦2]:PUResound:CHIRp:STARt*** or ***OUTPut:STEPpedsweep:STARt*** start the signal transmission.
- The analyzer starts sampling simultaneously with the signal transmission.

`EXT` RT-2M sends out the multitone signal with the proprietary header. The analyzer synchronizes its sampling clock to the frequency of the 'clock synchronization' block in the header of the received multitone burst.
- Command ***OUTPut:MTONe:STARt*** starts the signal transmission.
- The analyzer starts sampling as soon as it recognizes the proprietary header.
- The maximum allowable time delay (timeout condition) between the start command and the detection of the proprietary header can be defined with command ***INPut:TRIGger:TIMEout*** <***Timeout***> (default = 500 ms).
- If command ***INPut:TRIGger:ARMed*** has been sent to RT-2M prior to the start command, no timeout condition is applied, i.e. the analyzer waits until it detects the proprietary header or until it is interrupted with ***INPut:TRIGger:BREak***.

`EXTN` RT-2M sends out the multitone signal without the proprietary header. The analyzer applies the sampling clock that it has synchronized to the frequency of the 'clock synchronization' block in the header of the last multitone burst that was received in the "EXT" mode.
- Command ***OUTPut:MTONe:STARt*** starts the signal transmission.
- The analyzer starts sampling simultaneously with the signal transmission.

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THR The RT-2M generator and analyzer use the same sampling clock. The generator sends out the test signal without the proprietary header.

- Command ***OUTPut:MTONe:STARt***, ***OUTPut[1¦2]:PUResound:CHIRp:STARt*** or ***OUTPut:STEPpedsweep:STARt*** start the signal transmission.
- The analyzer starts sampling as soon as it has triggered to a user-defined threshold level, defined by ***INPut:TRIGger:THReshold:LEVel*** <***ThreshLevel***>.
- ***INPut:TRIGger:THReshold:PREmeasdelay*** <***PreMeasDelay***> allows introducing an additional delay between the trigger event and the beginning of the data acquisition.
- The maximum allowable time delay (timeout condition) between the start command and the trigger event can be defined with command ***INPut:TRIGger:TIMEout*** <***Timeout***> (default = 500 ms).
- If command ***INPut:TRIGger:ARMed*** has been sent to RT-2M prior to the start command, no timeout condition is applied, i.e. the analyzer waits until it detects the proprietary header or until it is interrupted with ***INPut:TRIGger:BREak***.

Default `INTernal¦INTNoheader` (multitone ¦ PureSound™ or stepped sweep analysis)

Query ***INPut[1¦2]:STATus?***

Example 💻 → `Inp:Sync Intn`

Explanation The trigger & synchronization mode command defines the operation of the RT-2M generator and analyzer.

- Multitone signal generation: with or without proprietary header (p. ***130***).
- Analyzer clock synchronization: generator clock or 'Clock synchronization' block (p. ***130***) of received multitone header.
- Start of analyzer sampling: simultaneous with start command, after detection of proprietary header or user-defined threshold level. If no trigger condition is met, the error message ***203 No trigger detected*** will be generated.

In addition to the ***INPut:SYNC …*** command, the instructions ***INPut:TRIGger:TIMEout*** <***Timeout***>, ***INPut:TRIGger:ARMed*** etc. allow adapting the test signal acquisition to the specific requirements of the application.

NOTE	**In case of a dual-channel burst transmission, the RT-2M analyzer starts sampling on both channels simultaneously, as soon as the trigger condition has been met on either channel.**

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INPut:TRIGger:ARMed

Use The command arms both input channels of the RT-2M analyzer in the Normal mode. Therein, the analyzer waits until the trigger condition is met before it starts sampling (p. ***186***).

Availability Normal mode (not available if the analyzer is already armed), whereby the ***INPutSYNC …*** mode must be set to ***INTernal***, ***EXTernal*** or ***THReshold***.

Query ***INPut:TRIGger:ARMed?***

Example 💻 → `Inp:Trig:Arm`

Explanation The command allows e.g. triggering to an externally generated signal (p. ***186***).

Interrupt the armed operation with command ***INPut:TRIGger:BREak***.

In the armed status, the "Trigger" LED is flashing until the trigger condition is met or until the analyzer is reset.

As soon as the trigger condition is met, the RT-2M analyzer starts sampling on both input channels simultaneously.

NOTE	**Not all commands are available after command *INPut:TRIGger:ARMed*. Please refer to the individual command descriptions for further details.**

INPut[1¦2]:TRIGger:ARMed

Use Arms the RT-2M analyzer input chn 1 *or* chn 2 in the PureSound™ mode. Therein, the analyzer waits until the trigger condition is met before it starts sampling (p. ***187***).

Availability PureSound™ mode (not available if the analyzer is already armed), whereby ***INPutSYNC …*** must be set to ***THReshold***.

Query ***INPut:TRIGger:ARMed?***

Example 💻 → `Input2:Trigger:Armed`

Explanation The command allows triggering to an externally generated chirp (p. ***187***).

Interrupt the armed operation with command ***INPut:TRIGger:BREak***.

In the armed status, the "Trigger" LED is flashing until the trigger condition is met or until the analyzer is reset.

NOTE	**Not all commands are available after command *INPut:TRIGger:ARMed*. Please refer to the individual command descriptions for further details.**

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INPut:TRIGger:ARMed?

Use Queries, whether the RT-2M analyzer is armed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`[ARMED¦`	*string*	In the armed status, RT-2M waits until the trigger condition is met (p. ***186ff***) or until the unit is reset into the normal operation.
`STOPPED]`	*string*	"`STOPPED`" indicates that RT-2M is in the normal mode (i.e. not armed). In this status, the "Trigger" LED remains dark.

Example

💻 → `Inp:Trigger:Armed?`
→ 💻 `ARMED`

INPut:TRIGger:BREak

Use Resets the RT-2M analyzer if it is armed.

Availability Normal and PureSound™ mode (especially if the analyzer is armed).

Query ***INPut:TRIGger:ARMed?***

Example 💻 → `Inp:Trigger:Break`

Explanation This command resets RT-2M to the normal operation, i.e. the analyzer is no longer armed. Consequently, the "Trigger" LED goes OFF.

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INPut:TRIGger:CONFiguration [LOOSE¦TIGHT¦USER]

Use Defines the trigger condition for the detection of the proprietary multitone header (p. ***196***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter

`[LOOSE¦`		Applies the normal trigger condition to an incoming multitone burst. This configuration is especially suited for industrial applications, where both multitone generator and analyzer are located in the same housing.
`TIGHT¦`	*string*	Applies the tight trigger condition to an incoming multitone burst. This configuration should be used for broadcast applications, where the signal is inserted into a shortly interrupted broadcast signal.
`USER]`		This configuration allows defining the trigger condition. However, since this requires a highly sophisticated fine-tuning, it is strongly recommended that this is only configured by very advanced users.

Default `LOOSE`

Query ***INPut[1¦2]:STATus?***

Example 💻 → `Inp:Trigger:Configuration Tight`

Explanation It is recommended to change the trigger configuration only for transmission line tests and to select the TIGHT condition in such cases. As soon as RT-2M is used again for industrial applications, the trigger configuration should be set to LOOSE.

NOTE	**The use of the command is only recommended to very advanced users.**

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INPut:TRIGger:THReshold:LEVel <ThreshLevel>

Usage Defines the threshold level for the ***INPut:SYNC THReshold*** trigger mode (p. ***194***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<ThreshLevel>` *float* 1.0 to 99.9 (threshold in % of input range; resolution = 0.1)

Default `25.1` (%)

Query ***INPut:TRIGger:THReshold:LEVel?***

Example 💻 → `INP:TRIG:THR:LEV 55.5`

Explanation The threshold level refers to the actual input range value.

In the ***INPut:SYNC THReshold*** mode, the analyzer monitors the amplitude of the input signal, until it exceeds the threshold level. From that moment, it waits for a time defined by ***INPut:TRIGger:THReshold:PREmeasdelay <PreMeasDelay>***, before the sampling starts.

INPut:TRIGger:THReshold:LEVel?

Usage Queries the ***INPut:SYNC THReshold*** trigger level (p. ***194***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `<ThreshLevel>` *float* 1.0 to 99.9 (trigger threshold in % of current input range)

Example
```
💻 → Input:Trigger:Threshold:Level?
→ 💻 75.00E+01
```

Explanation The threshold level refers to the actual input range value.

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INPut:TRIGger:THReshold:PREmeasdelay <PreMeasDelay>

Usage Defines the delay from the point when the input signal exceeds the threshold trigger level to when the analyzer starts sampling (p. ***194***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<PreMeasDelay>` *integer* 5 to 30000 (PreMeasdelay in ms; resolution = 1)

Default

Blocklength	***Default Delay***
512	**74**
1024	**170**
2048	**170**
4096	**426**
8192	**341**

Query ***INPut:TRIGger:THReshold:PREmeasdelay?***

Example 💻→ `inp:trig:thr:del 1000`

Explanation This command allows the DUT settling to the input signal, i.e. letting possible transient responses disappear, before the sampling process (i.e. signal acquisition) is executed.

INPut:TRIGger:THReshold:PREmeasdelay?

Usage Queries the PREmeas trigger delay time (p. ***194***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Answer `<PreMeasDelay>` *integer* 5 to 30000 (PreMeasdelay expressed in ms)

Example

```
💻→ INPut:TRIGger:THReshold:PREmeasdelay?
→💻 200
```


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INPut:TRIGger:THReshold:POSTmeasdelay <PostMeasDelay>

Usage Prevents the RT-2M analyzer for a user-defined period from re-triggering after it has once triggered and completed the data acquisition (p. ***194***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<PostMeasDelay>` *integer* 0 to 30000 (PostMeasdelay in ms; resolution = 1)

Default `0` (ms)

Query ***INPut:TRIGger:THReshold:POSTmeasdelay?***

Example 💻 → `INP1:TRIG:thr:post 3000`

Explanation The command allows blocking the RT-2M analayzer from retriggering after it has triggered to a threshold (trigger mode ***INPut:SYNC THReshold***). This can be necessary e.g. if RT-2M shall trigger to repeatedly incoming bursts that last longer than the data acquisition period.

INPut:TRIGger:THReshold:POSTmeasdelay?

Usage Queries the ***POSTmeasdelay***, i.e. the time during which RT-2M is blocked from re-triggering after it has once triggered and completed the data acquisition (p. ***194***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Answer `<PostMeasDelay>` *integer* 0 to 30000 (PostMeasdelay expressed in ms)

Example
💻 → `INP1:TRIG:thr:post?`
→ 💻 `500`

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INPut:TRIGger:TIMEout <Timeout>

Usage Defines the time period during which RT-2M waits that the trigger condition is met after it has received a start command. If this period expires, i.e. if the analyzer does not trigger during the ***Timeout***, it returns error ***203 (No trigger detected)***.

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the ***INPut:SYNC*** command must be set to ***INTernal***, ***EXTernal*** or ***THReshold***.

Parameter `<Timeout>` *integer* 50 to 10000 (trigger timeout in ms; resolution = 1)

Default `500` (ms)

Query ***INPut:TRIGger:TIMEout?***

Example
```
💻 →   INP:TRIG:TIME 1500
```

Explanation As soon as the RT-2M unit has received the start command ***OUTPut:MTONe:STARt*** or ***MEASurement[1¦2]:PUResound:STARt***, its analyzer waits during the <***Timeout***> period for an incoming signal. If the trigger condition is met during this period, the analyzer starts sampling. Otherwise the error message ***203 No trigger detected*** is generated.

INPut:TRIGger:TIMEout?

Usage Queries the analyzer ***Timeout***.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `<Timeout>` *integer* 50 to 10000 (trigger timeout expressed in ms)

Example
```
💻 →   INP:TRIG:TIME?
→ 💻   1500
```


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INPut:TRIGger:USRConfiguration <bin1>,<bin2>,<emptybin>

Use Defines a custom-specific proprietary multitone trigger (i.e. trigger bin levels, p. ***196***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter

`<bin1>,`	*float*	–10 to –50 dB
`<bin2>,`	*float*	–10 to –50 dB
`<emptybin>`	*float*	0 to –80 dB

Query ***INPut:TRIGger:USRConfiguration?***

Example 💻 → `Inp:Trig:Usrc –2.00E+01,-4.00E+01,-8.00E+01`

Explanation

NOTE	**This command requires highly sophisticated handling for proper operation and should only be applied by very advanced users!**

INPut:TRIGger:USRConfiguration?

Use Queries the user-defined multitone trigger (p. ***196***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`<setbin1>,`	*float*	–10 to –50 dB
`<setbin2>,`	*float*	–10 to –50 dB
`<emptybin>`	*float*	0 to –80 dB

Example

💻 → `Inp:Trigger:Usrconfiguration?`
→ 💻 `-4.00E+01,-3.00E+01,-4.50E+01`

Explanation Refer to chapter ***Trigger Configuration*** (p. ***196***).

INPut[1¦2]:VOLTagedividerratio <Ratio>

Usage Applies a correction factor to the input range and all absolute measurement results (p. ***201***).

Availability Normal, PureSound™ mode (not available if the analyzer is armed, LCL,RL,LCTL mode).

Parameter `<Ratio>` *float* 1.00 to 100.0 (voltage divider ratio defined by 1:<Ratio>)

Default 1.0

Query ***INPut[1¦2]:STATus?***

Example 💻 → `INPUT1:VOLTAGEDIVIDERRATIO 2`

Explanation This feature supports applications where voltages higher than 100 Vp have to be measured (e.g. 100 V PA-systems) by connecting a voltage divider to the RT-2M input (p. ***201***).

The command compensates the effect of an externally connected voltage divider. It corrects the input range and measurement result with the entered voltage divider <Ratio>.

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MEASurement Subsystem

MEASurement[1¦2]:CROSstalk:UNIT [%¦DB]

Usage Defines the unit, in which the crosstalk measurement is expressed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `[%¦DB]` *string* (percent ¦ decibel)

Default `%`

Example 💻 → `MEAS1:CROS:UNIT dB`

MEASurement[1¦2]:CROSstalk?

Usage Queries the measured crosstalk of the alternate channel to the active channel. The crosstalk result can be only evaluated if at least one signal bin of each channel in the transmitted multitone signal is set at an exclusive frequency (chapter ***Crosstalk,*** p. ***134***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`{SignalBin`$_n$`}/`	*integer*	(signal bin number, p. ***152***)
`{Xtalk`$_n$ `Unit},`	*float*¦NaN & *string*	(corresponding crosstalk result & unit)

Unit (defined by command ***MEASurement[1¦2]:CROSstalk:UNIT [%¦DB]***)

Example

💻 → `MEAS1:CROS?`
→ 💻 `13/-1.35764E+02 DB,121/-0.54340E+01 DB,235/NaN`

Explanation The returned vector is composed of pairs, indicating the crosstalk result at each signal bin. Every pair starts with the number of the signal bin, followed by a "/", the corresponding crosstalk value, a white space, the unit in which the result is expressed, and a comma (",").

If the crosstalk value is too small to be measured, '`NaN`' (not a number) will be returned.

NOTE	**In the 8 kHz mode the measuring bandwidth is limited to 20 Hz – 3.4 kHz.**

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MEASurement[1¦2]:DISTortion:UNIT [DBV¦V¦DBM]

Usage Defines the unit, in which the distortion result shall be expressed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[DBV¦`		(V_{RMS} in logarithmic scale, referred to 1 V_{RMS})
`V¦`	*string*	(V_{RMS} in linear scale)
`DBM]`		(RMS power in logarithmic scale, p. ***199***)

Default `DBV`

Example 💻 → `MEAS1:DIST:UNIT V`

Explanation

> **NOTE** **[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

MEASurement[1¦2]:DISTortion?

Usage Queries the distortion values of all bands between 20 Hz → Bin_Min, Bin_Min → Bin_1, etc., Bin_n → Bin_Max (chapter ***Distortion***, p. ***136***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`{SignalBin`$_n$`}/`	*integer*	(signal bin number, p. ***152***)
`{Dist`$_n$ `Unit},`	*float*¦NaN & *string*	(corresponding distortion result & unit)

Unit (defined by ***MEASurement[1¦2]:DISTortion:UNIT [DBV¦V¦DBM]***)

Example

💻 → `Measurement1:Dist?`

→ 💻
```
3/-1.07006E+02 dBV,11/-0.98914E+02 dBV,32/
-0.86325E+02 dBV,48/-0.72354E+02 dBV,214/NaN
```

Explanation The returned distortion vector starts with Bin_Min (i.e. the first possible bin number ≥20 Hz) followed by the distortion result between Bin_Min and the first signal bin. The second pair is the bin number of the first signal bin and the distortion result between this first signal bin and the second signal bin, etc. The last pair is the last signal bin with the distortion result between this last signal bin and Bin_Max (i.e. the last possible bin ≤ 20 kHz; ***Fig 21***, p. ***137***)

If a band between two signal bins is too narrow to measure a distortion, '`NaN`' is returned.

> **NOTE** **[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

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MEASurement[1¦2]:DTMF:STARt

Usage Resets the DTMF tone receiver buffer (32 keys wide) of channel 1 or 2 (p. ***114***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Example 💻 → `Meas1:Dtmf:Start`

Explanation RT-2M continuosly stores the incoming DTMF tones in its buffer after this command.

MEASurement[1¦2]:DTMF?

Usage Queries the DTMF tone receiver buffer (32 keys wide) of channel 1 or 2 (p. ***114***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`{Row}/`	*integer*	1 to 4	(row number)
`{Column},`	*integer*	1 to 4	(column number)
`;` *string*	(no DTMF signal received)		

Examples

💻 → `MEAS1:DTMF?`
→ 💻 `1/2,3/2,2/2` (3 keys detected: 2,8,5)

💻 → `Meas2:Dtmf?`
→ 💻 `;` (empty buffer - no keys received since last reset)

Explanation RT-2M returns pairs of row / column numbers that identify the DTMF sinals in the order as they have been received. The decoding of these numbers is described in ***Table 6*** (p. ***114***).

Use the command ***MEASurement[1¦2]:FREQuency:SELective? <binstart> <binstop>*** to measure the exact frequencies of an incoming DTMF signal.

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MEASurement[1¦2]:FREQuency:FULLband?

Usage Queries the frequency of the sine component with the highest amplitude within the frequency band from 23 Hz to 20 kHz ¦ 4 kHz (p. ***117***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`<Bin_Max>/`	*integer*	(Bin_Max of current blocklength, p. ***156***)
`<Frequency> Hz`	*float*¦NaN & *string*	(measured frequency, expressed in Hz)

Example

💻 → `MEAS1:FREQ:FULL?`
→ 💻 `213/1.23456E+03 Hz` (dominant frequency = 1234.56 Hz)

Explanation This command allows measuring the exact frequency of a sine component generated by an external device that does not need to be synchronous to the RT-2M analyzer. If no dominant frequency can be measured, an error message will be returned.

Before a frequency measurement is executed, a signal has to be acquired, i.e. the analyzer has to be triggered to sample the incoming signal. This can be done in different ways as described in chapter ***Test Setups*** (p. ***182***).

MEASurement[1¦2]:FREQuency:SELective? <binstart> <binstop>

Usage Queries the frequency of the dominant signal component in a user-defined band (p. ***117***).

Availability Normal mode (not available if the analyzer is armed).

Parameter

`<binstart>`	*integer*	`1 to 3413`	(<binstart> = upper, <binstop> = lower limit of the frequency band; refer to p. ***117***, ***152***)
`<binstop>`		`1 to 3413`	

Answer

`<binstop>/`	*integer*	(binstop)
`<Frequency> Hz`	*float*¦NaN & *string*	(measured frequency, expressed in Hz)

Example

💻 → `MEAS1:FREQ:SEL? 23 34`
→ 💻 `34/1.03132E+03 Hz`

Explanation The command measures the frequency of the sine signal with the highest amplitude in the selected frequency band.
Before the measurement, the signal has to be acquired (i.e. the analyzer has to trigger and to sample the incoming signal). This can be done in several different ways as described in chapter ***Test Setups*** (p. ***182***).
If no dominant signal can be detected, an error is returned.

The investigated input signal can have been generated by an external device, whereby the external generator does not need to be synchronous to the RT-2M analyzer.

The available range of <***binstart***> and <***binstop***> depends on the curent blocklength (p. ***156***).

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MEASurement[1¦2]:GAIN?

Usage Queries the gain of every signal bin, i.e. output level [dB] – the input level [dB] (p. ***138***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`{SignalBin`$_n$`}/`	*integer*	(signal bin number, p. ***152***)
`{Gain`$_n$ `DB},`	*float*¦NaN & *string*	(gain @ SignalBin$_n$, expressed in dB)

Example

💻 → `Measurement1:Gain?`
→ 💻 `3/1.55E-02 DB,11/1.36E-02 DB, 32/2.13E-02 DB` (signal bin #3 → gain 155 dB, #11 → 136 dB, #32 → 213 dB)

Explanation The result vector starts with the first signal bin No., /, the corresponding gain and 'dB', followed by the second signal bin No., /, gain and 'dB' etc.

Please note that all gain values are expressed in dB.

MEASurement[1¦2]:HEADroom?

Usage Queries the headroom of the last received test signal (p. ***125***), i.e. the difference:

"current *input range* of RT-2M – received *input level* of the test signal"

(the first as defined by command ***INPut[1¦2]:RANGe <InputRange> [DBVP¦VP]***, p. ***54***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`<Headroom> DB`	*float & string*	(headroom, expressed in dB)

Example

💻 → `MEAS1:HEAD?`
→ 💻 `3.43200E+01 DB` (received level = 34.4 dB below the input range)

Explanation This command is very helpful to optimize the input range of RT-2M. In practice, it is recommended to proceed as follows:

1. Adjust the initial input range IR_{Init} to a value that is high enough (e.g. +40 dBVp).
2. Start the test (***OUTPut:MTONe:STARt***, ***OUTPut[1¦2]:PUResound:CHIRp:STARt*** or ***OUTPut:STEPpedsweep:STARt***).
3. Query the headroom result *HR* [dB].
4. Adjust the new input range to $IR_{New} = IR_{Init} - HR + 6$ (6 dB = security margin).

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MEASurement[1¦2]:LEVel:UNIT [DBVP¦VP¦DBV¦V¦DBM]

Usage Defines the unit, in which the level results shall be expressed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

[DBVP¦		(V_{Peak} in logarithmic scale, referred to 0 V)
VP¦		(V_{Peak} in linear scale)
DBV¦	*string*	(V_{RMS} in logarithmic scale, referred to 1 V_{RMS})
V¦		(V_{RMS} in linear scale)
DBM]		(RMS Power in logarithmic scale, p. ***199***)

Default DBVP

Example 💻 → `MEAS1:LEV:UNIT Vp`

Explanation

NOTE	**[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

MEASurement[1¦2]:LEVel?

Usage Queries the measured signal bin levels of the last received multitone signal for one channel, expressed in the selected unit (chapter ***Level***, p. ***139***).

Availability Normal mode (not available if the analyzer is armed).

Answer

{$SignalBin_n$}/	*integer*	(signal bin number, p. ***152***)
{$Level_n$ Unit},	*float*¦NaN & *string*	(corresponding level result & unit)

Unit (defined by command ***MEASurement[1¦2]:LEVel:UNIT ...***)

Example

💻 → `MEAS1:LEV?`

→ 💻 `3/-2.19404E+01 dBV,11/-1.35249E+01 dBV,32/-1.23547E+01 dBV,48/-1.27921E+01 dBV`

Explanation The returned vector is grouped in pairs, starting with the first signal bin number, a "/", the respective level result, a white space, and the unit in which the result is expressed. Pairs are separated by commas (",").

If a received level is too low to be measured, 'NaN' (not a number) is returned.

NOTE	**[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

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MEASurement[1|2]:LOUDnessrating:SLR?

Usage Queries the measured SLR (Send Loudness Rating, p. ***142***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`<LastSignalBin>/`	*integer*	(No. of the highest signal bin)
`<SLR_Result> DB`	*float*¦NaN & *string*	(SLR result, expressed in dB)

Example

💻 →	`MEAS1:LOUD:SLR?`	
→ 💻	`170/9.22375E+00 DB`	(bin No. 170 = 3984 Hz; SLR = 9.224 dB)

Explanation Use the "LOUDNESS" signal for SLR analysis (***OUTPut:MTONe:ACTive:LOUDNESS***).

NOTE **Calibrate the setup prior to SLR measurements (p. *141*).**

MEASurement[1|2]:LOUDnessrating:STMR?

Usage Queries the measured STMR (Sidetone Masking Loudness Rating, p. ***144***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`<LastSignalBin>/`	*integer*	(No. of the highest signal bin)
`<STMR_Result> DB`	*float*¦NaN & *string*	(STMR result, expressed in dB)

Example

💻 →	`MEAS1:LOUD:STMR?`	
→ 💻	`170/1.9760E+01 DB`	(bin No. 170 = 3984 Hz; STMR = 19.76 dB)

Explanation Use the "LOUDNESS" signal for STMR analysis (***OUTPut:MTONe:ACTive:LOUDNESS***).

NOTE **Calibrate the setup prior to STMR measurements (p. *141*).**

MEASurement[1|2]:LOUDnessrating:RLR?

Usage Queries the measured RLR (Receive Loudness Rating, p. ***143***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`<LastSignalBin>/`	*integer*	(No. of the highest signal bin)
`<RLR_Result> DB`	*float*¦NaN & *string*	(RLR result, expressed in dB)

Example

💻 →	`MEAS1:LOUD:RLR?`	
→ 💻	`170/2.25365E+00 DB`	(bin No. 170 = 3984 Hz; RLR = 2.254 dB)

Explanation Use the "LOUDNESS" signal for RLR analysis (***OUTPut:MTONe:ACTive:LOUDNESS***).

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MEASurement[1¦2]:MTTDan:UNIT [DB¦%]

Use Defines the unit, in which the TD+N result (Total Distortion + Noise, refer to p. ***137***) shall be expressed.

Availability Normal or PureSound™ mode (also if the analyzer is armed).

Parameter `[DB¦%]` *string* (decibel ¦ percent)

Default `DB`

Example 💻 → `MEAS1:MTTD:UNIT %`

MEASurement[1¦2]:MTTDan?

Use Queries the TD+N result (Total Distortion + Noise, refer to p. ***137***) of a transmitted multitone signal in the frequency band from 23 Hz to 20 kHz.

Availability Normal mode (not available if the analyzer is armed).

Answer

`<Bin_Max>/`	*integer*	(Bin_Max, p. ***152***)
`<TD+N Unit>`	*float*¦NaN & *string*	(TD+N result & unit)

Example

💻 → `Measurement1:MTTDAN?`
→ 💻 `854/-6.40217E+01 DB`

Explanation The result string starts with Bin_Max, followed by a slash "/", the TD+N result and the unit. The measurement considers the frequency band from the first bin ≥ 20 Hz (Bin_Min) to the last bin ≤ 20 kHz (i.e. Bin_Max), whereby the TD+N result is calculated out of the noise, distortion and signal levels according to ***Equation 6***.

MEASurement[1¦2]:MTSinad?

Use Queries the MT-SINAD result (p. ***140***) of a transmitted multitone signal in the frequency band from 23 Hz to 20 kHz.

Availability Normal mode (not available if the analyzer is armed).

Answer

`<Bin_Max>/`	*integer*	(Bin_Max, p. ***152***)
`<MT_Sinad> DB`	*float*¦NaN & *string*	(MT-SINAD result, expressed in dB)

Example

💻 → `Measurement1:MTSinad?`
→ 💻 `213/5.22350E+01 DB`

Explanation The result string starts with Bin_Max, followed by a slash "/", the MT-SINAD result and the unit dB. The measurement considers all signal components from the first bin ≥ 20 Hz (Bin_Min) to the last bin ≤ 20 kHz (i.e. Bin_Max), wheerby the MT-SINAD result is calculated out of the noise, distortion and signal levels according to ***Equation 9***.

If two signal bins are too narrow to measure the distortion energy of the band in between, error ***246 Measurement not possible*** is returned.

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MEASurement[1¦2]:NOISe:UNIT [DBV¦V¦DBM]

Usage Defines the unit, in which the noise measurement result is expressed (p. ***146***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

[DBV¦		(V_{RMS} in logarithmic scale, referred to 1 V_{RMS})
V¦	*string*	(V_{RMS} in linear scale)
DBM]		(RMS power in logarithmic scale, p. ***199***)

Default DBV

Example 💻 → `MEAS1:NOISE:UNIT V`

Explanation

NOTE	**[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

MEASurement[1¦2]:NOISe?

Usage Queries the noise values of the bands between Bin_Min → SignalBin_1, SignalBin1 → SignalBin2, etc., SignalBin_n → Bin_Max (chapter ***Noise***, p. ***146***).

Availability Normal mode (not available if the analyzer is armed).

Answer

{SignalBin$_n$}/	*integer*	(signal bin number, p. ***152***)
{Noise$_n$ Unit},	*float*¦NaN & *string*	(measured noise result & unit)

Unit (defined by ***MEASurement[1¦2]:NOISe:UNIT [DBV¦V¦DBM]***)

Example

💻 → `Measurement1:Noise?`
→ 💻 `3/-1.22176E+02 dBV,11/-1.08494E+02 dBV,32/-1.03108E+02 dBV,48/-1.03342E+02 dBV,214/NaN`

Explanation The returned noise vector starts with Bin_Min, followed by the noise result between this bin and the first signal bin. he second pair is the bin number of SignalBin_1 and the noise value between SignalBin_1 and SignalBin_2, etc. The last pair is the last signal bin with the noise result between this signal bin and Bin_Max. Refer also to ***Fig 29***.

If a band between two signal bins is too narrow to measure a noise value, 'NaN' (not a number) is returned.

NOTE	**[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

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MEASurement[1¦2]:NOISe:FULLband?

Usage Queries the full band noise from 20 Hz to 20 kHz ¦ 4 kHz (***Full Band Noise***, p. ***147***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`<Bin_Max>/`	*integer*	(Bin_Max, p. ***152***)
`<FullBandNoise Unit>`	*float*¦NaN & *string*	(full band noise result & unit)

Unit (defined by ***MEASurement[1¦2]:NOISe:UNIT [DBV¦V¦DBM]***)

Example

```
💻 →   Measurement1:Fullband?
→ 💻   213/1.23456E-02 dBV
```

Explanation The returned result string starts with the highest possible bin (Bin_Max), followed by a "/", the fullband noise result and the unit.

The fullband noise result is calculated according to ***Equation 11*** (p. ***147***).

If two or more signal bins are set directly besides each other (with no bin in between), an error message is returned.

NOTE	**[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

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MEASurement:PHASe:SCALe <Scale> [RAD¦DEG]

Usage Defines the lower scaling end of the multitone and stepped sweep phase-plot (p. ***147***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `-6.28318E+00 to 0 RAD¦ -360.000E+00 to 0 DEG` *float & string* (–6.28318 = –2π)

Default `0`

Examples

💻 → `MEAS:PHASE:SCALE -2.70E-02 DEG` (–270° to +90°)

💻 → `Meas:Phas:Scal -3.14159E+00 RAD` (–π to + π)

Explanation The complete phase scale encompasses a full circle, i.e. 2π [rad] or 360° [deg].

The scale applies on multitone as well as stepped sweep measurements, i.e. regardless whether the measurement is executed with command ***MEASurement[1¦2]:PHASe?*** or ***MEASurement[1¦2]:STEPpedsweep:PHASe? <MeasFrequency>***.

MEASurement:PHASe:UNIT [RAD¦DEG]

Usage Defines the unit (radiant or degree) of the multitone phase measurement result (p. ***147***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `[RAD¦DEG]` *string* (radiant: 0 to 2π @ degree: 0° to 360°)

Default `RAD`

Example

💻 → `MEAS:PHASE:UNIT DEG`

Explanation The command defines the phase unit for multitone measurements.

Please note that phase measurements can also be executed with a stepped sweep (p. ***181***).

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MEASurement[1¦2]:PHASe?

Usage Queries the phase-difference between identical signal bins of a two-channel multitone signal (p. ***147***).

Availability Normal mode (not available if the analyzer is armed).

Answer

{SignalBin$_n$}/	*integer*	(signal bin number, p. ***152***)
{Phase$_n$ Unit},	*float*¦NaN & *string*	(phase result & unit)
;	(no trigger detected, i.e. no phase measurement possible)	

Unit (defined by command ***MEASurement:PHASe:UNIT [RAD¦DEG]***)

Examples

```
💻 → MEAS1:PHASE?
→ 💻 13/1.24001E00 DEG,123/9.27300E-01 DEG

💻 → MEAS1:PHASE?
→ 💻 ;                (phase measurement not successful)
```

Explanation The multitone phase measurement is only available:

- If at least one identical signal bin is set in both channels of the multitone signal (p. ***148***).
- If the RT-2M analyzer has triggered on both channels to the incoming signal.

The returned vector is composed of blocks, indicating the measured phase value at a signal bin. Each block starts with the number of the signal bin, followed by a "/", the corresponding phase value, a white space, the unit in which the result is expressed, and a comma (",").

';' indicates that the analyzer did not trigger.

Please note that phase measurements can also be acquired with a stepped sweep (p. ***181***).

NOTE	**Set the input range of both channels to the same value to get accurate phase results.**

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MEASurement:PUResound:LENGth <Duration>

Usage Defines the acquisition length of the steepness analysis (p. ***169***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter
A) INOUT:PUResound:MODE RNB
`<Duration>` *integer* 100 to 10000 (sampling duration in ms; resolution = 1)

B) INOUT:PUResound:MODE CORRelation
`<Duration>` *integer* 300 to 180000 (sampling duration in ms; resolution = 1)

Default `1000` (ms)

Query ***MEASurement:PUResound:STATus?***

Example 💻 → `meas:pur:leng 1500`

Explanation If the internal stimulus signal (chirp) is used for a RNB measurement, <Duration> should be equal to the value defined by ***OUTPut:PUResound:CHIRp:LENGth <Duration>***

MEASurement:PUResound:NRESults <#Results>

Usage Defines the number of results for the steepness calculation (p. ***169***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `<#Results>` *integer* 1 to 1000 (number of results; resolution = 1)

Default `100`

Query ***MEASurement:PUResound:STATus?***

Example 💻 → `MEAS:PUR:NRES 500`

Explanation <#Results> defines the resolution of the returned result vector, but not of the RNB test.

MEASurement[1¦2]:PUResound:STARt

Usage Starts the PureSound™ analysis (RNB or CORRELATION) of an incoming signal (p. ***185***).

Availability PureSound™ mode (not available if the analyzer is armed).

Example 💻 → `MEAS1:PUR:STAR`

Explanation The command starts only the analysis of an incoming signal, regardless whether it was generated by RT-2M or by an external signal generator.

NOTE	**Select an appropriate trigger mode with command *INPut:SYNC INTN* or *THR* before starting the PureSound™ data acquisition.**

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MEASurement:PUResound:STATus?

Usage Queries the measurement status of the PureSound™ option.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

A) INOUT:PUResound:MODE OFF

; *string* (not applicable)

B) INOUT:PUResound:MODE RNB

NRESULTS [1 to 1000],	*string & integer*	(number of results)
LENGTH [100 to 10000],	*string & integer*	(chirp duration)
LIMIT1 [ENABLE¦DISABLE],	*string & float*	
LIMIT2 [ENABLE¦DISABLE],	*string & float*	
LIMIT3 [ENABLE¦DISABLE],	*string & float*	(status of the individual
LIMIT4 [ENABLE¦DISABLE],	*string & float*	steepness limits for band No. 1 – 6)
LIMIT5 [ENABLE¦DISABLE],	*string & float*	
LIMIT6 [ENABLE¦DISABLE]	*string & float*	

C) INOUT:PUResound:MODE CORRelation

NRESULTS [1 to 1000],	*string & integer*	(number of results)
LENGTH [100¦300 to 10000],	*string & integer*	(test signal duration)
ACTIVEREFERENCE [A¦B],	*string*	(reference signal)
REFERENCELENGTH [300 to 10000],	*string & integer*	(duration of the reference signal)
REFERENCEVALIDITY [VALID¦INVALID],	*string*	(validity of the reference signal)
NAME <RefName>	*string*	(name of the reference signal)

Examples

💻 → `INOUT:PURESOUND:MODE OFF`
`MEASUREMENT:PURESOUND:STAT?`
→ 💻 `;`

💻 → `INOUT:PUR:MODE RNB`
`MEASUREMENT:PUR:STAT?`
→ 💻 `NRESULTS 100,LENGTH 1000,LIMIT1 ENABLE,LIMIT2 ENABLE,LIMIT3 DISABLE,LIMIT4 ENABLE,LIMIT5 ENABLE, LIMIT6 DISABLE`

💻 → `INOUT:PUR:MODE CORRELATION`
`MEASUREMENT:PUR:STAT?`
→ 💻 `NRESULTS 134,LENGTH 500,ACTIVEREFERENCE B, REFERENCELENGTH 500,REFERENCEVALIDITY VALID, NAME MOZART`

Explanation The syntax of the returned string depends on the status of the PureSound™ mode as defined by ***INOUT:PUResound:MODE [OFF¦RNB¦CORRelation]***.

If the test signal length (PureSound™ mode CORRelation) is invalid, "0" will be returned.

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MEASurement:PUResound:STEepness[1¦2¦3¦4¦5¦6]?

Usage Queries the measured steepness results of the selected band (#1–6) for the last signal that was acquired through the active channel (p. ***169***).

Availability PureSound™ mode (not available if the analyzer is armed).

Answer

{TimeStamp$_n$}/	*float*	(time since the start of the chirp, expressed in ms)
{Steepness$_n$},	*float*¦NaN	(steepness result, expressed in the active unit)

Unit (defined by ***MEASurement:PUResound:STEepness:UNIT [PA|S¦V|S]***)

Example

💻 → `MEAS:PUR:STE1?`

→ 💻 `1.00E+00/3.16E-02,2.00E+00/3.13E-02,..,1.0E+02/5.30E-02`

Explanation The returned vector is grouped in pairs, starting with the first timestamp, a slash "/" and the corresponding steepness result (without unit). Pairs are separated by commas (",").

Select the active channel with command ***MEASurement[1¦2]:PUResound:STARt***

Select the active unit with ***MEASurement:PUResound:STEepness:UNIT [PA|S¦V|S]***

If required, query the number of returned pairs with ***MEASurement:PUResound:STATus?***

MEASurement:PUResound:STEepness:CORRelation?

Usage Queries the sound correlation between the active reference signal and the last acquired test signal (p. ***164***).

Availability PureSound™ mode in status ***INOUT:PUResound:MODE CORRelation*** (not available if the analyzer is armed).

Answer

<Delay/>	*float*	(trigger delay reference → test signal, expressed in ms)
<Correl %>	*float & string*	(sound correlation: 0 % to 100 %)

Example

💻 → `MEAS:PUR:STE:CORR?`

→ 💻 `-6.73E+01/8.96E+01 %`

Explanation The sound correlation represents the similarity between the active reference signal and the test signal. 100 % correlation corresponds to identical signals, whereby 0 % correlation indicates that there is no similarity.

The returned vector starts with the delay, followed by a slash "/", the correlation result, a white space and the unit "%".

The active channel is defined by command ***MEASurement[1¦2]:PUResound:STARt***.

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MEASurement:PUResound:STEepness:LEVelcorrection?

Usage Queries the level difference between the active reference signal and the test signal (p. ***164***).

Availability PureSound™ mode in status ***INOUT:PUResound:MODE CORRelation*** (not available if the analyzer is armed).

Answer

`<SignalDuration>/`	*float*	(test signal duration, expressed in ms)
`<LevelCorrection> %`	*float & string*	(level correlation, expressed in %)

Example

💻 → `MEAS:PUR:STE:LEV?`
→ 💻 `5.00E+02/2.18E+03%` (duration: 500 ms; level correction: reference signal level = 218 % of test signal level [ref./test = 2.18)

Explanation The level correction result represents the RMS level difference between the active reference signal and the test signal: LevelCorrection [%] = (RefSignalLevel / TestSignalLevel) * 100

The returned vector starts with the duration of the test signal, followed by a slash "/", the level correction result, a white space and the unit "%".

The active channel is defined by command ***MEASurement[1¦2]:PUResound:STARt***.

MEASurement:PUResound:STEepness:OK?

Usage Queries for the last acquired signal, whether the results of all six bands are below the user-defined steepness limits (p. ***169***).

Availability PureSound™ mode in status ***INOUT:PURessound:MODE RNB*** (not available if the analyzer is armed).

Answer `[PASSED¦FAILED]` *string* (no steepness limit exceeded ¦ ≥ 1 steepness limit exceeded)

Example

💻 → `MEAS:PUR:STE:OK?`
→ 💻 `PASSED`

Explanation Refer to command ***MEASurement:PUResound:STEepness:VARLimit:SET …*** about the definition of individual steepness limits for the six bands.

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MEASurement:PUResound:STEepness:REFerence:ACTive [A¦B]

Usage Activates the reference signal (memory A or B) for sound correlation measurements (p. ***164***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[A¦B]` *string* (memory location of RT-2M)

Default A

Query ***MEASurement:PUResound:STATus?***

Example 💻 → `MEAS:PUR:STE:REF:ACT B`

Explanation The command activates a previously saved reference signal. Execute one of the following procedures to save a reference signal on the internal memory of RT-2M:

a) Record a test signal (***MEASurement[1¦2]:PUResound:STARt***) and make it the reference signal (***MEASurement:PUResound:STEepness:REFerence:USELastmeas***) *or*

b) Transfer a previously stored reference signal from the PC to the RT-2M unit with the command ***MEASurement:PUResound:STEepness:REFerence:SET***.

Execute a sound correlation measurement with ***MEASurement[1¦2]:PUResound:STARt*** and ***MEASurement:PUResound:STEepness:CORRelation?***

MEASurement:PUResound:STEepness:REFerence:NAME <RefName>

Usage Assigns a user-defined name to the active reference signal (memory A or B, p. ***164***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `<RefName>` *string* (user-defined reference signal name, up to 8 characters)

Query ***MEASurement:PUResound:STEepness:REFerence:NAME?***

Example 💻 → `MEAS:PUR:STE:REF:NAME mozart`

Explanation The command overwrites the previous name of the currently active reference signal. The name remains stored in the non-volatile RT-2M memory even after power OFF.

Use command ***MEASurement:PUResound:STEepness:REFerence:ACTive [A¦B]*** to select the active reference signal.

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MEASurement:PUResound:STEepness:REFerence:NAME?

Usage Queries the name of the active reference signal (memory A or B, p. ***164***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Answer `<RefName>` *string* (user-defined signal name)

Default `[REF_A001¦REF_B001]` (default names of reference signals in memory A¦B)

Example
💻 → `MEAS:PUR:STE:REF:NAME?`
→ 💻 `MOZART`

Explanation Use command ***MEASurement:PUResound:STEepness:REFerence:NAME*** **<*RefName*>** to define the name of the active reference signal.

MEASurement:PUResound:STEepness:REFerence:USELastmeas

Usage Stores the last acquired test signal in the active reference memory (A or B), thus making it the reference signal (i.e. 'golden' sample, p. ***164***).

Availability PureSound™ mode in status ***INOUT:PUResound:MODE CORRELATION*** (not available if the analyzer is armed).

Query ***MEASurement:PUResound:STATus?***

Example 💻 → `MEAS:PURESOUND:STEEPNESS:REFERENCE:USELASTMEAS`

Explanation The command overwrites the contents of the currently active reference memory (A or B) with the last acquired signal.

Use command ***MEASurement[1¦2]:PUResound:STARt*** to record a test signal.

Stored reference signals remain in the non-volatile memory even after power OFF.

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MEASurement:PUResound:STEepness:REFerence:GET?

Usage Transfers the contents of the currently active reference memory (i.e. the reference signal) to the controlling PC in the form of a compressed data string (p. ***164***).

Availability PureSound™ mode in status ***INOUT:PUResound:MODE CORRELATION*** (not available if the analyzer is armed).

Answer

`3,`	*integer*	(compression type = correlation)
`<NoOfChars>,`	*integer*	(number of characters of the compressed string)
`<RefLength>,`	*integer*	(duration of the reference signal, expressed in ms)
`<RefName>,`	*string*	(user-defined name of the reference signal)
`<NormFactor>`	*integer*	(normalization factor)
`#0<Data>`	*string*	("#0" + compressed data string)

Examples

💻 → `MEAS:PUR:STE:REF:GET?`

→ 💻 `3,109,40,MUSIC,171008#0…Û…‡„í …–ˆ‰Žé„É,'ƒñƒ˜,Ñ,®,¹ Â,°,ùƒž‡ ‰ÎŒôŽ,Šö‹¬ ‹‹‹ÛŒÔ‹ÜŒÔŒ«‰û ‡ö‡Œˆ Þ‹Ç ìŽœ °  å˜«œŽ‘'  ï „ŒŸ‹ î Ê'¢ ÷ †'®'Á Ò`

(compressed data string = 109 chars; reference signal name = "MUSIC"; normalization factor = 171008; 109 ASCII characters, representing the compressed reference signal)

Explanation The command saves the active reference signal in a compressed form on the PC.

Thus, it can be downlaoded back from the PC to the RT-2M unit at a later time by using the command ***MEASurement:PUResound:STEepness:REFerence:SET 3,<NoOfChars>, <RefLength>,<RefName>,<NormFactor>#0<Data>***.

MEASurement:PUResound:STEepness:REFerence:SET 3,<NoOfChars>, <RefLength>,<RefName>,<NormFactor>#0<Data>

Usage Transfers the compressed data string that represents a reference signal from the PC to the active RT-2M memory (p. ***164***).

Availability PureSound™ mode in status ***INOUT:PUResound:MODE CORRELATION*** (not available if the analyzer is armed).

Example

💻 → `MEAS:PUR:STE:REF:SET 3,109,40,MUSIC, 171008#0…Û…‡„í…–ˆ‰Žé„É,'ƒñƒ˜,Ñ,®,¹ Â ,°,ùƒž‡ ‰ÎŒôŽ,Šö‹¬ ‹‹‹ÛŒÔ‹ÜŒÔŒ«‰û ‡ö‡Œˆ Þ‹Ç ìŽœ °  å˜«œŽ‘'  ï „ŒŸ‹ î Ê'¢ ÷  †'®'Á Ò`

(hyroglyphs represent the compressed reference data)

Explanation The command downloads a previously stored referenece signal from the PC to RT-2M.

NOTE	**The content of the active reference memory is overwritten as soon as this commands is sent to RT-2M.**

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MEASurement:PUResound:STEepness:RMSLevel:UNIT [DBV¦V¦DBSPL¦DBPA¦DBM]

Usage Defines the unit, in which the RMS level of a correlation analysis shall be expressed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[DBV¦`		(V_{RMS} in logarithmic scale, referred to 1 V_{RMS})
`V¦`		(V_{RMS} in linear scale)
`DBSPL¦`	*string*	(Sound Pressure Level in logarithmic scale, p. ***149***)
`DBPA¦`		(air pressure in logarithmic scale, p. ***200***)
`DBM]`		(RMS power in logarithmic scale, p. ***199***)

Default `DBV`

Example 💻 → `MEAS:PUR:STE:RMSL:UNIT V`

Explanation

> **NOTE** **[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

MEASurement:PUResound:STEepness:RMSLevel?

Usage Queries the RMS level of the last correlation analysis, expressed in the selected unit (p. ***164***).

Availability Normal mode (not available if the analyzer is armed).

Answer `Signal_Level` *float*¦NaN & *string* (test signal RMS level & unit)

Unit (defined by command ***MEASurement:PUResound:STEepness:RMSLevel:UNIT ...***)

Example

💻 → `MEAS:PUR:STE:RMSL?`
→ 💻 `-2.19404E+01 dBV`

Explanation The returned result reflects the RMS level of the whole signal that has been acquired for a sound correlation analysis.

If a received level is too low to be measured, '`NaN`' (not a number) is returned.

> **NOTE** **[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

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MEASurement:PUResound:STEepness:UNIT [PA|S¦V|S]

Usage Defines the unit, in which the steepness results shall be expressed (p. ***169***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[PA|S¦V|S]` [1] *string* (Pascal per Second ¦ Volt per Second)

Default `PA|S`

Example 💻 → `MEAS:PUR:STE:UNIT PA|S`

Explanation In case of acoustical measurement with a microphone connected, the unit PA|S should be used. In this case, RT-2M considers the stored microphone sensitivity as defined by the command ***INPut[1¦2]:MICSensitivity <Sensitivity>***

Select the steepness unit PA|S only if the signal has been acquired with a microphone.

MEASurement:PUResound:STEepness:VARLimit:ACTive[1¦2¦3¦4¦5¦6] [ENABLE¦DISABLE]

Usage Activates the individual limit test defined by ***MEAS:PUR:STE:VARL:SET …*** (p. ***169***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[1¦2¦3¦4¦5¦6]` *integer* (number of the active transient steepness band)
`[ENABLE¦DISABLE]` *string*

Default `DISABLE`

Example 💻 → `MEAS:PUR:STE:VARL3 ENABLE`

Explanation The command activates an user-defined, individual PASS/FAIL test for each steepness band. Refer to chapter ***Steepness Limits for PASS/FAIL Test (Rub & Buzz Detection)*** (p. ***169***) for further details.

[1] Enter the character "|" by pressing the keys <AltGr> + <7>

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MEASurement:PUResound:STEepness:VARLimit:SET[1¦2¦3¦4¦5¦6] <NoOfPoints> [PA|S¦V|S] <X_Point$_1$>,<X_Point$_2$>,..., <X_Point$_{NoOfPoints}$>,<Y_Limit$_1$>,<Y_Limit$_2$>,...,<Y_Limit$_{NoOfPoints}$>

Usage Defines individual limits for the transient steepness bands (refer to p. ***169***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter

`[1¦2¦3¦4¦5¦6]`	*integer*	(number of the steepness analysis band)
`<NoOfPoints>`	*integer*	1 to 200 (number of points that build the individual limit)
`[PA|S¦V|S]`	*string*	(Pascal per second ¦ Volt per second)
`<X_Point`$_n$`>`	*float*	0.00 to 100.00 (location of point "n", expressed in percent of the X-axis; resolution = 0.01)
`<Y_Limit`$_n$`>`	*float*	0.00 to 100000.00 (individual limit of point "n", expressed in the selected unit; resolution = 0.01)

Default `2 PA|S 0,100,20,20` (2 points, Pa/s, location 0% and 100%, limit value 20)

Example

💻 → `MEAS:PUR:STE:VARL:SET3 5`
`PA|S 0.00E00,1.00E+01,`
`1.50E+01,2.30E+01,1.00E+02,`
`0.33E+01,0.50E+01,1.20E+02,`
`0.60E+01,0.20E+01`

(Variable limit definition:
- Band #3
- 5 points
- Unit: Pascal per Second
- Points at: 0%, 10%, 15%, 23%, 100%
- Limits: 3.3, 5, 120, 6, 2 [Pa/S])

Explanation The command defines the individual PASS/FAIL limits for the steepness analysis (refer to chapter ***Steepness Limits for PASS/FAIL Test (Rub & Buzz Detection)***, p. ***169***). Thereby, the user-defined points & limits represent a tolerance band that is split into intervals with individual steepness limits.

MEASurement:PUResound:STEepness:VARLimit:SET[1¦2¦3¦4¦5¦6]?

Usage Queries the individual limits of a transient steepness band (refer to p. ***169***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter

`[1¦2¦3¦4¦5¦6]`	*integer*	(number of the transient steepness band)

Answer

`<NoOfPoints>,`	*integer*	(number of points that build the individual limit)
`[PA|S¦V|S],`	*string*	(unit, in which the limit values are expressed)
`{Point`$_n$`},`	*float*	(relative locations of the points on the X-axis)
`{Limit`$_n$`},`	*float*	(individual limits of the points, expressed in the active unit)

Default `2,PA|S,0,100,20,20` (2 points, Pa/S, 0 – 100%, 20 – 20 [Pa/S]

Example

💻 → `MEAS:PUR:STE:VARL:SET3?`
→ 💻 `4,V|S,0,25,50,100,0.10E00,0.50E00,1.2E00,0.75E00`

Explanation The command queries variable PASS/FAIL limits for the steepness analysis (refer to chapter ***Steepness Limits for PASS/FAIL Test (Rub & Buzz Detection)***, p. ***169***).

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MEASurement[1¦2]:SELectiverss:UNIT [DBV¦V¦DBSPL¦DBPA¦DBM]

Use Defines the unit, in which the RSS selective result is expressed (p. ***149***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[DBV¦`		(V_{RMS} in logarithmic scale, referred to 1 V_{RMS})
`V¦`		(V_{RMS} in linear scale)
`DBSPL¦`	*string*	(Sound Pressure Level in logarithmic scale, p. ***149***)
`DBPA¦`		(air pressure in logarithmic scale, p. ***200***)
`DBM]`		(RMS power in logarithmic scale, p. ***199***)

Default `DBV`

Example 💻 → `Meas1:Sel:Unit V`

Explanation

> **NOTE** **[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

MEASurement[1¦2]:SELectiverss? <Binstart> <Binstop>

Use Queries the RSS Selective result for the frequency band from <binstart> to <binstop> including these two bins (chapter ***RSS Selective***, p. ***149***).

Availability Normal mode (not available if the analyzer is armed).

Parameter <Binstart> <Binstop> *integer* (signal bin numbers that define the band, p. ***152***)

Answer

`<Binstop>/`	*integer*	(the bin that represents the upper band limit)
`<RSS_Sel Unit>`	*float*¦NaN & *string*	(measured RSS result & unit)

Unit (defined by ***MEASurement[1¦2]:SELectiverss:UNIT [DBV¦V¦DBSPL¦DBPA¦DBM]***)

Examples

💻 → `Meas1:Sel? 11 11`
→ 💻 `11/-1.283429E+02 dBV` (RSS value of Bin #11)

💻 → `MEAS2:SEL? 11 32`
→ 💻 `32/-1.013521E+02 dBV` (RSS value from Bin #11 to Bin #32, including levels of Bins #11 and #32)

💻 → `MEAS2:SEL? 1 213`
→ 💻 `213/0.176425E+01 dBSPL` (Sound Pressure Level in dB_{SPL} from 94 Hz – 20 kHz [blocklength = 512])

Explanation The RSS selective measurement returns the overall input level + distortion + noise in a user-defined frequency band. <binstart> and <binstop> define the lower and the upper end of this band (***Equation 14*** and ***Equation 15***, p. ***152***).

"`NaN`" indicates that the acquired result is not valid.

To measure the sound pressure level (SPL), connect a microphone to RT-2M, activate the Phantom power if required (***INPut[1¦2]:IMPedance PHANTOM***) and save the microphone sensitivity on RT-2M (***INPut[1¦2]:MICSensitivity <Sensitivity>***).

> **NOTE** **[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

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MEASurement:STEPpedsweep:ACQUisition [RMSLEVEL¦DISTORTION]

Usage Activates the acquisition mode of the stepped sweep analysis (p. ***180***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL or SELECTIVE (p. ***100***).

Parameter

`[RMSLEVEL¦DISTORTION]`	*string*	(required for stepped sweep level or phase measurements) (required for stepped sweep THD+N, k2 or k3 measurements)

Default `RMSLEVEL`

Query ***MEASurement:STEPpedsweep:STATus?***

Example 💻 → `MEAS:STEP:ACQU DISTORTION`

Explanation The acquisition mode optimizes the RT-2M signal analysis (accuracy, speed) for the available stepped sweep measurements:

- RMSLEVEL mode must be activated prior to stepped sweep Level or Phase measurements (***MEAS[1¦2]:STEP:RMSL?*** or ***MEAS[1¦2]:STEP:PHAS?*** <***MeasFreq***>). The mode is identical to the default signal analysis of RT firmware ≤ V6.0.
- DISTORTION mode is mandatory for stepped sweep THD+N, k2 or k3 measurements, but can be applied as well for Level or Phase measurements. The DISTORTION mode noticeably prolongs the measurement duration.

NOTE	**As soon as the RMSLEVEL or DISTORTION mode is activated, all stepped sweep settling parameters are automatically switched to the corresponding default values.** **In addition, the DISTORTION mode automatically activates the HIPRecision mode.**

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MEASurement:STEPpedsweep:DISTortion:ACQUisitionlength <Length>

Usage Adjusts the signal acquisition length during a stepped sweep distortion measurement.

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL or SELECTIVE (p. ***100***).

Parameter `<Length>` *float* 0.0 to 200.0 (acquisition length in ms; resolution = 0.1 ms)

Default `10.7` (ms)

Query ***MEASurement:STEPpedsweep:DISTortion:ACQUisitionlength?***

Example 💻 → `MEAS:STEP:DIST:ACQU 50.0`

Explanation By adjusting the signal acquisition length, unwanted low-frequency components (e.g. 50 Hz hum) can be filtered out (e.g. by adjusting the acquisition length to > 20 ms).

NOTE	**Adjusting the acquisition length prolongs the measurement.**

MEASurement:STEPpedsweep:DISTortion:ACQUisitionlength?

Usage Queries the user-defined acquisition length.

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL or SELECTIVE (p. ***100***).

Answer `<Length>` *float* 0.0 to 200.0 (acquisition length in ms; resolution = 0.1 ms)

Example 💻 → `MEAS:STEP:DIST:ACQU?`
→ 💻 `5.000E+01`

Explanation By adjusting the signal acquisition length, unwanted low-frequency components (e.g. 50 Hz hum) can be filtered out (e.g. by adjusting the acquisition length to > 20 ms).

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MEASurement[1¦2]:STEPpedsweep:DISTortion:HARMONIC:UNIT [DB¦%¦DBV¦V¦DBM]

Usage Defines the unit, in which the 2nd or 3rd harmonic distortion results shall be expressed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

[DB¦		(harmonic distortion ratio in logarithmic scale)
%¦		(harmonic distortion ratio in linear scale)
DBV¦		(V_{RMS} in logarithmic scale, referred to 1 V_{RMS})
V¦	*string*	(V_{RMS} in linear scale)
DBSPL¦		(Sound Pressure Level in logarithmic scale)
DBPA¦		(air pressure in logarithmic scale, p. ***200***)
DBM]		(RMS power in logarithmic scale, p. ***199***)

Default DB

Example 💻 → `MEAS1:STEP:DIST:HARM:UNIT V`

Explanation

> **NOTE** **[dBm] is a power unit that refers to 600 Ω input impedance. Thus, if another input impedance is selected, the dBm level result changes.**

MEASurement[1¦2]:STEPpedsweep:DISTortion:HARMonic? [2¦3¦4¦5]

Usage Queries the 2nd, 3rd, 4th or 5th harmonics results after a stepped sweep transmission (p. ***181***).

Availability Normal mode (not available if the analyzer is armed).

Parameter `[2¦3¦4¦5]` *integer* (2nd ¦ 3rd ¦ 4th ¦ 5th harmonic)

Answer

{SweepFrequency$_n$}/	*float*	(sweep frequency, expressed in Hz)
{Harmonic$_n$ Unit},	*float*¦NaN & *string*	(harmonic distortion result & unit)

Unit (defined by ***MEASurement[1¦2]:STEPpedsweep:DISTortion:HARMONIC:UNIT [DB¦%¦DBV¦V¦DBM]***)

Examples

💻 → `MEAS1:STEP:DIST:HARM? 2`
→ 💻 `2.000E+01/-5.64063E+01 DB,2.000E+02/-4.75937E+01 DB,`
`1.000E+03/-1.63773E+02 DB,2.000E+04/NaN`

💻 → `MEAS2:STEP:DIST:HARM? 4`
→ 💻 `2.000E+01/0.124E-02 %,2.000E+02/0.880E-02 %,`
`2.000E+03/1.086E+02 %`

Explanation The command measures 2nd, 3rd, 4th or 5th harmonics in the following frequency ranges:

- 20 Hz – 11 kHz (2nd harmonic measurement).
- 20 Hz – 7.33 kHz (3rd harmonic measurement).
- 20 Hz – 5.5 kHz (4th harmonic measurement).
- 20 Hz – 4.4 kHz (5th harmonic measurement).

The returned vector is grouped in pairs, starting with the first frequency in Hz, a "/", the respective level result, a white space, and the unit in which the result is expressed. Pairs are separated by commas (","). "NaN" indicates that the acquired result is not valid or that the fundamental frequency exceeds the limits of the 2nd, 3rd, 4th, 5th harmonic analysis.

> **NOTE** **Activate the DISTORTION acquisition mode and the HARMONIC settling type prior to a 2nd, 3rd, 4th or 5th harmonic measurement.**

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MEASurement[1¦2]:STEPpedsweep:DISTortion:THD:UNIT [DB¦%]

Usage Defines the unit, in which the THD result shall be expressed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `[DB¦%]` *string* (harmonic distortion ratio in logarithmic ¦ linear scale)

Default `DB`

Example 💻 → `MEAS1:STEP:DIST:THD:UNIT %`

MEASurement[1¦2]:STEPpedsweep:DISTortion:THD?

Usage Queries the THD result after a stepped sweep transmission (p. ***181***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`{SweepFrequency`$_n$`}/`	*float*	(sweep frequency, expressed in Hz)
`{THD`$_n$ `Unit},`	*float*¦NaN & *string*	(THD result & unit)

Unit (defined by ***MEASurement[1¦2]:STEPpedsweep:DISTortion:THD:UNIT [DB¦%]***)

Examples

💻 →
```
MEAS1:STEP:DIST:THD?
```
→ 💻
```
2.000E+01/-8.72321E+01 DB,2.000E+02/-9.80808E+01 DB,
2.000E+03/-1.02866E+02 DB,2.000E+04/-7.05641E+01 DB
```

Explanation The returned vector is grouped in pairs, starting with the first frequency in Hz, a "/", the respective level result, a white space, and the unit in which the result is expressed. Pairs are separated by commas (","). "`NaN`" indicates that the acquired result is not valid.

> **NOTE** **Activate the DISTORTION acquisition mode and the proper settling type (p. *103*) prior to a THD measurement.**

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MEASurement[1¦2]:STEPpedsweep:DISTortion:THDN:UNIT [DB¦%]

Usage Defines the unit, in which the THD+N result shall be expressed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `[DB¦%]` *string* (harmonic distortion ratio in logarithmic ¦ linear scale)

Default `DB`

Example 💻 → `MEAS1:STEP:DIST:THDN:UNIT %`

MEASurement[1¦2]:STEPpedsweep:DISTortion:THDN?

Usage Queries the THD+N result after a stepped sweep transmission (p. ***181***).

Availability Normal mode (not available if the analyzer is armed).

Answer

`{SweepFrequency`$_n$`}/`	*float*	(sweep frequency, expressed in Hz)
`{THDN`$_n$ `Unit},`	*float*¦NaN & *string*	(THD+N result & unit)

Unit (defined by ***MEASurement[1¦2]:STEPpedsweep:DISTortion:THD:UNIT [DB¦%]***)

Examples

💻 →
```
MEAS1:STEP:DIST:THDN?
```
→ 💻
```
2.000E+01/-8.72321E+01 DB,2.000E+02/-9.80808E+01 DB,
2.000E+03/-1.02866E+02 DB,2.000E+04/-7.05641E+01 DB
```

Explanation The returned vector is grouped in pairs, starting with the first frequency in Hz, a "/", the respective level result, a white space, and the unit in which the result is expressed. Pairs are separated by commas (","). "`NaN`" indicates that the acquired result is not valid.

> **NOTE** **Activate the DISTORTION acquisition mode and the proper settling type (p. *103*) prior to a 2nd or 3rd harmonic measurement.**

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MEASurement:STEPpedsweep:HIPRecision [OFF¦ON]

Usage Activates the high precision mode of the stepped sweep analysis (p. ***176***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[OFF¦ON]` *string*

Default `OFF`

Query ***MEASurement:STEPpedsweep:STATus?***

Example 💻 → `MEAS:STEP:HIPR ON`

Explanation In the high precision mode, RT-2M acquires at least one full period for the signal analysis (otherwise it acquires only half a period). Activate the high precision mode if:

- A high measurement resolution at low frequencies is required.
- The DUT's resonance impedance is only slightly higher than its DC resistance.
- Wideband high-end drivers (speakers, capsules etc.) have to be tested.

Please note that the high precision mode noticeably prolongs the measurement duration and that it is activated automatically in the ***MEAS:STEP:ACQU DISTORTION*** mode.

Refer to chapter ***High Precision Mode*** (p. ***176***) for further details.

MEASurement:STEPpedsweep:NOISeimmunity [OFF¦ON]

Usage Activates the "Noise Immunity" algorithm for a stepped sweep analysis (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[OFF¦ON]` *string*

Default `ON`

Query ***MEASurement:STEPpedsweep:STATus?***

Example 💻 → `MEAS:STEP:NOIS OFF`

Explanation Activate the noise immunity algorithm if the system is located in a noisy environment.

Please note the noise immunity prolongs the measurement duration.

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MEASurement:STEPpedsweep:PHASe:UNIT [RAD¦DEG]

Usage Defines the unit (radiant or degree) of the stepped sweep phase measurement result (p. ***181***).

Availability Normal, LCL, RL and PureSound™ mode (not available if the analyzer is armed).

Parameter `[RAD¦DEG]` *string* (radiant: 0 to 2π ¦ degree: 0° to 360°)

Default `RAD`

Example 💻 → `MEAS:STEP:PHAS:UNIT DEG`

Explanation The command defines the phase unit for stepped sweep measurements. The phase scale is defined by ***MEASurement:PHASe:SCALe <Scale> [RAD¦DEG]***.

Please note that phase measuremens can also be executed with a multitone test (p. ***148***).

MEASurement[1¦2]:STEPpedsweep:PHASe? <MeasFrequency>

Usage Queries the phase results after a stepped sweep transmission (p. ***181***).

Availability Normal mode (not available if the analyzer is armed).

Parameter `<MeasFrequency>` *float* (optional parameter; restricts the phase measurement to the corresponding sweep frequency)

Answer

`{SweepFrequency`$_n$`}/`	*float*	(sweep frequency, expressed in Hz)
`{Phase`$_n$ `Unit},`	*float*¦NaN & *string*	(phase result & unit)

Unit (defined by command ***MEASurement:STEPpedsweep:PHASe:UNIT [RAD¦DEG]***)

Examples

💻 → `MEAS1:STEP:PHASE?`
→ 💻 `2.00E+01/1.248E00 RAD,2.00E+02/0.934E00 RAD,`
`2.00E+03/0.567E00 RAD,2.00E+04/0.106E00 RAD`

💻 → `MEAS2:STEP:PHASE? 1000.0`
→ 💻 `1.00E+03/2.71E+02 DEG` (phase @ 1000 Hz = 271 degree)

Explanation The command executes a phase measurement at one sweep frequency:

- Appending the optional parameter <***Frequency***> to the command queries only the phase result of the corresponding frequency.
- Without the optional parameter the phase results of all sweep frequencies are returned.

Please note that phase measuremens can also be executed with a multitone test (p. ***148***).

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MEASurement[1¦2]:STEPpedsweep:RMSLevel:UNIT [DBV¦V¦DBSPL¦DBPA¦DBM]

Usage Defines the unit, in which the stepped Sweep RMS-level (i.e. frequency response) result shall be expressed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter

`[DBV¦`		(V_{RMS} in logarithmic scale, referred to 1 V_{RMS})
`V¦`		(V_{RMS} in linear scale)
`DBSPL¦`	*string*	(Sound Pressure Level in logarithmic scale)
`DBPA¦`		(air pressure in logarithmic scale, p. ***200***)
`DBM]`		(RMS power in logarithmic scale, p. ***199***)

Default `DBV`

Example 💻 → `MEAS1:STEP:RMSL:UNIT V`

Explanation

> **NOTE** **A level expressed in dBm always refers to the current input impedance, since [dBm] is a power unit. Thus, if the input level is measured in dBm, the result depends on the selected input impedance.**

MEASurement[1¦2]:STEPpedsweep:RMSLevel?

Usage Queries the RMS level results of the last stepped sweep measurement (p. ***181***).

Availability Normal mode (also if the analyzer is armed).

Answer

`{Frequency`$_n$`}/`	*float*	(sweep frequency, expressed in Hz)
`{Level`$_n$ `Unit},`	*float*¦NaN & *string*	(corresponding level result & unit)

Unit (defined by command ***MEASurement[1¦2]:STEPpedsweep:RMSLevel:UNIT ...***)

Example

💻 →
```
Meas:step:rmsl?
```
→ 💻
```
2.000E+01/-6.416E+01 dBV,2.000E+02/-6.396E+01 dBV,
2.000E+03/-6.425E+01 dBV,2.000E+04/-6.400E+01 dBV
```

Explanation The returned vector is grouped in pairs, starting with the first frequency in Hz, a "/", the respective level result, a white space, and the unit in which the result is expressed. Pairs are separated by commas (",").

"`NaN`" indicates that the acquired result is not valid.

> **NOTE** **A level expressed in dBm always refers to the current input impedance, since [dBm] is a power unit. Thus, if the input level is measured in dBm, the result depends on the selected input impedance.**

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MEASurement:STEPpedsweep:SETTling:ACTive [CHANNEL1¦CHANNEL2¦BOTHCHANNELS]

Usage Defines the active channel(s) for the stepped sweep settling (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL (***MEAS:STEP:SETT:MODE NORMAL***).

Parameter `[CHANNEL1¦CHANNEL2¦BOTHCHANNELS]` *string*

Default `CHANNEL1` (RMSLEVEL and DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `Measurement:steppedsweep:settling:active channel1`

Explanation It is strongly recommended to activate the settling only for the active channel, since the mode BOTHCHANNELS prolongs the measurement in case of an open input connector.

Refer to chapter ***Stepped Sweep*** (p. ***175***) for further details.

MEASurement:STEPpedsweep:SETTling:ALGorithm [EXPONENTIAL¦FLAT]

Usage Defines the active algorithm for the stepped sweep settling (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL (***MEAS:STEP:SETT:MODE NORMAL***).

Parameter `[EXPONENTIAL¦FLAT]` *string* (the settling criterion is less strict for older samples) (the settling criterion is equally strict for all samples)

Default `EXPONENTIAL` (RMSLEVEL and DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `Measurement:steppedsweep:settling:algorithm flat`

Explanation Refer to chapter ***Stepped Sweep*** (p. ***175***) for further details.

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MEASurement:STEPpedsweep:SETTling:CYCLes <Cycles>

Usage Applies a frequency-dependent delay before every stepped sweep measurement (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed), regardless whether the settling is active or not.

Parameter `<Cycles>` *float* 0.00 to 1000.00 (No. of cycles; resolution = 0.25, i.e. ¼ of a peroid)

Default `0¦8` (RMSLEVEL ¦ DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `MEAS:STEP:SETT:CYCL 0.525E+01`

Explanation The delay is defined in cycles (periods) of the currently active sweep frequency. Thus, it is proportional to the sweep frequency. If a fixed delay is required, please refer to the command ***MEASurement:STEPpedsweep:SETTling:DELay*** <***Delay***>.

Typically, the <***Cycles***> delay is used to compensate for the transient behaviour of the DUT.

Refer to chapter ***Stepped Sweep*** (p. ***175***) for further details.

NOTE **The <*Cycles*> delay is also applied if the settling mode is turned OFF.**

MEASurement:STEPpedsweep:SETTling:DELay <Delay>

Usage Applies a fixed delay that is applied before every stepped sweep measurement (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed), regardless whether the settling is active or not.

Parameter `<Delay>` *float* 0. to 10000.0 (settling delay in ms; resolution = 0.1)

Default `1` (RMSLEVEL and DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `MEAS:STEP:SETT:DEL 0.50E+02`

Explanation The delay is defined in milliseconds, i.e. independent of the sweep frequency. A frequency dependent delay can be defined with ***MEASurement:STEPpedsweep:SETTling:CYCLes*** <***Cycles***>.

Typically, this command is used to compensate for fixed time delays on the signal path, e.g.:
- The running time of the test signal from the RT-2M generator → amplifier → speaker → air → microphone → RT-2M analyzer.
- The internal delay of a Codec etc.

Refer to chapter ***Stepped Sweep*** (p. ***175***) for further details.

NOTE **The <*Delay*> is also applied if the settling mode is turned OFF.**

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MEASurement:STEPpedsweep:SETTling:FBEGin <Frequency1>

Usage Defines one limit of the frequency band, wherein the selective settling is active.

Availability Normal mode (not available if the analyzer is armed), whereby the settling mode must be SELECTIVE (***MEASurement:STEPpedsweep:SETTling:MODE SELECTIVE***).

Parameter `<Frequency1>` *float* (20.00 to 20000.00)

Default `3.00E+01` (RMSLEVEL and DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `MEAS:STEP:SETT:FBEG 1.00E+02`

Explanation In combination with ***MEASurement:STEPpedsweep:SETTling:FENd <Frequency2>*** and ***MEASurement:STEPpedsweep:SETTling:MODE SELECTIVE***, the command allows applying the stepped sweep settling on a user-defined frequency band.

Please refer to chapter ***Settling*** (p. ***176***) for further details.

MEASurement:STEPpedsweep:SETTling:FENd <Frequency2>

Usage Defines the other limit of the frequency band, wherein the selective settling is active.

Availability Normal mode (not available if the analyzer is armed), whereby the settling mode must be SELECTIVE (***MEASurement:STEPpedsweep:SETTling:MODE SELECTIVE***).

Parameter `<Frequency2>` *float* (20.00 to 20000.00)

Default `2.00E+02` (RMSLEVEL and DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `MEAS:STEP:SETT:FEN 3.00E+02`

Explanation In combination with ***MEASurement:STEPpedsweep:SETTling:FBEGin <Frequency1>*** and ***MEASurement:STEPpedsweep:SETTling:MODE SELECTIVE***, the command allows applying the stepped sweep settling on a user-defined frequency band.

Please refer to chapter ***Settling*** (p. ***176***) for further details.

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MEASurement:STEPpedsweep:SETTling:FLOor <Floor> [V¦DBV]

Usage Defines the lowest input level that is considered for the stepped sweep settling (p. ***175***).

Availability Normal mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL (***MEASurement:STEPpedsweep:SETTling:MODE NORMAL***).

Parameter `<Floor> [V¦DBV]` *float & string* 0.000001 to 1.0 V ¦ –120 to 0 DBV

Default `-70 DBV¦-90 DBV` (RMSLEVEL ¦ DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `MEAS:STEP:SETT:FLO 1.00000e-3 V`

Explanation Any input signal level that is below the <Floor> is not considered for the settling. This has two advantages:

- The measurement is speeded up by neglecting very low input signals (e.g. noise).
- The system is prevented from "hanging itself up" if the input signal is very close to the lower limit of the measurable range.

Refer to chapter ***Stepped Sweep*** (p. ***175***) for further details.

MEASurement:STEPpedsweep:SETTling:MODE [OFF¦NORMAL¦SELECTIVE]

Usage Activates the settling mode for stepped sweep measurements (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Parameter `[OFF¦NORMAL¦SELECTIVE]` *string*

Default `NORMAL` (RMSLEVEL and DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `Meas:step:sett:mode selective`

Explanation In the NORMAL mode, the settling applies on all stepped sweep measurement results.

In the SELECTIVE mode, the settling applies only in the frequency band defined by the command ***MEASurement:STEPpedsweep:SETTling:FBEGin <Frequency1>*** and the command ***MEASurement:STEPpedsweep:SETTling:FENd <Frequency2>***.

The command does not affect other measurements than the stepped sweep analysis.

Refer to chapter ***Settling*** (p. ***176***) for further details.

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MEASurement:STEPpedsweep:SETTling:NOISe <Level> [V¦dBV¦dBSPL¦dBPa]

Usage Defines a flat settling limit in addition to the exponential settling (refer to p. ***176f***).

Availability Normal, LCL, RL and PureSound™ mode (not available if the analyzer is armed).

Parameter

`0.0000001 to 1.0 V¦` `-120.0 to 0.0 dBV¦` `0.0 to 120.0 dBSPL¦` `-94.0 to +26.0 dBPa`	*float & string*		(width of noise acceptance band)

Default `-120 dBV ¦ -68 dBV` (settling type RMSLEVEL ¦ distortion)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `Meas:step:sett:noise 5.0E-02 V`

Explanation The command allows introducing an additional settling criterion for noisy environments, where the exponential settling is not met. In this case, the RT-2M provides the measurement result as soon as the user-defined number of samples (p. ***101***) has been acquired within the <**`Level`**> band, regardless whether the **`EXPONENTIAL`** condition (p. ***100***) is met or not.

Refer to chapter ***Settling*** (p. ***176***) for further details.

MEASurement:STEPpedsweep:SETTling:SAMple <Samples>

Usage Defines the number of acquired samples that must meet the settling condition to get a valid sweep measurement result (p. ***176***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL (***MEAS:STEP:SETT:MODE NORMAL***).

Parameter

`<Samples>`	*integer*	2 to 20	(number of valid samples; resolution = 1)

Default `3` (RMSLEVEL and DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Example 💻 → `MEASUREMENT:STEPPEDSWEEP:SETTLING:SAMPLE 5`

Explanation Refer to chapter ***Settling*** (p. ***176***) for further details.

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MEASurement:STEPpedsweep:SETTling:STATus?

Usage Queries the status of the settling parameters (only for stepped sweep measurements, p. ***175***).

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`MODE [OFF¦NORMAL¦SELECTIVE],`	*string*
`ACTIVE [CHANNEL1¦CHANNEL2¦BOTHCHANNELS],`	*string*
`TYPE [RMSLEVEL¦HARMONIC2¦HARMONIC3¦THDN],`	*string*
`DELAY [0.0 to 10000.0],`	*float*
`CYCLES [0.0 to 1000.0]`	*float*
`ALGORITHM [EXPONENTIAL¦FLAT],`	*string*
`SAMPLE [2 to 20],`	*integer*
`TOLERANCE [0.0 to 400.0 %¦8.68E-3 to 12 DB],`	*float & string*
`FLOOR [1.0E-06 to 1.0 V¦-120 to 0 DBV],`	*float & string*
`NOISE [1.0E-06 to 1.0 V¦-120.0 to 0.0 DBV¦ 0.0 to 120.0 DBSPL¦-94.0 to 26.0 DBPA]`	*float & string*
`TIMEOUT [0.1 to 5000.0]`	*float*
`FBEGIN [20.0 to 20000.0],`	*float*
`FEND [20.0 to 20000.0]`	*float*

Example

💻 → `MEASUREMENT:STEPPEDSWEEP:SETTLING:STATUS?`

→ 💻 `MODE NORMAL,ACTIVE CHANNEL1,TYPE THD,DELAY 1.00E+00, CYCLES 8.00E00,ALGORITHM EXPONENTIAL,SAMPLE 3, TOLERANCE 3.00E-01 DB,NOISE -2.00E-03 DBV, FLOOR 9.00E-01 DBV,TIMEOUT 3.00E+02, FBEGIN 3.00E+01,FEND 2.00E+02`

Explanation Refer to chapter ***Stepped Sweep*** (p. ***175***) for further details.

MEASurement:STEPpedsweep:SETTling:TIMEout <Timeout>

Usage Defines the settling timeout for a stepped sweep measurement (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL (***MEAS:STEP:SETT:MODE NORMAL***).

Parameter `<Timeout>` *float* 0.1 to 5000.0 (settling timeout in ms; resolution = 0.1 ms)

Default `600¦3000` (RMSLEVEL ¦ DISTORTION mode)

Example 💻 → `MEAS:STEP:SETT:TIME 500`

Explanation Every sweep measurement that exceeds the <Timeout> will be stopped, i.e. the corresponding measurement result will be marked with an asterisk ("*") and the RT-2M system proceeds to the next frequency. Thus, the system is prevented from "hanging itself up" if it cannot settle to a stable measurement result.

Refer to chapter ***Stepped Sweep*** (p. ***175***) for further details.

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MEASurement:STEPpedsweep:SETTling:TOLerance <Tolerance> [%¦DB]

Usage Defines the tolerance limit of the settling algorithm for the stepped sweep (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL (***MEAS:STEP:SETT:MODE NORMAL***).

Parameter `<Tolerance> [%¦DB]` *float & string* 0.1 to 400.0 % ¦ 0.00868 to 12.0 dB

Default `1.0 %¦3.0 %` (RMSLEVEL ¦ DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Examples 💻 → `MEAS:STEP:SETT:TOL 6 DB`

Explanation Refer to chapter ***Stepped Sweep*** (p. ***175***) for further details.

MEASurement:STEPpedsweep:SETTling:TYPE [RMSLEVEL¦HARMONIC2¦ HARMONIC3¦HARMONIC4¦HARMONIC5¦THD¦THDN]

Usage Defines the settling type for the stepped sweep measurement (p. ***175***).

Availability Normal, LCL, RL and PureSound™ mode (not available if the analyzer is armed), whereby the settling mode must be NORMAL or SELECTIVE.

Parameter

`[RMSLEVEL¦`		(settling tracks on acquired RMS Level results)
`HARMONIC2¦`		(settling tracks on acquired 2nd Harmonic results)
`HARMONIC3¦`	*string*	(settling tracks on acquired 3rd Harmonic results)
`HARMONIC5¦`		(settling tracks on acquired 4th Harmonic results)
`HARMONIC5¦`		(settling tracks on acquired 5th Harmonic results)
`THD¦THDN]`		(settling tracks on acquired THD ¦ THD+N results)

Default `RMSLEVEL¦HARMONIC2` (RMSLEVEL ¦ DISTORTION mode)

Query ***MEASurement:STEPpedsweep:SETTling:STATus?***

Examples 💻 → `MEAS:STEP:SETT:TYPE HARMONIC3`

Explanation The settling types are optimized for the corresponding measurement function. Generally, it is recommended to apply the ***RMSLEVEL*** settling for Level and Phase measurements and the ***HARMONICx*** settling for any kind of Distortion analysis, but not the ***THDN*** settling.

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MEASurement:STEPpedsweep:SMOothing:ACTive [CHANNEL1¦CHANNEL2¦BOTHCHANNELS]

Usage Defines the active channel(s) for the stepped sweep data smoothing (p. ***179***).

Availability Normal, LCL, RL and PureSound™ mode (not available if the analyzer is armed).

Parameter `[CHANNEL1¦CHANNEL2¦BOTHCHANNELS]` *string*

Default `BOTHCHANNELS`

Query ***MEASurement:STEPpedsweep:SMOothing:STATus?***

Example 💻 → `MEAS:STEP:SMO CHANNEL2`

MEASurement:STEPpedsweep:SMOothing:MODe [OFF¦AVERAGE]

Usage Activates the data smoothing for the stepped sweep measurement (p. ***179***).

Availability Normal, LCL, RL and PureSound™ mode (not available if the analyzer is armed).

Parameter `[OFF¦AVERAGE]` *string*

Default `OFF`

Query ***MEASurement:STEPpedsweep:SMOothing:STATus?***

Example 💻 → `MEASurement:STEPpedsweep:MODe AVERAGE`

MEASurement:STEPpedsweep:SMOothing:RESolution <Percent>

Usage Defines the active channel(s) for the stepped sweep data smoothing (p. ***179***).

Availability Normal, LCL, RL and PureSound™ mode (not available if the analyzer is armed).

Parameter `<Percent>` *float* 0.0 to 300.0 (percent of an octave)

Default `33.33` (33.33% = 1/3rd octave)

Query ***MEASurement:STEPpedsweep:SMOothing:STATus?***

Example 💻 → `MEAS:STEP:SMO:RES 1.00E+02` (100% = full octave)

Explanation Calculation of the lower and upper limit of the frequency window is described in chapter ***Smoothing*** (p. ***179***).

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MEASurement:STEPpedsweep:SMOothing:STATus?

Usage Queries the stepped sweep data smoothing status (p. ***179***).

Availability Normal, LCL, RL and PureSound™ mode (not available if the analyzer is armed).

Answer

`MODE [OFF¦AVERAGE],`	*string*	(data smoothing Off or On)
`ACTIVE [CHANNEL1¦ CHANNEL2¦BOTHCHANNELS],`	*string*	(active channel(s))
`RESOLUTION [0.00E00 to 3.00E+02]`	*string & float*	(width of frequency window)

Example

```
💻 →   MEAS:STEP:SMO:STAT?
→ 💻   MODE OFF,ACTIVE BOTHCHANNELS,RESOLUTION 3.30E+01
```

Explanation Refer to chapter ***Smoothing*** (p. ***179***) for further details.

MEASurement:STEPpedsweep:STATus?

Usage Queries the stepped sweep analyzer status (p. ***175***).

Availability Normal and PureSound™ mode (not available if the analyzer is armed).

Answer

`ACQUISITION [RMSLEVEL¦DISTORTION],`	*string*
`NOISEIMMUNITY [OFF¦ON],`	*string*
`HIPRECISION [OFF¦ON]`	*string*

Example

```
💻 →   MEAS:STEP:STAT?
→ 💻   ACQUISITION RMSLEVEL, NOISEIMMUNITY ON,HIPRECISION OFF
```

Explanation Refer to chapters ***Acquisiton Mode*** (p. ***180***), ***Noise Immunity*** (p. ***175***) and ***High Precision Mode*** (p. ***176***) for further details.

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Commands for Device Status

*CLS

Usage The CLear Status command clears the *standard event status register* and consequently also the ESB bit of the *status byte register*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Example 💻 → `*CLS`

Explanation The *CLS command has the same effect as the *ESR? command.

Refer to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

*ESE <NRf>

Usage The Event Status Enable command sets the indicated bits of the *standard event status enable register*, thus enabling the corresponding bits of the *standard event status register*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `<NRf>` *integer* 0 – 255 (<NRf> = $n_7 + n_5 + n_3 + n_0$, refer to p. ***121***)

Query ***ESE?**

Example 💻 → `*ESE 160` (enable bit $n_7 + n_5$ {128 + 32}: Power ON & Command Error events)

Explanation The *standard event status enable register* defines, which messages of the *standard event status register* are forwarded to bit n_5 (ESB = Event Summary Bit) of the *status byte register*.

Refer also to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

*ESE?

Usage The standard Event Status Enable query reads the current contents of the *standard event status enable register*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `[0-255]` *integer* (the sum of all active bits, refer to p. ***121***)

Example 💻 → `*ESE?`
→ 💻 `160` (160 = 128 + 32 → Power On & Command Error events enabled)

Explanation The contents of the *standard event status enable register* must be defined with the command ***ESE** <**NRf**>.

Refer to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

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*ESR?

Usage The standard Event Status Register query reads and clears the current contents of the *standard event status register*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `[0-255]` *integer* (the sum of all active bits, refer to p. ***121***)

Example
💻 → `*ESR?`
→ 💻 `32` (a Command Error has occurred)

Explanation The content of the *standard event status register* indicates the events that occurred since it has been cleared.

Refer to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

*IDN?

Usage The IDentificatioN query reads the unique identification of RT-2M.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer

`NEUTRIK,`	*string*	(manufacturer)
`RT2M,`	*string*	(instrument type)
`<S_No>,`	*integer*	(serial number: 4 characters)
`<FW_Rev>`	*float*	(firmware revision)

Example
💻 → `*IDN?`
→ 💻 `NEUTRIK,RT2M,0123,5.15`

Explanation The command returns the same information as the ***SYSTem:INFormation?*** query.

Refer to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

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*OPC

Usage The OPeration Complete command sets bit n_0 (Operation Complete) of the *standard event status register* as soon as all pending operations have been finished.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Example 💻 → `output:mtone:start;*opc` (RT-2M activates "Operation Complete" as soon as the measurement is completed)

Explanation The command allows synchronizing the controlling PC to RT-2M by using the ESB bit in the *status byte register* according to following procedure:

1. Enable the bit n_0 in the *standard event status register* and bit n_5 in the *status byte register* with the commands ***ESE 32*** and ***SRE 1***.
2. Generate the event "Operation Complete" (bit n_0) in the *standard event status register* with command ***OPC*** (the string `*opc?` must follow the RT command, separated by a "`;`").
3. Consequently, RT-2M transmits a Service Request through the IEEE interface as soon as all pending commands have been executed.

Refer to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

*OPC?

Usage The OPeration Complete query is used to let RT-2M generate a response message.

- First, the command ***OPC?*** places a "1" in the RT-2M *output queue*.
- Consequently, as soon as all pending device operations have been completed, a service request (SRQ) is executed.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `[0¦1]` *integer* (not completed ¦ completed)

Example

💻 → `*OPC?` (the command places a "1" in the output queue)
→ 💻 `1` (as soon as the pending commands are completed, the "1" causes a service request via the MAV bit of the status byte register)

Explanation The command allows synchronizing the controlling PC to RT-2M by using the MAV bit in the *status byte register* according to following procedure:

1. Enable the bit n_4 in the *status byte register* with the command and ***SRE 16***.
2. Place a '1' in the *output queue* with the command ***OPC?***
3. Consequently, RT-2M transmits a Service Request through the IEEE interface as soon as all pending commands have been executed.

Refer to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

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*PSC [0¦1]

Usage The Power-on Status Clear command defines, whether the *standard event status enable register* and the *service request enable register* shall be cleared automatically after system power ON or not.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `[0¦1]` (0: enable registers are not cleared, i.e. their last status remains active ¦
1: enable registers are cleared, i.e. all bits are disabled by setting them to '0')

Default `0`

Examples 💻 → `*PSC 0`

Explanation If the enable registers are cleared (reset), it is necessary to enable the required bits every time after a power ON.

Refer also to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

*PSC?

Usage The Power-on Status Clear query reads the status of the RT-2M power-on status clear flag.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `[0¦1]` *integer* (no clearing ¦ clearing active)

Example 💻 → `*PSC?`
→ 💻 `0`

Explanation If the enable registers are cleared (reset), it is necessary to enable the required bits every time after a power ON.

Refer also to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

*RST

Usage The ReSeT command executes a device reset. All parameters are set to their default values except of the *output queue* and the *command queue*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Example 💻 → `*RST`

Explanation Refer also to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

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*SRE <NRf>

Usage The Service Request Enable command sets bits of the *service request enable register*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Parameter `<NRf>` *integer* 0 to 255 (<NRf> = $n_7 + n_5 + n_4$, refer to p. ***121***)

Example 💻 → `*SRE 32` (enables standard event status bit ESB)

Explanation The *service request enable register* defines, which bits of the *status byte register* can generate a Service ReQuest (SRQ) to the controlling PC.

Refer also to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

*SRE?

Usage The Service Request Enable query reads the contents of the *service request enable register*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `[0-255]` *integer* (the sum of all active bits, refer to p. ***121***)

Example 💻 → `*SRE?`
→ 💻 `32` (32 represents bit n_5 that enables bit ESB of the *status byte register*)

Explanation The contents of the *standard event status enable register* must be defined with the command ***SRE** <**NRf**>.

Refer to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

*STB?

Usage The STatus Byte query reads the contents of the *status byte register*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `[0-255]` *integer* (the sum of all active bits, refer to p. ***121***)

Example 💻 → `*STB?`
→ 💻 `48` (48 = 16 + 32, i.e. n_5 {ESB} and n_6 {MAV}are TRUE)

Explanation The contents of the *status byte register* are given by messages from the *standard event status register* and the *output queue*.

Refer to chapter ***IEEE Standard Status Data Structure*** (p. ***120***).

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*TST?

Usage The TeST query starts an internal self-test and writes the result to the *output queue*.

Availability Normal and PureSound™ mode (also if the analyzer is armed).

Answer `[0¦1]` *integer* (at least one error has occurred ¦ self-test OK)

Example
💻 → `*TST?`
→ 💻 `1`

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Compatibility of RT-1M, RT-2M and RT-2X Commands

RT-2M is able to properly handle most *RT-1M* and *RT-2X* commands with the few exceptions and incompatibilities that are listed below.

	RT-1M	*RT-2M*	*RT-2X*
SYSTEem:LICense?	n/a	✓	✓
SYSTem:MODE 8K*, *SYSTEM:MODE?	n/a	n/a	✓
INOUT:ISDn …*, *INOUT:LCLBridge …*, *INOUT:RLBridge …*, *INOUT:T1 …	n/a	n/a	✓
INOUT:PUResound …	n/a	✓ (if licensed)	✓ (if licensed)
OUTPut:ACCOupling …	n/a	n/a	✓ (with LCL/RL option)
OUTPut:ARBSIN …	n/a	✓	✓
OUTPut:DTMF …	n/a	✓	✓
OUTPut:IMPedance …	n/a	✓ (range: [150¦600])	✓ (full range)
OUTPut:ISDn …*, *OUTPut:LCLBridge …*, *OUTPut:RLBridge …*, *OUTPut:T1 …	n/a	n/a	✓ (with the corresponding option)
OUTPut: MTONe:ACTive …	✓ (range: [1¦2¦3¦4])	✓ (range: [1¦2¦3¦4])	✓ (full range)
OUTPut:MTONe:PARameter …	✓ (specific format)	✓ (specific format)	✓ (specific format)
OUTPut:PUResound …	n/a	✓ (if licensed)	✓ (if licensed)
OUTPut:SOURce …	n/a	n/a	✓ (with ISDN or T1 option)
OUTPut:STATus?	✓ (specific format)	✓ (specific format)	✓ (specific format)
OUTPut:STEPpedsweep…	n/a	✓	✓
OUTPut:ZREF …	n/a	n/a	✓

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	RT-1M	RT-2M	RT-2X
INPut:ACCOupling …	n/a	n/a	✓ (with LCL/RL option)
INPut:FRONt ON	✓	n/a	n/a
INPut:IMPedance …	n/a	✓ (range: [100k¦600])	✓ (full range)
INPut:ISDn …, ***INPut:LCLBridge …***, ***INPut:RLBridge …***, ***INPut:T1 …***	n/a	n/a	✓ (with the corresponding option)
INPut:MICSensitivity …	n/a	✓	✓
INPut:SOURce …	n/a	n/a	✓ (with ISDN or T1 option)
INPut[1¦2]:STATus?	✓ (specific format)	✓ (specific format)	✓ (specific format)
INPut:TRIGger:THReshold …	n/a	✓	✓
INPut:VOLTagedividerratio..	n/a	✓	✓
INPut:ZREF …	n/a	n/a	✓

MEAS:DTMF …	✓ (with DTMF option)	✓	✓
MEAS:ERL?	n/a	n/a	✓ (with LCL/RL option)
MEAS:NOISe:FULLband?	n/a	✓	✓
MEAS:PUResound …	n/a	✓ (if licensed)	✓ (if licensed)
MEAS:RL?	n/a	n/a	✓ (with LCL/RL option)
MEAS:SRLHI?	n/a	n/a	(with LCL/RL option)
MEAS:SRLLO?	n/a	n/a	(with LCL/RL option)
MEAS:STEPpedsweep…	n/a	✓	✓

Table 5 Command Incompatibilities

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DTMF Analysis

RT-2M provides of a DTMF module that can generate & analyze DTMF tones completely independently of the other test functions (e.g. multitone or stepped sweep measurements).

Column ↓ / Row →		1	2	3	4
		1209 Hz	1336 Hz	1477 Hz	1633 Hz
1	697 Hz	1	2	3	*a*
2	770 Hz	4	5	6	*b*
3	852 Hz	7	8	9	*c*
4	941 Hz	*	0	#	*d*

Table 6 Typical DTMF Signal Coding

Table 6 shows the definition of DTMF tones as well as their correspondence to a standard 4x4 keypad. Every key is represented by a dual tone comprising of the frequencies in the respective column & row. For instance, the DTMF tone for key #6 consists of 770 Hz & 1477 Hz. The meaning of the four 'empty' keys *a-d* in the last row is user-defined.

- ***OUTPut:DTMF [1¦2¦3¦4],[1¦2¦3¦4],<Time>,<RowFrqDev>,<ColFrqDev>,<AmpRatio>*** generates a DTMF tone – identified by its column & row – for a user-defined duration. In addition, the user can apply an independent frequency deviation for the dual tone and amend the amplitude ratio if required.
- ***MEASurement[1¦2]:DTMF:STARt*** lets the DTMF module of RT-2M continuously monitor both input channels and store all received DTMF tones in the two internal buffers (in parallel to any other operation of RT-2M).
- ***MEASurement[1¦2]:DTMF?*** queries the contents of the selected 32 keys wide DTMF signal buffer and resets it (i.e. deletes the stored contents).

Application Example

Typically, the complete analysis of an external DTMF device comprises of three topics:

- Stimulation of the device with standard and de-tuned DTMF tones.
- Decoding of the DTMF signals, generated by the device.
- Exact frequency & amplitude measurement of the DTMF tones, coming from the device.

First, use ***OUTPut:DTMF [1¦2¦3¦4],[1¦2¦3¦4],<Time>,<RowFrqDev>,<ColFrqDev>,<AmpRatio>*** to generate a DTMF signal with the required number, frequency deviation and amplitude ratio. After its transmission, check whether the device correctly decodes the transmitted DTMF signal.
Next use commands ***MEASurement[1¦2]:DTMF:STARt*** and ***MEASurement[1¦2]:DTMF?*** to 'arm' the DTMF decoder of RT-2M and to query the received numbers. If the latter corresponds to the externally generated ones, the tested device complies to the DTMF standards.
The third point is more complex to verify since it requires the correct triggering of the RT-2M analyzer to the incoming DTMF signal. Please read the **NTI** Application Sheet '***DTMF Analysis***' (available as *.pdf file on the **NTI** homepage) for further details.

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External Signal Analysis

RT-2M supports several measurement functions for the analysis of externally generated signals.

Measurement function	Description	Page	Normal mode	PureSound™ mode
DTMF	• Decoding of DTMF key codes • DTMF frequency measurement • DTMF amplitude measurement	**114**	✓	✓
Energy / signal level	Measurement of the energy (signal level) in a user-defined band	**149**	✓	
Frequency	Measurement of the dominant frequency in a user-defined band	**117**	✓	
Rub & Buzz defects	Detection of defective electroacoustic transducers, drivers, speakers etc.	**171**, **169**		✓
Sound correlation	Comparison of a test signal against a previously recorded reference signal (i.e. "golden sample")	**164**		✓
Sound pressure level (SPL)	Calibrated SPL measurements in a user-defined band	**149**	✓	

Table 7 External Signal Analysis Functions

Please observe following chapters that refer to anxiliary settings that must be considered for an external signal analysis:

- ***Test Setups*** (p. ***182***)
- ***Triggering & Signal Acquisition*** (p. ***188***)
- ***Multitone Signal Recording Duration*** (p. ***155***)

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Filtering

Selectable Filters

RT-2M provides of a standard set of three weighting and one Emphasis filter, each with a gain of 1 (0 dB) that are implemented in the internal firmware.

- C-message weighting according to ITU O.41
- CCITT Psophometric weighting according to North American Standard
- A-weighting according to IEC 651
- 750 µs Emphasis

The filters can be activated independently of each other, and can be applied even *after* the signal transmission. Consequently, it is possible to query the unweighted *and* weighted measurement results after the transmission of the test signal.

- ***INPut:SWFilter [OFF¦CWEighting¦CCITt¦AWEighting]*** disables the filter or selects the required weighting (C-message, CCITT Psophometric or A-weighting).
- ***INPut:DEEMphasis [OFF¦ON]*** disables or activates the 750 µs Emphasis.

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Frequency Measurements

RT-2M provides two functions to measure the *frequency* of the input signal's dominant component, whereby the (e.g. external) signal generator does not need to be synchronous with the *RT-2M* analyzer.

- ***OUTPut:MTONe:STARt*** immediately starts the data acquisition (p. ***182***). Alternatively, the command ***INPut:TRIGger:ARMed*** lets the analyzer wait for the incoming signal (p. ***186***).
- ***MEASurement[1¦2]:FREQuency:FULLband?*** queries the sine component with the highest amplitude in the full frequency band (20 Hz – 20 kHz).
- ***MEASurement[1¦2]:FREQuency:SELective? <binstart> <binstop>*** queries the frequency of the sine component with the highest amplitude in an user-defined frequency band.

Fig 4 explains the selective frequency measurement.
The frequencies f_{sel} *#1-3* represent the signals with the highest amplitude that occur in the three user-defined bands #1-3. Therefore, the returned results of the selective frequency measurement are these three frequency values.

The accuracy of a (full band or selective) frequency measurement depends on the actual sampling rate and of the blocklength of the active multitone signal. ***Table 8*** lists the corresponding values.

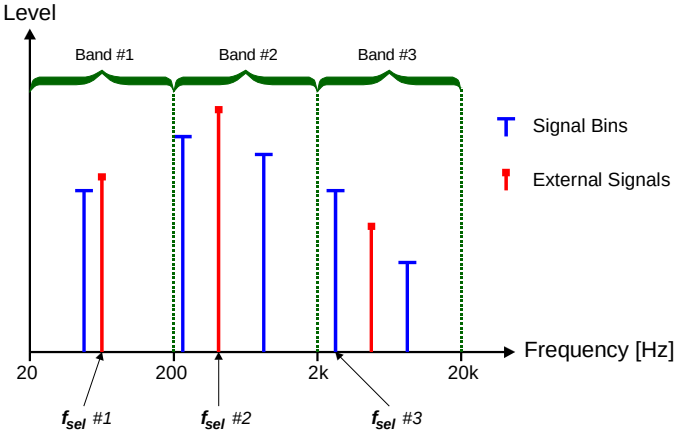


Fig 4 Selective Frequency Measurement

Blocklength	*Measuring Accuracy*	*Lowest measurable Frequency*	*Bin_Min*	*Highest measurable Frequency*	*Bin_Max*
512	0.4 Hz	187.5 Hz	2	19968.8 Hz	213
1024	0.2 Hz	93.8 Hz	2	19968.8 Hz	426
2048	0.1 Hz	46.8 Hz	2	19992.2 Hz	853
4096	0.05 Hz	23.45 Hz	2	19992.2 Hz	1706
8192	0.025 Hz	23.43 Hz	4	19998.05 Hz	3413

Table 8 Frequency Measurement Parameters

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Ground Connections

Every improper connection between *RT-2M* and a DUT may cause a ground loop. The subsequent rules help to avoid the unpleasant effects of such loops. However, each setup has to be considered individually, taking into account the actual connections between the reference grounds of the involved instrument to earth.

- Link the cable shield to GND only at one end and leave it open at the other end.
- Switch the *RT-2M* generator to FLOAT with the command ***OUTPut:FLOAT ON*** if the DUT's ground is connected to earth (chapter ***Analog Output Connections***, p. ***204***).

NOTE **Remember to disassemble the ground bars from the *RT-2M* input connectors for a balanced connection.**

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IEEE-488 Parallel Interface

RT-2M provides of a GPIB IEEE-488 interface (standard design interface for programmable instrumentation) with a standard IEEE-488 connector on the rear panel as shown in ***Fig 5***.

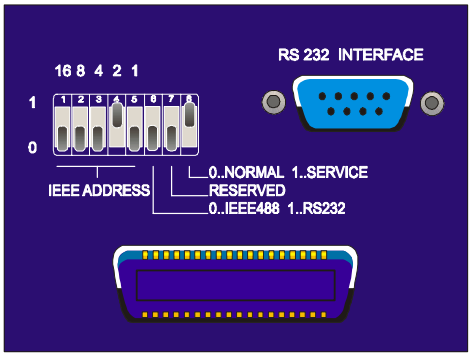


Fig 5 IEEE / RS232 Interfaces

The IEEE interface bus allows controlling up to 30 instruments from one PC. The IEEE cables have identical piggyback connectors on each end, so that they can be used to connect the controlled devices in virtually any configuration, as long as there is a path from the PC to every device.

As a practical matter, avoid stacking of more than three or four IEEE cables to a single connector. Otherwise, any force on the stack can damage the instrument's connector. Make sure that every cable connector is firmly fixed in its place.

Each IEEE device has at least one talk and listen address. The address of the *RT-2M* can be selected with the DIP-switch at the rear panel of the instrument. Each switch position has a number printed above. The resulting IEEE address is the sum of those numbers where the switch is in position "1". The available address range is 1 to 31.

Fig 5 shows an example with following status:

- DIP-switch #8: position "0" ⇒ *RT-2M* is operated in the measuring mode.
- DIP-switch #6: position "0" ⇒ IEEE interface active.
- DIP-switch #1–5: only switch #2 in position "1" ⇒ IEEE address of this unit = 2.

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IEEE Standard Status Data Structure

The standard IEEE 488.2–1992 specifies the IEEE Standard Status Device Structure, i.e. the standard codes, formats, protocols and common commands.

Overview

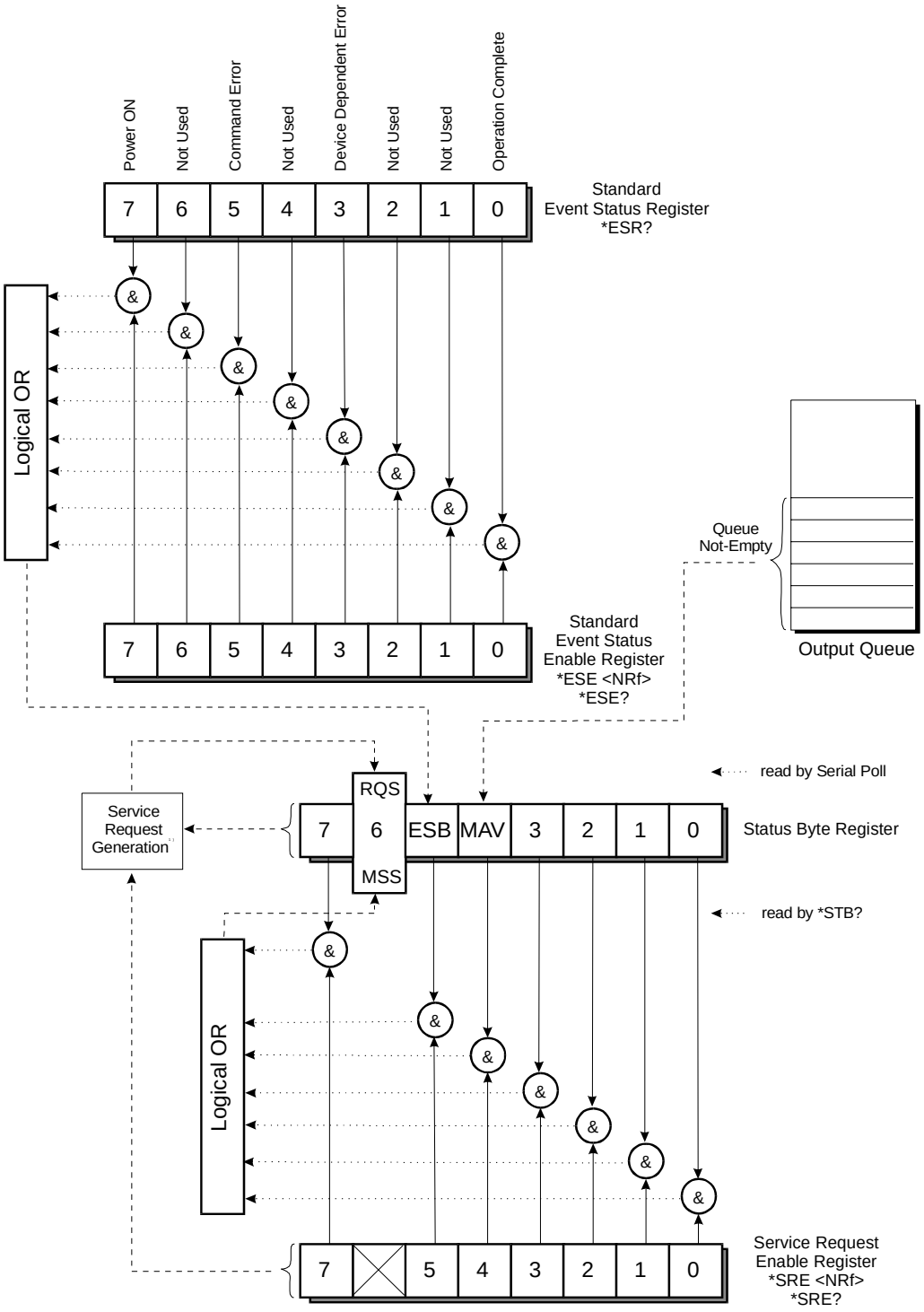


Fig 6 IEEE Device Status Registers

[1)] Service Request clears RQS but not MSS!

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Registers

RT-2M has four internal registers, each comprising one Byte, i.e. 8 bits. The registers are grouped in two blocks, whereby the ***Commands for Device Status*** (refer to p. ***106ff***) allow accessing the registers:

- The *standard event status register* and the *status byte register* are status registers that indicate the RT-2M device status.
- The *standard event status enable register* are the *service request enable register* are enable registers that define, which messages of the status registers are forwarded.

Standard Event Status Register

This register records the events "Power ON" (n_7), "Command Error" (n_5), "Device Dependent Error" (n_3) and "Operation Complete" (n_0) and forwards these messages to the *status byte register*, supposed that the corresponding bits are enabled by the *standard event status enable register*. Thereby, the bits of the *standard event status register* are coded according to the following scheme:

$$\text{<Reg_Status>} = n_7*128 + n_6*64 + n_5*32 + n_4*16 + n_3*8 + n_2*4 + n_1*2 + n_0$$

whereby

n_7 = *Power ON event flag*. This event bit indicates that an Off-to-On transition has occurred in the power supply of RT-2M.

n_6 = Not used

n_5 = *Command error event flag*. This event bit indicates that either a syntax or a semantic error has been detected. The error-number can be read with the corresponding register query command.

n_4 = Not used

n_3 = Device specific error event flag (e.g. no trigger detected). The error-number can be read with the corresponding register query command.

n_2 = Not used

n_1 = Not used

n_0 = *Operation complete event flag*. This event bit is generated in response to the *OPC command. It indicates that the device has completed all pending operations.

Standard Event Status Enable Register

This register enables the bits of the *standard event status register* according to the user settings defined with command ****ESE** <NRf>*. It thus defines, which messages are forwarded from the *standard event status register* to bit n_5 (ESB = Event Summary Bit) of the *status byte register*.

Status Byte Register

This register records the messages "RQS / MSS" (ReQuest Service / Master Summary Status, n_6), "ESB" (Event Status Summary, n_5) and "MAV" (Message AVailable, n_4) and creates a service request (SRQ) to the controlling PC, supposed that the corresponding bits are enabled by the *service request enable register*.

Service Request Enable Register

This register enables the bits of the *status byte register* according to the user settings defined with command ****SRE** <NRf>*. It thus defines, which events can create a service request (SRQ) at the controlling PC. In other words, the programmer can define the cases that result in a service request by altering the contents of the service request enable register.

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Example: Use of an *OPC Command

The *OPC command and the *OPC? query allow synchronizing the controlling PC to the time when *RT-2M* has completed a command execution.

💻 →	`*esr?`	(clear previous events)
	`*sre 32;*ese 1`	(enable operation complete event)
	`output:mtone:start;*opc`	(RT-2M starts the multitone transmission)
→ 💻		(as soon as the multitone measurement has been completed, RT-2M sends a SRQ via serial polling to the controlling PC)

Example: Use of MAV Bit in the Status Byte Register

💻 →	`*sre 16`	(enable bit n_5 = output queue not empty)
	`output:mtone:start`	(start the multitone transmission)
	`meas1:distortion?`	(read the distortion results)
→ 💻		(as soon as the output queue has the valid distortion results, RT-2M sends a SRQ via serial polling to the controlling PC)

As soon as e.g. command ***SRE 16*** has been sent, *RT-2M* is set to the service request mode. This means that *RT-2M* sends back a service request (SRQ) to the PC every time when a new message (e.g. measurement result) is ready. However, please note that the SRQ message can only be transferred to the PC by serial polling, since *RT-2M* cannot add any further information to the service request.

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Impedance of Analog Output & Input

The standard version of *RT-2M* provides two output impedance as well as two input impedance plus two microphone (Phantom) power voltages.

Output		*Input*
Balanced	***Unbalanced***	***Balanced or Unbalanced***
150 Ω 600 Ω	75 Ω 300 Ω	100 kΩ 600 Ω
		15 V / 48 V Phantom

Table 9 Standard Output & Input Impedance

Activate the required output and input impedance with ***OUTPut[1¦2]:IMPedance [150¦600]*** and ***INPut[1¦2]:IMPedance [100K¦600¦PHANTOM]***.

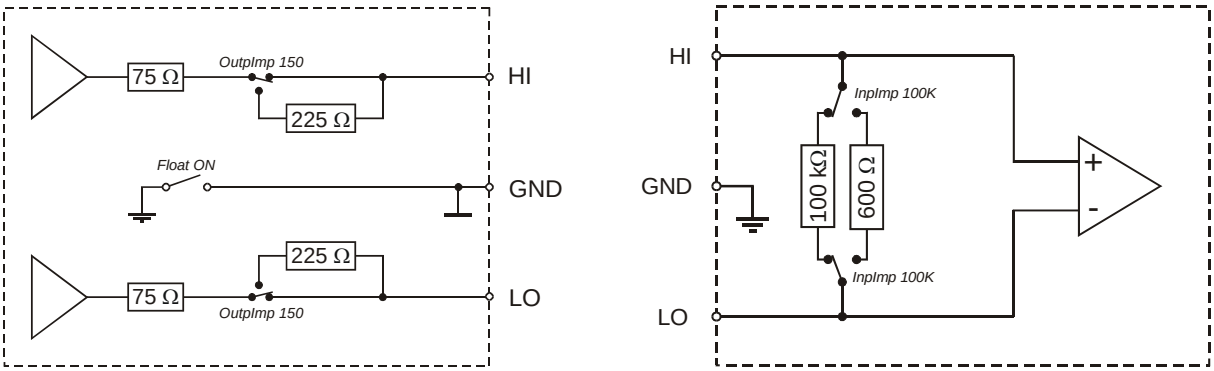


Fig 7 RT-2M Output & Input Impedance Circuits

As stated earlier, the actual output impedance of *RT-2M* depends not only on the selected impedance value, but also on the way how the unit is connected to the DUT. This is explained in the subsequent examples.

Example #1

In case of a *balanced* connection, the actual output impedance equals the selected value.

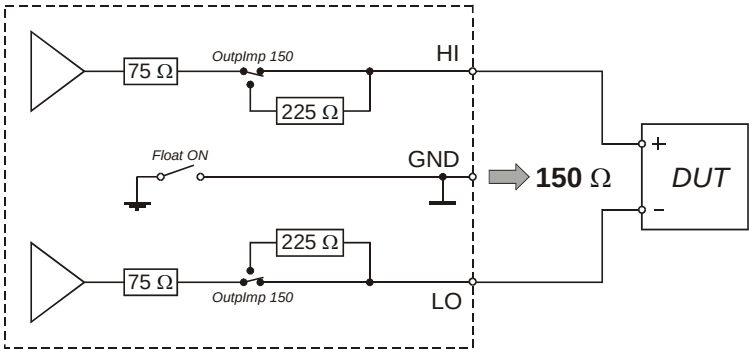


Fig 8 Balanced Output Impedance

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Example #2

In case of an *unbalanced* output connection, the actual output impedance equals only half of the selected value.

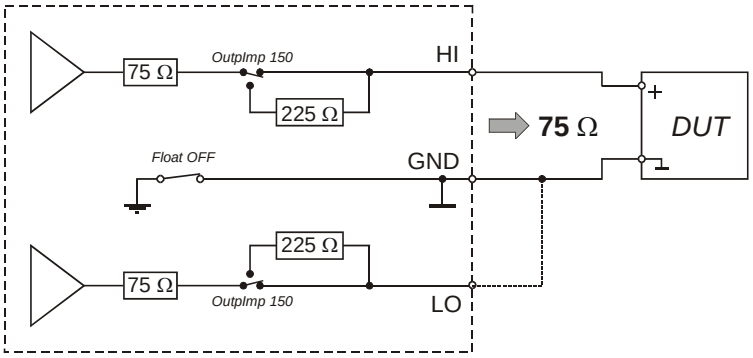


Fig 9 Unbalanced Output Impedance

NOTE **The minimum possible *balanced* output impedance is 150 Ω, the minimum possible *unbalanced* output impedance is 75 Ω.**

NOTE **With an unbalanced output connection, the actual output voltage equals only half of the selected output level: $U_{Out} = U_{Selected} - 6$ dB.**

NOTE **As soon as the input level exceeds 30 Vp, *RT-2M* automatically**
– switches the input impedance to 100 kΩ,
– links the output connectors to the input connectors internally, and
– generates the error messages 321, 322.

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Input Range

INPut[1¦2]:RANGe **<*InputRange*>** ***[DBVP¦VP]*** defines the *RT-2M* analyzer *sensitivity*, i.e. the maximum allowable input signal level. An input level that exceeds this value results in an overload of the *RT-2M* analyzer.

The input range should be set to a value that provides enough headroom (e.g. +6 dB) to the maximum input signal amplitude. It must be adjusted before the test execution and cannot be changed during the test signal transmission & sampling.

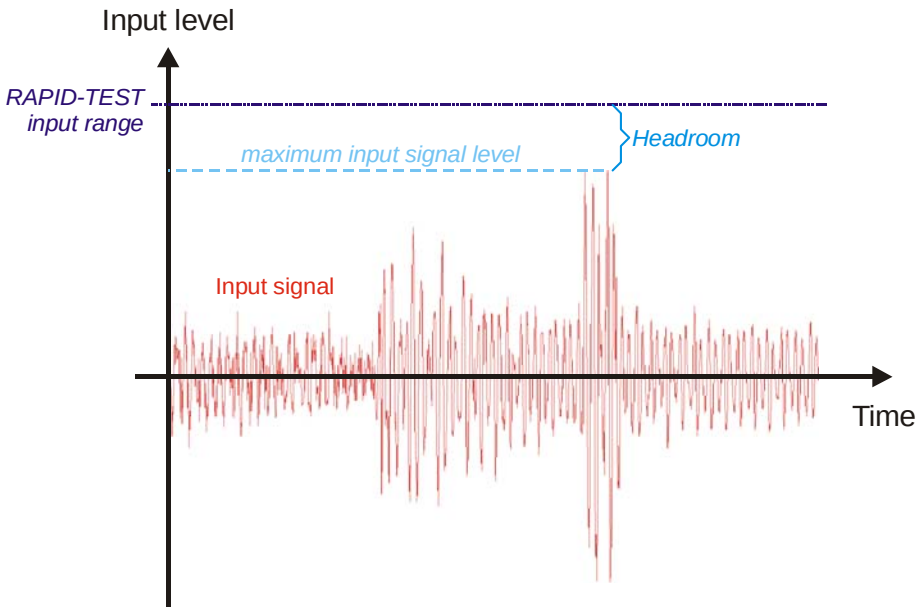


Fig 10 Input signal level, input range & headroom

NOTE **If a voltage divider is inserted between the DUT and *RT-2M*, enter the divider's ratio with the command *INPut[1¦2]:VOLTagedividerratio* <*Ratio*> and adjust the *RT-2M* input range to the output voltage of the DUT (p. *201*).**

Headroom

MEASurement[1¦2]:HEADroom? queries the headroom of the last transmitted test signal. The returned result reflects the difference between the actual input range and the maximum level of the received signal.

HINT *To optimize the headroom, proceed as follows:*

- *Adjust the input range to a value that is certainly high enough (e.g. +20 dBVp).*
- *Select the trigger mode* ***INPut:SYNC INTNoheader****.*
- *Start a signal acquisition (****OUTPut:MTONe:STARt****,* ***OUTPut:STEPpedsweep:STARt****,* ***OUTPut[1¦2]:PUResound:CHIRp:STARt*** *or* ***MEASurement[1¦2]:PUResound:STARt****).*
- *Query the headroom of this transmission (****MEASurement[1¦2]:HEADroom?****).*
- *Reduce the input range by considering the required headroom:*

$$InputRange_{New} = InputRange_{Previous} - HeadroomResult + 6\ dB$$

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LED Indicators

RT-2M has six LEDs on its front panel to display the current instrument status.

LED Name	*RT-2M status if the LED is ON*
POWER	The unit is switched ON.
COMMUNICATING	The RT-2M remote control interface (IEEE or RS232) is receiving a command. Under IEEE control, the LED remains lit after a query command until the host PC has read back the answer.
CALCULATING	An internal calculation is in progress.
TRIGGER	RT-2M has successfully triggered. The LED remains lit until the unit receives the next start command.
OVERLOAD	The input signal has overloaded one or both channels, i.e. the input voltage was higher than 40 dBVp (+70 Vp) or higher than the actual input range. The LED goes OFF as soon as a multitone burst has been transmitted without overload.
ERROR	One or more error(s) have occurred. The LED goes OFF as soon as the controlling PC queries the stored error message(s).

Table 10 LED Indicators

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Microphone Power Supply, Sensitivity & Adapter

RT-2M features 15 V or 48 V Phantom power as a standard, thus allowing directly connecting measuring microphones.

INPut[1-2]:IMPedance PHANTOM activates the Phantom power. The default voltage is 15 V. Alternatively, if 48 V are required (e.g. for the NTI 3384 microphone) an internal switch has to be adjusted within the unit. Please contact your local **NTI** representative for detailed information.

Enter the microphone sensitivity, expressed in mV/Pa (millivolt per Pascal) with the command ***INPut[1¦2]:MICSensitivity*** <***Sensitivity***>.

NTI provides an adapter as accessory that allows connecting XLR cables (e.g. of a microphone) to the *RT-2M* inputs.



Fig 11 XLR – Banana Adapter

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Multitone Analysis (Overview)

Conventional audio test systems stimulate the device under test (DUT) with a single sinusoidal wave (***Fig 12***).

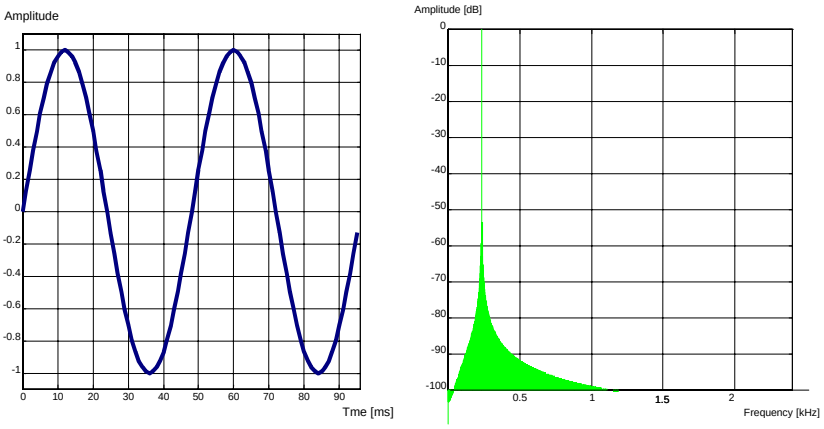


Fig 12 Time Plot & Spectrum of a Sinusoidal Signal

This method is relatively easy to handle, but slow & lacking the correlation to real-word signals as e.g. speech or music.

Other approaches like IMD (i.e. intermodulation distortion) tests stimulate the DUT with a pair of sinusoidal signals to come closer to a real audio signal transmission. Thus, the typically nonlinear characteristic of the DUT causes new harmonics and intermodulation products. However, real world signals such as music or speech are even more complex than the IMD stimulus, due to the much higher number of frequencies and their non-correlated phase relations.

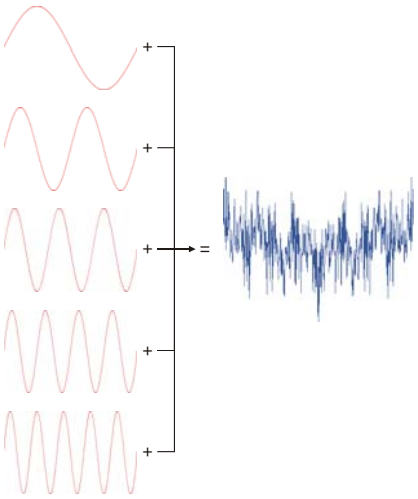


Fig 13 Multitone Signal Composition

Multitone testing comes much closer to the complex structure of natural sound and therefore is a much more realistic approach to audio testing. A multitone signal typically contains 2 to ~31 signal frequencies, all with individual phase relations, distributed over the frequency band of interest. Obviously, sophisticated test instruments are necessary to analyze such multitone signals.

Fig 13 shows how a typical multitone signal is composed of several sine waves with different frequencies, called *signal bins*. ***Fig 14*** shows the signal in the time & frequency domain.

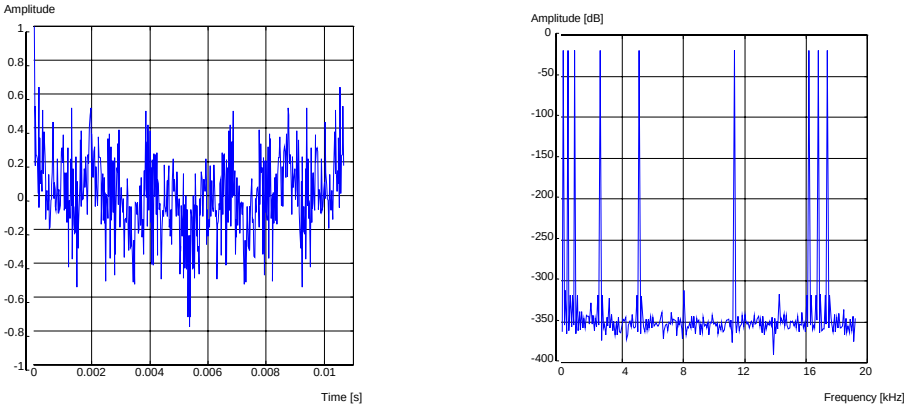


Fig 14 Time Plot & Spectrum of a Multitone Signal

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Multitone Blocklength

RT-2M internally processes a multitone signal always as digitized data. This has the advantage of accuracy, speed and flexibility, as well as the possibility of post-processing a recorded signal.

A core characteristic of the multitone test signal is its *blocklength*, i.e. the *number of samples* that build the signal within *RT-2M*. The available blocklengths of *RT-2M* are 512, 1024, 2048, 4096 and 8192.

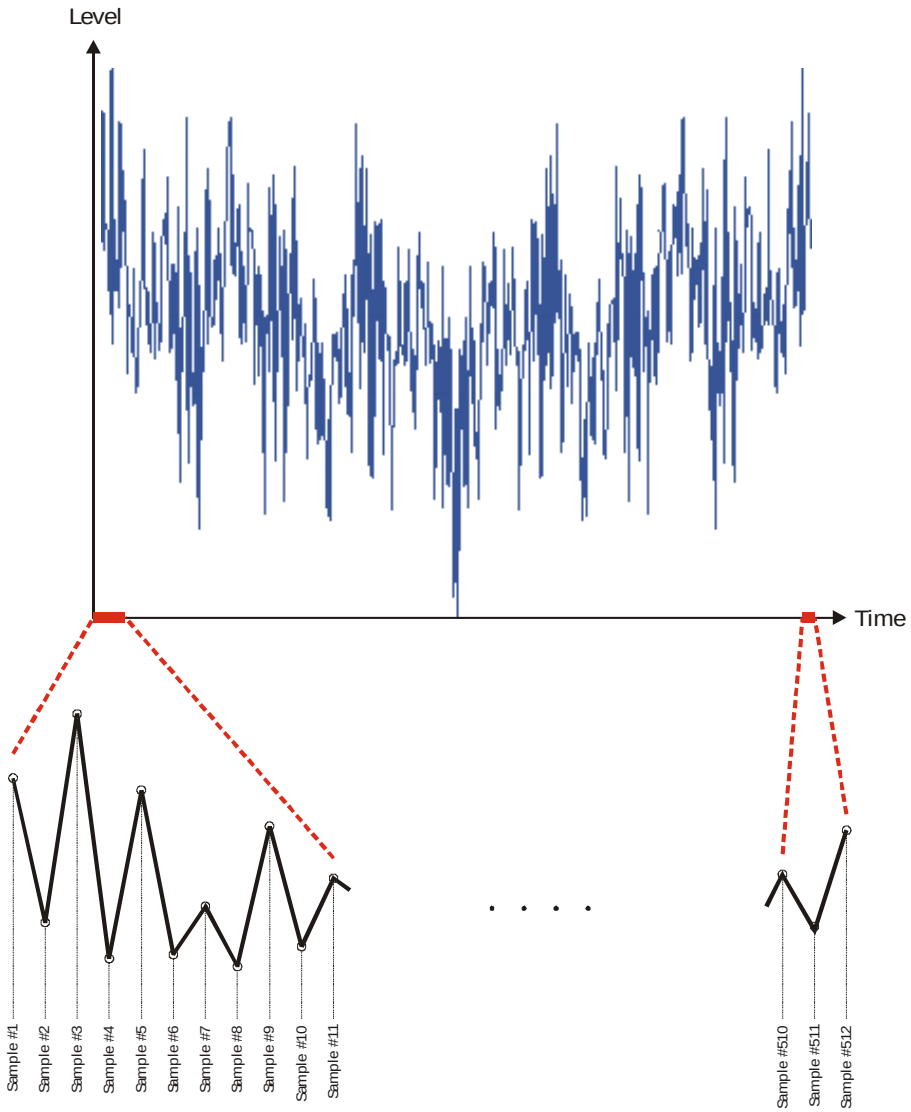


Fig 15 Multitone Signal and Blocklength

Fig 15 shows how a multitone signal is composed of a certain number of samples, given by the blocklength.
Apart from that, the blocklength also defines two other signal characteristics, the *multitone signal duration* and the *frequency spacing* (p. ***154***, ***132***).

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Multitone Burst Structure

A *RT-2M* multitone burst comprises of two blocks:

1. The *proprietary header* with the *trigger* and the "*Clock Sync*" block.
   - The *trigger* allows the analyzer triggering to an incoming multitone burst that has been generated by a RAPID-TEST unit.
   - The "Clock Sync" block allows the analyzer synchronizing its internal sampling frequency to the one of the multitone burst.

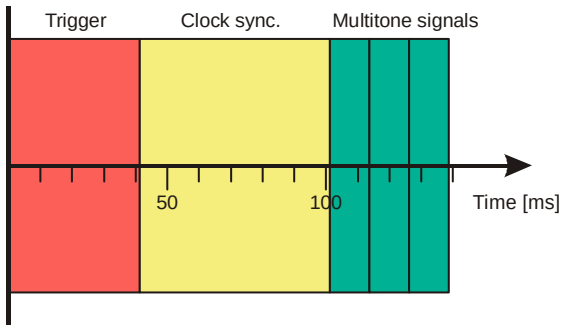


Fig 16 Multitone Burst

2. The *multitone signal* with the user-defined signal bins (i.e. frequencies). Every *RT-2M* multitone burst comprises of a 3 – 5 multitone signals (depending on the blocklength), of which the last two are sampled & processed for the measurement result calculation.

Trigger

The duration of the *trigger* is 42 ms. It comprises of 5 fixed frequencies in the voice band with predefined levels. The listening *RT-2M* analyzer recognizes this frequency & level pattern as the trigger of an incoming *RT-2M* multitone burst and immediately starts recording the signal. Please refer to chapter ***Triggering & Signal Acquisition*** (p. ***188***) for further details.

RT-2M detects the trigger down to –20 dB below the current input range. For instance, at an input range of –6 dBVp the trigger can be detected down to a level of –26 dBVp.

'Clock Sync' Block

The *Clock Sync* block has a fixed duration of 64 ms and consists of a 3 kHz single sine wave. Thus, the analyzer can synchronize its sampling frequency to the incoming multitone burst. This allows compensating for frequency shifts that have been caused by the DUT (e.g. modulators / demodulators or tape machines with speed differences) or slightly different clock frequencies of separated *RT-2M* units.

Multitone Signal

Right after the proprietary header follows the *multitone signal* with the user-defined signal bins (i.e. frequencies). Depending on the blocklength, the multitone signal is repeated at least 3 times within a burst, whereby the *RT-2M* analyzer samples the *last two* multitone signals to calculate the measurement results.

The reason to repeat the multitone signal ≥ 3 times is to eliminate the transient behavior of the DUT. Thus, it is assured that the signal transmission has settled to a stable status at the time when the analyzer starts sampling & calculating the measurement results.

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Multitone Crest Factor & Signal Bin Phases

The shape of a given multitone signal – plotted in the time domain – strongly depends on the *phases* of its signal bins. If these phases are assigned in a 'good' way, the signal will show only few high 'peaks'. However, in case of a 'bad' signal bin phase selection, the resulting multitone signal comprises of high peaks (***Fig 17***).
The biggest disadvantage of a 'bad' signal definition is the large dynamic range that is required for its transmission without clipping the signal peaks.

Consequently, it is important to select the phases of the signal bins in a good way that results in a signal characteristic with as little & small peaks as possible. In mathematical words, the Crest factor *Cf* should be kept as low as possible:

$$Cf = \frac{PeakLevel}{RMSLevel}$$

Equation 1 Crest Factor

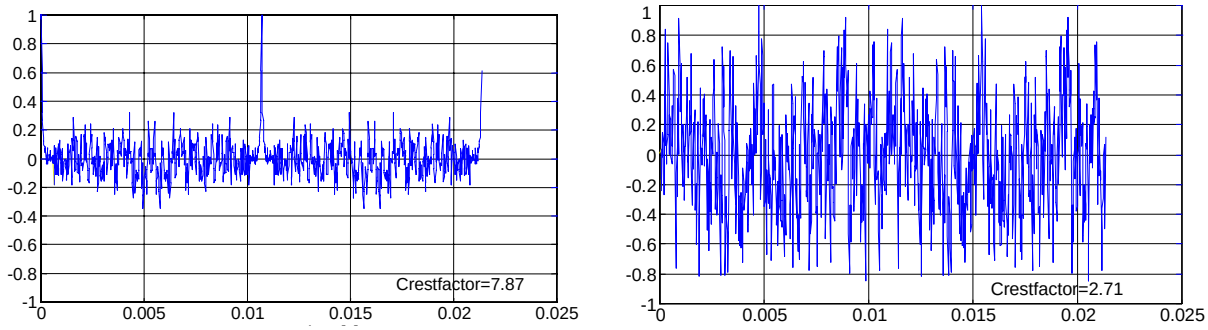


Fig 17 Multitone Signal with 'bad' and 'good' Signal Bin Phases Definition

Since the maximum signal amplitude directly determines the dynamic range of the DUT and of the analyzer, a low peak value is important & desirable. Therefore, the user should optimize the signal bin phases to get a low peak value of the time signal, i.e. a low Crest factor.

HINT ***NTI****'s software package RT-EVAL automatically optimizes the phases of the multitone signal. Please contact your local* ***NTI*** *agent or visit our homepage http://www.rapid-test.com to get a free copy.*

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Multitone Frequency Spacing

A multitone signal can only be composed of sine waves that fit with an integral number of time periods in the blocklength.

The simplest sine wave that fulfills this condition has a time period that equals the multitone signal duration. Consequently, the frequency of this signal is $f_1 = 1/t_{MT}$. The next allowed signal has a frequency of $2 * f_1$, the next $3 * f_1$ and so forth.

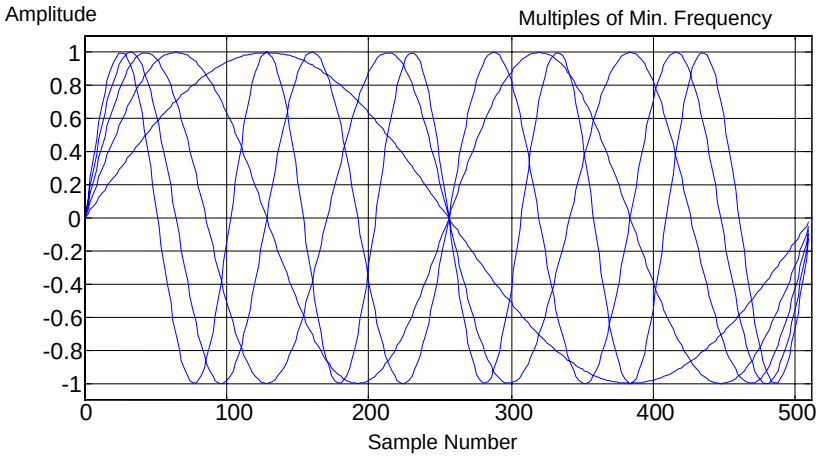


Fig 18 Time Plot of Sine Waves with f_1, $2*f_1$, $3*f_1$, $4*f_1$ and $5*f_1$

f_1 is the smallest available frequency that can be part of a multitone signal. All the other available frequencies are multiples of f_1. Therefore, this 'parent' frequency is called the *frequency spacing* (or *frequency resolution*) Δf of a multitone signal.

$$\Delta f = \frac{48000}{Blocklength}$$

Equation 2 Frequency Spacing

The frequency spacing depends on the actual blocklength and on the sampling rate (i.e. 48 kHz) of the multitone signal. Please refer to ***Table 12*** (p. ***156***) for further details.

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Multitonelength

OUTPut:MTONe:MTONelength **<*Length*>** includes *additional* multitone signal blocks to the burst. For instance, this can be necessary to let the DUT stabilizing (e.g. to let transients disappear) before the analyzer starts sampling.

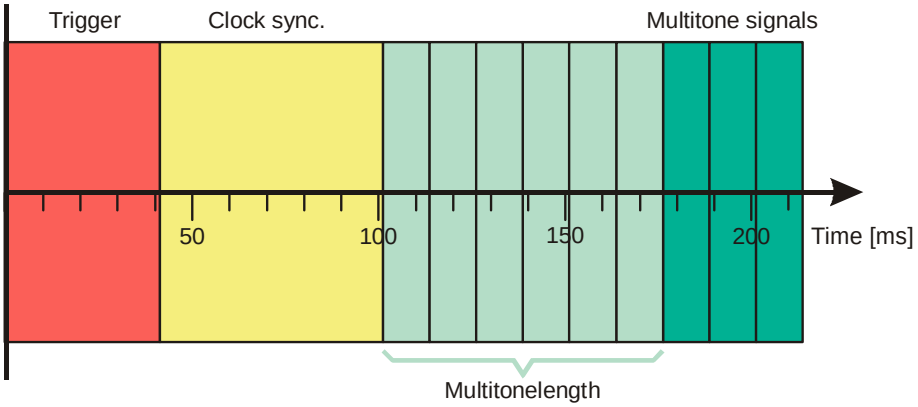


Fig 19 Multitonelength (example)

HINT *If the parameter <Length> is set to 0 (default), a minimum number of 3 – 5 multitone signal blocks is transmitted, depending on the actual blocklength.*

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Multitone Measurements

Crosstalk

Crosstalk is the signal energy that is transferred from channel onto the other in a stereo transmission. For instance, if the DUT has a bad channel separation, the frequencies of channel A will 'talk' into channel B, i.e. they will appear in the received signal of channel B, and vice versa.

- The transmitted multitone test signal must have signal bins on *both* channels.
- The signal bins of the two channels must be defined at *different* frequencies.
- ***MEASurement[1¦2]:CROSstalk:UNIT [%¦DB]*** defines the unit, in which the result is expressed.
- ***MEASurement[1¦2]:CROSstalk?*** queries the measurement results. The returned results of channel A are calculated as the ratio of the received BinLevels of channel A to the signal-BinLevels of channel B, as stated in ***Equation 3*** (*n* = the signal bin number of channel B):

$$Crosstalk(ChA)_n[\%] = \frac{ReceivedBinlevel_ChA_n}{SignalBinlevel_ChB_n} * 100$$

$$Crosstalk(ChA)_n[dB] = ReceivedBinlevel_ChA_n[dB] - SignalBinlevel_ChB_n[dB]$$

Equation 3 Crosstalk Calculation

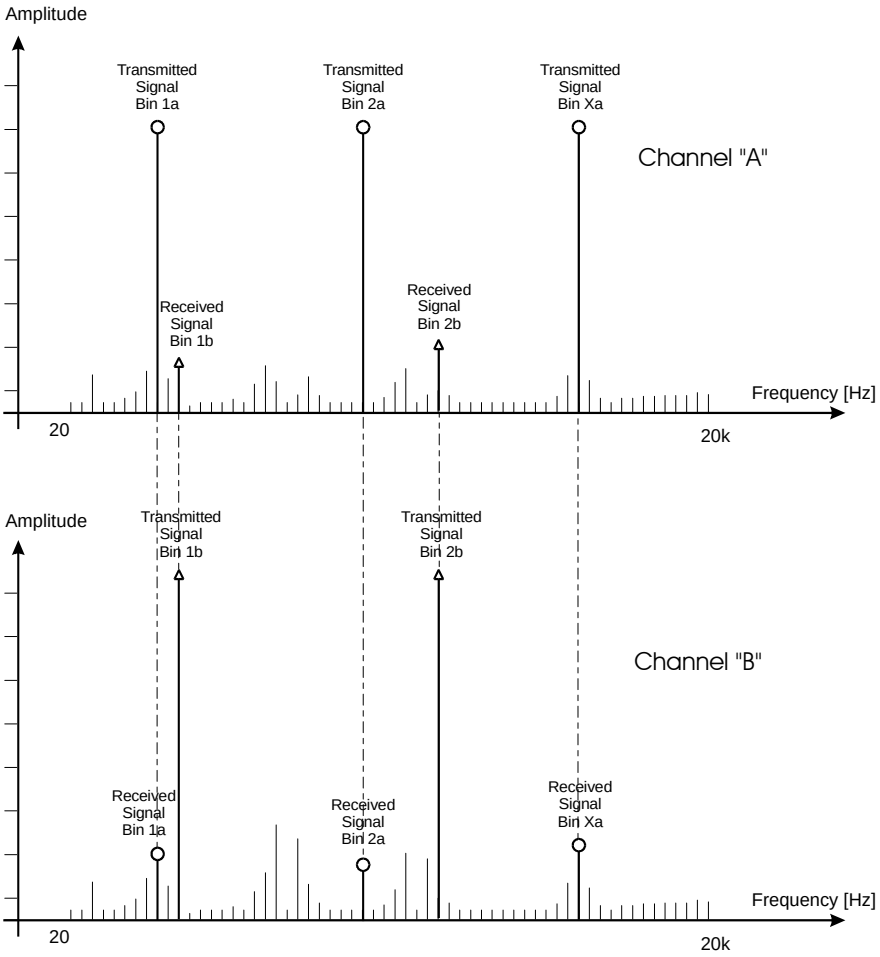


Fig 20 Crosstalk Plot

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Example

Given Signal-BinLevel of channel A = 10 dBV @ 1 kHz

Measured Received BinLevel of channel B = –30 dBV @ 1 kHz

Result $Crosstalk_{B \rightarrow A}$ = 1 % = –40 dB

NOTE	**A noisy DUT will falsify the crosstalk results since the noise will be added to the 'pure' crosstalk level.**

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Distortion

Distortion characterizes the nonlinear behavior of a DUT, i.e. the degree to which it generates new signal components at other frequencies than the stimulating signal.

- ***MEASurement[1¦2]:DISTortion:UNIT [DBV¦V¦DBM]*** defines the unit, in which the distortion results are expressed.
- ***MEASurement[1¦2]:DISTortion?*** queries the *total distortion + noise energy* (TD+N) of every band between the signal bins of the transmitted multitone signal.

Watch ***Equation 4*** and ***Equation 5*** to understand the way, in which ***RT-2M*** calculates the TD+N values in the frequency bands of interest.

RMS and RSS Value

Conventional test instruments evaluate the distortion energy as *RMS* (Root Mean Square) voltage by summing up all received signal components V_i according to following equation.

$$V_{RMS} = \sqrt{\frac{\sum_{i=1..n} (V_i)^2}{n}} \quad with\ n = number\ of\ \ signal\ components$$

Equation 4 RMS Calculation

When applying this formula on the discrete spectrum of a FFT analysis, the result correlates in inverse proportion to the number of bins. Therefore, ***RT-2M*** calculates the *RSS* value (Root Sum Square) for the TD+N (i.e. distortion per band) result.

$$V_{RSS} = \sqrt{\sum_{i=1..n} (V_i)^2} \quad with\ i = counter\ over\ all\ bins$$

Equation 5 RSS Calculation

TD+N vs. THD+N

A conventional THD+N analysis stimulates the DUT with a *single* tone. This frequency component is subtracted from the received signal after transmission. The ratio of the remaining level to the total input level gives the THD+N or *SINAD* result respectively.
On the other hand, a multitone signal transmission creates not only harmonics but also intermodulation products that cannot be related backwards to the signal bins. Therefore, TD+N results differ slightly from a conventionally measured *THD+N* value.

Multitone Distortion Results

Fig 21 shows a typical distortion plot of a ***RT-2M*** measurement.

- The first value in the plot *D1* equals the RSS result (TD+N value) of the band between the first bin ≥ 20 Hz up to the last bin < SignalBin#1.
- All further results *Dn* represent the bands between the first bin > SignalBin#n up to the last bin < SignalBin#n+1.
- The last distortion result represents the band between the first bin above the highest signal bin up to the last bin ≤ 20 kHz.

Please note that the even as well as the odd bins of the received signal are considered for the TD+N calculation.

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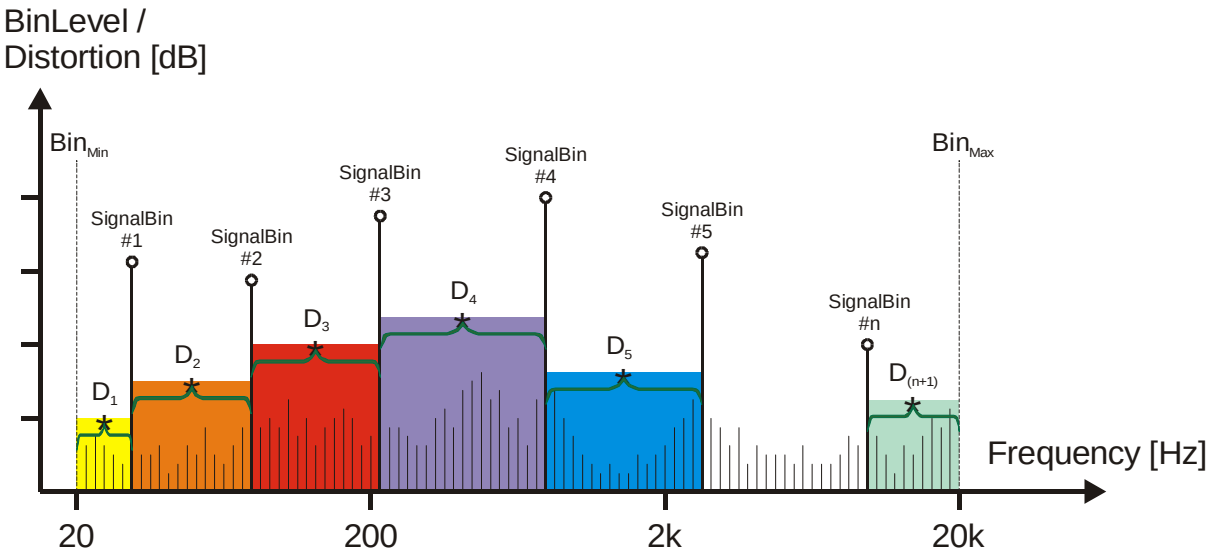


Fig 21 Multitone Distortion Measurement

Full Band TD+N

To evaluate the TD+N value in the full frequency band (20 Hz – 20 kHz), use the command ***MEASurement[1¦2]:MTTDan?*** that is calculated according to the following equation:

$$TD+N_{FullBand} = \sqrt{D_1[V]^2 + D_2[V]^2 + ... + D_n[V]^2}$$

Equation 6 Full Band TD+N

wherein D_1-D_n are the returned distortion results, expressed in [V].

THD+N

To evaluate the true THD+N result of a DUT, the following requirements have to be met:

- Stimulation of the DUT with a single bin signal.
- Calculation of the THD+N value (expressed in %) according to

$$THD+N\ [\%] = \frac{\sqrt{D_1[V]^2 + D_2[V]^2}}{\sqrt{D_1[V]^2 + L_1[V]^2 + D_2[V]^2}} * 100$$

Equation 7 THD+N Calculation

with D_1 = distortion between 20 Hz and the signal bin, D_2 = distortion between the signal bin and 20 kHz and L_1 = received signal bin level.

NOTE ***RT-2M*** **supports THD+N measurements in the stepped sweep mode (p. *181*).**

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Gain

Command ***MEASurement[1¦2]:GAIN?*** queries the *gain* of the DUT. It is calculated for each signal bin *n* according to ***Equation 8***.

$$Gain_n\,[dB] = 20*\log_{10}\left(\frac{U_{In_n}\,[V]}{U_{Out_n}\,[V]}\right) = U_{In_n}\,[dB] - U_{Out_n}\,[dB]$$

Equation 8 Gain

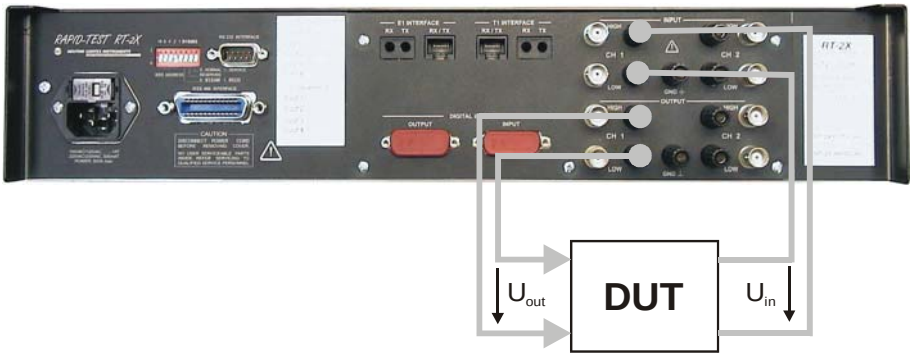


Fig 22 A-A Gain Measurement

The gain query returns the DUT's *gain vs. frequency* according to the signal bins of the transmitted multitone signal. The results are always expressed in dB, regardless of the selected output or input level unit.

When measuring the gain it is important to be aware of the difference between *voltage* gain measurements and *power* gain measurements.

- For a *voltage gain* measurement, it is recommended to set the ***RT-2M*** output and input impedance to 150 Ω and 100 kΩ, whereby the generator level must be expressed in a voltage unit, i.e. V, Vp, dBV or dBVp. Regardless of which of these units is selected, the gain calculation refers to the output and input level in dBV.
- For a *power gain* measurement, the ***RT-2M*** output and input impedance should match the corresponding impedance of the DUT (e.g. 600 Ω output → 600 Ω input). Furthermore, the generator level must be expressed in the (power) unit dBm. Consequently, the gain calculation refers to the output / input level in dBm.

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Level

The level measurement provides the *frequency response* of the DUT.

- ***MEASurement[1¦2]:LEVel:UNIT [DBVP¦VP¦DBV¦V¦DBM]*** defines the unit, in which the level result shall be expressed.
- ***MEASurement[1¦2]:LEVel?*** queries the level measurement results of the last multitone burst transmission.

The returned results correspond to the signal bin levels of the last received multitone signal. This analysis considers only the energies of the signal bins, and not the distortion + noise energy in the bands between the signal bins. Therefore, it is a very selective measurement that accurately reflects the DUT's frequency response.

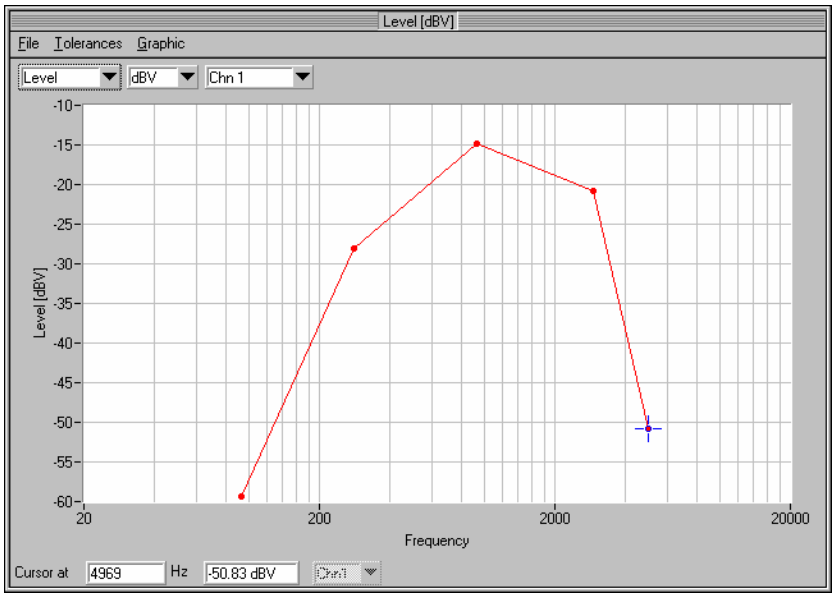


Fig 23 Level Plot

Please note that the *overall input level*, i.e. the total energy of all received *signal bin + (unused) bin levels* would correspond to the RMS level of the received multitone signal (signal bin levels + distortion + noise). However, this value is of almost no interest for the characterization of a DUT, since it only reflects its overall attenuation or amplification and not the frequency response.

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Loudness Rating (SLR, RLR, STMR accord. to ITU-T P.79)

Loudness Rating is a measure to indicate how loud the user perceives the speech transmission through a phone. *RT-2M* supports the following measurements:

- SLR (Send Loudness Rating)
- RLR (Receive Loudness Rating)
- STMR (SideTone Masking Rating)

The standards that refer to Loudness Rating – e.g. ITU-T (CCITT) Recommendation P.79 or GSM 03.50 – specifiy the measurement setup through an artificial mouth and ear. Although the test could be executed without these items, it is recommended to comply with the standard in practice.

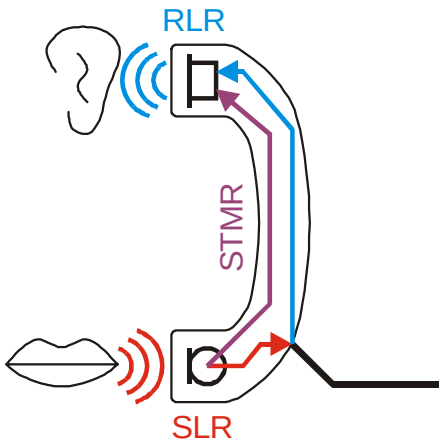


Fig 24 Loudness Rating Overview

Predefined Testsignal

RT-2M comprises a predefiend loudness testsignal according to the ITU-T recommendation and GSM standard 03.50. Due to the multitone principle, the actual frequencies of the testsignal differ slightly from the standard. However, this does not compromise the accuracy of the measurement results.

ITU Rec.	***RT-2M @ blocklength 2048***		
Frequency [Hz]	*Frequency [Hz]*	*Frequency Error [%]*	*Signal Bin No.*
200	210.9	–5.45	9
250	257.8	–3.12	11
315	328.1	–4.16	14
400	398.4	0.40	17
500	492.2	1.56	21
630	632.8	–0.44	27
800	796.9	0.39	34
1000	1007.8	–0.78	43
1250	1242.2	0.62	53
1600	1593.8	0.39	68
2000	1992.2	0.39	85
2500	2507.8	–0.31	107
3150	3140.6	0.30	134
4000	3984.4	0.39	170

Table 11 Loudness Testsignal Frequencies

Activate the loudness testsignal with command ***OUTPut:MTONe:ACTive LOUDNESS***, whereby the blocklength should be set to 2048 (command ***OUTPut:MTONe:PARameter …***). If a higher frequency resolution is required, copy the loudness signal to a standard multitone memory, chose a higher blocklength and amend the signal bins.

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Setup Calibration for SLR, STMR Measurements

Prior to a SLR or STMR measurement, the setup – i.e. the artificial mouth – must be calibrated to make sure that the acoustic sound pressure level at the MRP is identaical for all frequencies.

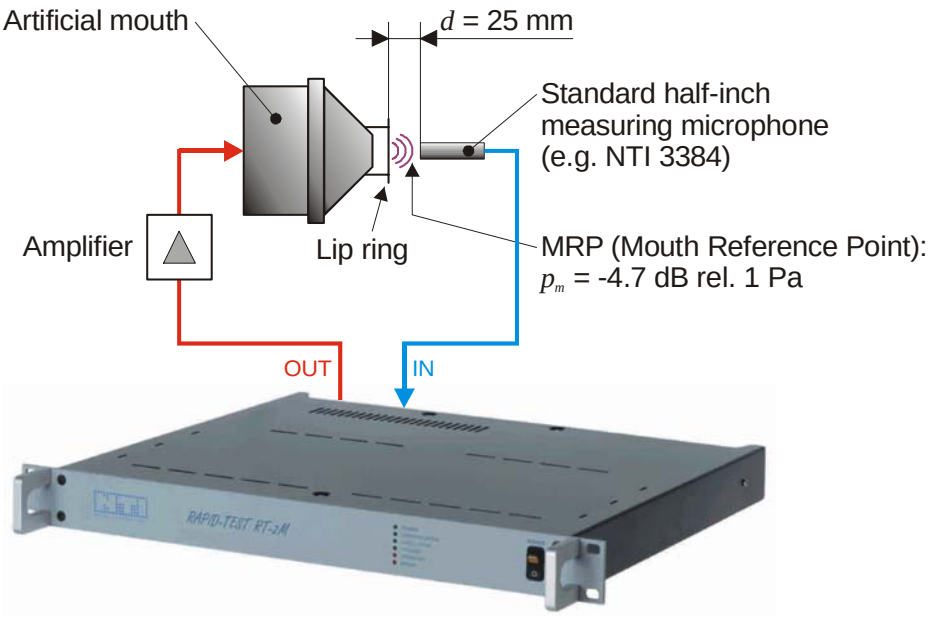


Fig 25 SLR, STMR Calibration Setup

The following list describes the calibration procedure.

1. Place a reference microphone 25 mm in front of the artifical mouth and connect it to the RT-2M input channel 1.
2. Select the predefined loudness multitone signal (***OUTPut:MTONe:ACTive LOUDNESS***).
3. Clear all binlevel weightings (***OUTPut:MTONe:CLEarweightings***).
4. Activate the Phantom power on input channel 1 (***INPut1:IMPedance PHANTOM***).
5. Enter the sensitivity of the connected microphone (***INPut[1¦2]:MICSensitivity*** <***Sensitivity***>).
6. Set the output level to a very low voltage (e.g. –30 dBVp) to make sure that the artifical mouth will not be overdriven (***OUTPut1:LEVel –30 DBVP***).
7. Execute a measurement (***OUTPut:MTONe:STARt***).
8. Query the RSS Selective result, expressed in dBPA in the band from 20 Hz to 20 kHz (***MEASurement1:SELectiverss:UNIT dBPA***, ***MEASurement1:SELectiverss? 1 853***).
9. Stepwise increase the RT-2M output level and repeat the RSS Selective measurement until the result reaches –4.7 dBPA.
10. Equalize the RT-2M output signal (***OUTPut[1¦2]:MTONe:EQUalize***).
11. Repeat step ***9.*** to make sure that the acquired RSS Selective is still –4.7 dBPA.
12. Note the current RT-2M output level (***OUTPut1:LEVel? DBVP***) and binlevel weighting (***OUTPut:MTONe:PARameter?***).

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SLR Measurements

SLR reflects the signal loudness in sending direction, i.e. from the artificial mouth through the phone to the transmission line. A small SLR result indicates that the signal at the end of the transmission line is perceived as being loud. The SLR of a phone should be:

- 8 dB +6/-3 dB (acc. to ITU-T P.79)
- 8 dB ±3 dB (acc. to GSM 03.50)

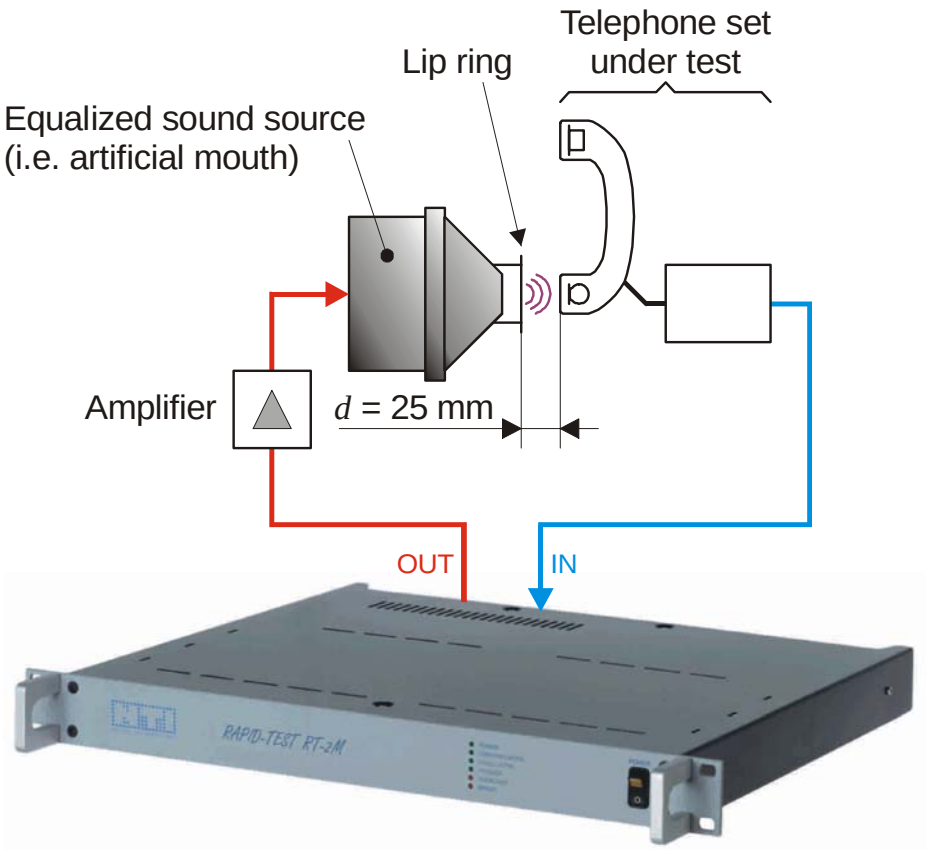


Fig 26 SLR Measurement Setup

NOTE **Prior to SLR measurements, a calibration must be executed.**
Make sure that no DC voltage is connected to the RT-2M output.

The following list describes the required steps for a SLR measurement:

1. Place the phone's mouthpiece 25 mm in front of the artifical mouth.
2. Select the RT-2M output level and binlevel weighting according to the values that have been acquired during calibration (***OUTPut1:LEVel …***, ***OUTPut:MTONe:PARameter …***).
3. Select the input impedance that matches best the DUT, e.g. 600 Ω (***INPut1:IMPedance 600***).
4. Query the headroom (***MEASurement[1¦2]:HEADroom?***) and adjust the input range properly (***INPut[1¦2]:RANGe <InputRange> [DBVP¦VP]***).
5. Transmit the test signal (***OUTPut:MTONe:STARt***).
6. Query the SLR result (***MEASurement[1¦2]:LOUDnessrating:SLR?***).

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RLR Measurements

RLR reflects the signal loudness in receiving direction, i.e. from the transmission line through the phone to the artificial ear. A small RLR result indicates that the signal at the end of the artificial ear is perceived as being loud. The RLR of a phone should be in the range of 2 dB ±3 dB (acc. to ITU-T P.79, GSM 03.50).

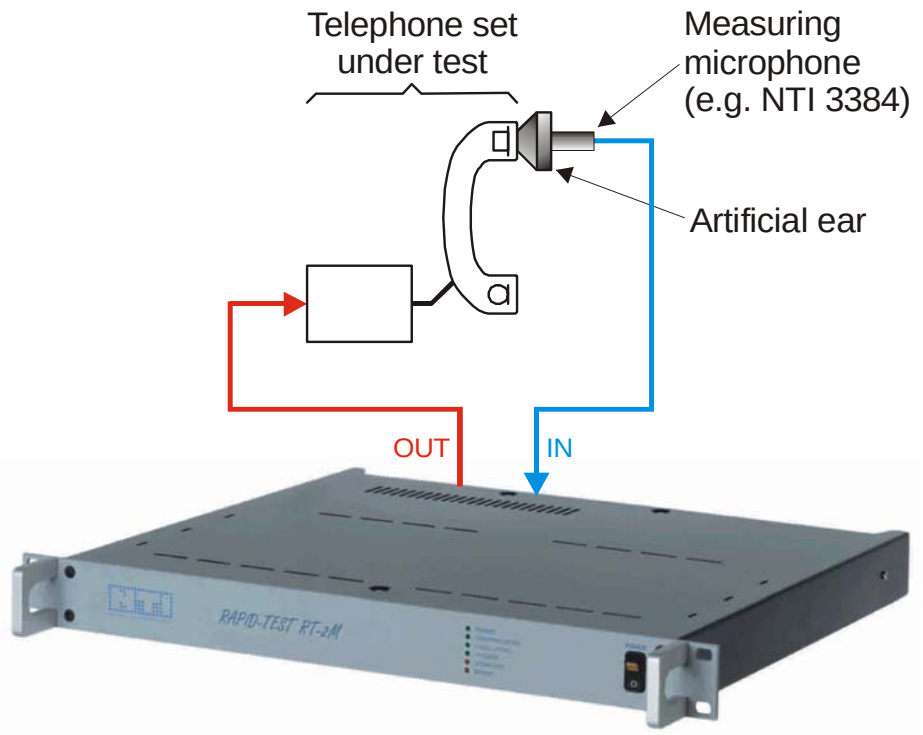


Fig 27 RLR Measurement Setup

NOTE **Make sure that no DC voltage is connected to the RT-2M output.**

Execute a RLR measurement as described below:

1. Press the earpiece of the telephone set onto the artifical ear.
2. Select the output impedance matching to the DUT, e.g. 600 Ω (***OUTPut1:IMPedance 600***).
3. Activate the internal RT-2M Phantom power (***INPut1:IMPedance PHANTOM***; only if no external microphone power supply is used).
4. Enter the microphone sensitivity (***INPut[1¦2]:MICSensitivity*** <***Sensitivity***>).
5. Select the predefined loudness multitone signal (***OUTPut:MTONe:ACTive LOUDNESS***).
6. Clear all binlevel weightings (***OUTPut:MTONe:CLEarweightings***).
7. Adjust the RT-2M output SineLevel to –12 dBV (***OUTPut1:SINelevel –1.2E+01 DBV***) or to –15.8 dBm (***OUTPut1:SINelevel –1.58E+01 DBM***).
8. Query the headroom (***MEASurement[1¦2]:HEADroom?***) and adjust the input range properly (***INPut[1¦2]:RANGe <InputRange> [DBVP¦VP]***).
7. Transmit the test signal (***OUTPut:MTONe:STARt***).
9. Query the RLR result (***MEASurement[1¦2]:LOUDnessrating:RLR?***).

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STMR Measurements

STMR reflects the loudness of the feedback signal, i.e. the sidetone from the mouthpiece of the phone to its earpiece. A small STMR result indicates that the signal at the earpiece is perceived as being loud. The STMR of a phone should be in the range of 15 dB ±5 dB (acc. to ITU-T P.79).

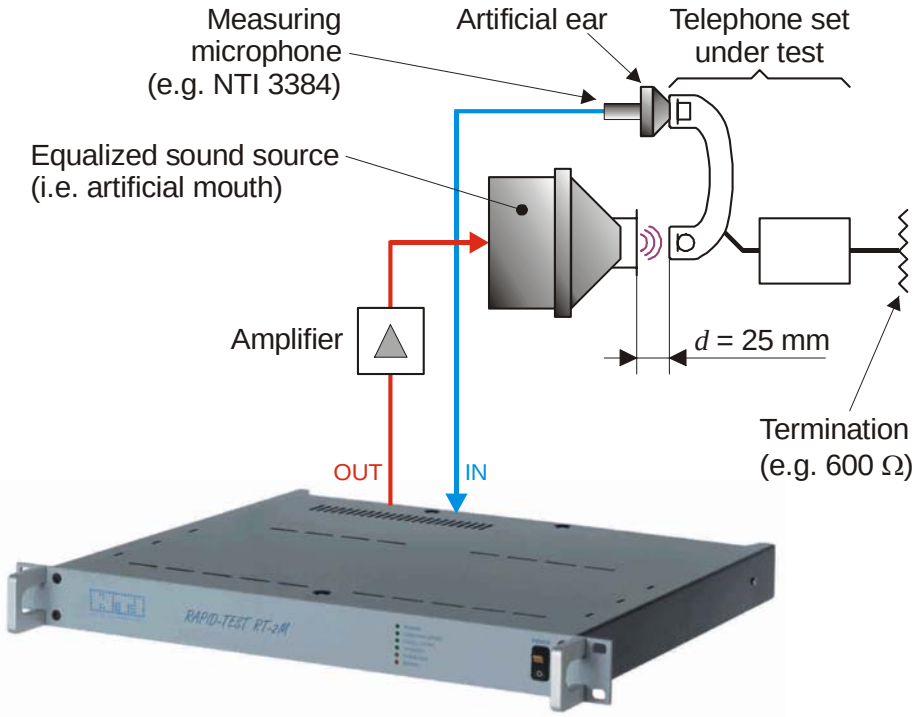


Fig 28 STMR Measurement Setup

NOTE	**Prior to STMR measurements, a calibration must be executed. Make sure that no DC voltage is connected to the RT-2M output.**

The following list describes the required steps for a STMR measurement:

1. Place the phone's mouthpiece 25 mm in front of the artifical mouth and press the earpiece onto the artifical ear.
2. Make sure hat the telephone set is terminated properly (if you connect it to an unused RT-2M input or output, activate the corresponding output or input impedance).
3. Select the RT-2M output level and binlevel weighting according to the values that have been acquired during calibration (***OUTPut1:LEVel …***, ***OUTPut:MTONe:PARameter …***).
4. Enter the microphone sensitivity (***INPut[1¦2]:MICSensitivity*** <***Sensitivity***>).
5. Activate the internal RT-2M Phantom power (***INPut1:IMPedance PHANTOM***; only if no external microphone power supply is used).
6. Query the headroom (***MEASurement[1¦2]:HEADroom?***) and adjust the input range properly (***INPut[1¦2]:RANGe <InputRange> [DBVP¦VP]***).
7. Transmit the test signal (***OUTPut:MTONe:STARt***).
8. Query the STMR result (***MEASurement[1¦2]:LOUDnessrating:STMR?***).

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MT-SINAD

SINAD is the reciprocal of THD+N:

$$SINAD = \frac{Signal + Noise + Distortion}{Noise + Distortion}$$

Equation 9 SINAD Definition

The command ***MEASurement[1¦2]:MTSinad?*** allows querying the corresponding result after a multitone signal transmission.

HINT *To get a* true *SINAD result it is necessary to stimulate the DUT only with a* single sine wave*. If a* multitone *signal is applied, intermodulation products appear that increase the* Noise+Distortion *value. Therefore, the RT-2M result is called* MT-SINAD *herein.*

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Noise

The noise measurement divides the frequency band in sub-bands, split by the signal bins, and calculates the noise values of these sub-bands.

- ***MEASurement[1¦2]:NOISe:UNIT [DBV¦V¦DBM]*** defines the unit, in which the noise results are expressed.
- ***MEASurement[1¦2]:NOISe?*** queries the noise results after a multitone signal transmission.

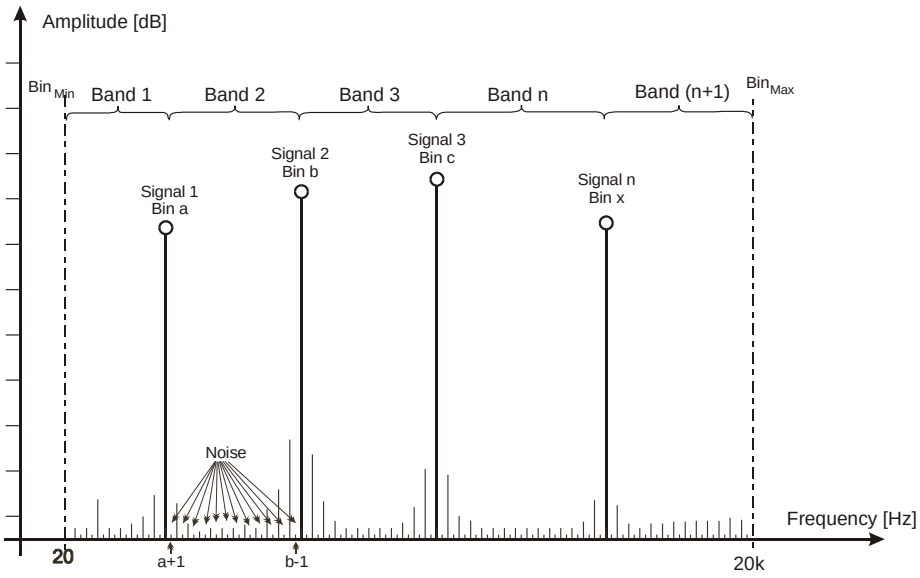


Fig 29 Multitone Noise Measurement

A noise measurement of a multitone signal with *n* signal bins results in *n+1* noise values, each calculated internally by ***RT-2M*** according to the following formula.

$$Noise_i = \sqrt{2 * \sum_{i=a+1}^{b-1} (U_{2i-1})^2} \quad = RSS\ value\ of\ \ all\ odd\ bins\ in\ a\ band$$

Equation 10 Internal Noise Calculation

wherein *a+1* and *b-1* = numbers of the odd bins above bin *a* and below bin *b*
U_{2i-1} = level of odd bin No. *(2*i)-1* with *i* = counter variable (integer)

NOTE ***Equation 10*** **describes the internal noise calculation of *RT-2M*, i.e. the actually returned noise results must not be re-calculated in any way.**

Example

Let's assume that a multitone signal with 3 signal bins (300 Hz, 1 kHz and 3 kHz) has been transmitted through the DUT. By sending the command ***MEASurement[1¦2]:NOISe?*** to ***RT-2M***, the four noise results N_{300}, N_{1k}, N_{3k} and N_{20k} are calculated.

- N_{300} = noise energy from 20 Hz – 300 Hz
- N_{1k} = noise energy from 300 Hz – 1 kHz
- N_{3k} = noise energy from 1 kHz – 3 kHz
- N_{20k} = noise energy from 3 kHz – 20 kHz

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Full Band Noise

Command ***MEASurement[1¦2]:NOISe:FULLband?*** calculates the noise in the full frequency band (20 Hz – 20 kHz) according to the following equation.

$$N_{Fullband} = \sqrt{N_1[V]^2 + N_2[V]^2 + ... + N_n[V]^2}$$

Equation 11 Full Band Noise

wherein N_1-N_n [V] = the noise results of the bands between the signal bins.

*HINT The returned results of the individual and the fullband noise queries (**MEASurement[1¦2]:NOISe?** and **MEASurement[1¦2]:NOISe:FULLband?**) can be expressed in three different units, selected by **MEASurement[1¦2]:NOISe:UNIT [DBV¦V¦DBM]**.*

Idle Channel Noise

To evaluate the *idle channel noise* of a DUT with ***RT-2M***, proceed in the following way:

- Mute the generator output (***OUTPut[1¦2]:MUTe ON***)
- Set the trigger mode to InternalNoHeader (***INPut:SYNC INTNoheader***)
- If required (e.g. for telecom applications), activate the C-message weighting filter (***INPut:SWFilter CWEighting***) and set the measurement unit to dBm (***MEASurement[1¦2]:SELectiverss:UNIT DBM***)
- Transmit the multitone signal (***OUTPut:MTONe:STARt***)
- Query the measurement result with ***MEASurement[1¦2]:SELectiverss? <Binstart> <Binstop>***, where the values of **<*binstart*>** and **<*binstop*>** that define the frequency band of interest, must be selected by the user (p. ***149***).

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Phase

The *phase* measurement results reflect the *differences of the phase shifts* for the signal bins of a transmitted multitone signal. This measurement requires the transmission of a stereo signal with at least one identical signal bin on both channels.

- ***MEASurement:PHASe:UNIT [RAD¦DEG]*** defines the unit, in which the result is expressed.
- ***MEASurement:PHASe:SCALe <Scale>*** defines the scaling of the reasult.
- ***MEASurement[1¦2]:PHASe?*** queries the phase results after a multitone signal transmission.

RT-2M only calculates the phases φ_i of those signal bins *i* that are identical on both channels of the received multitone signal, according to

$$\varphi_i = \varphi\left(U_i^{Left}\right) - \varphi\left(U_i^{Right}\right)$$

Equation 12 Phase Calculation

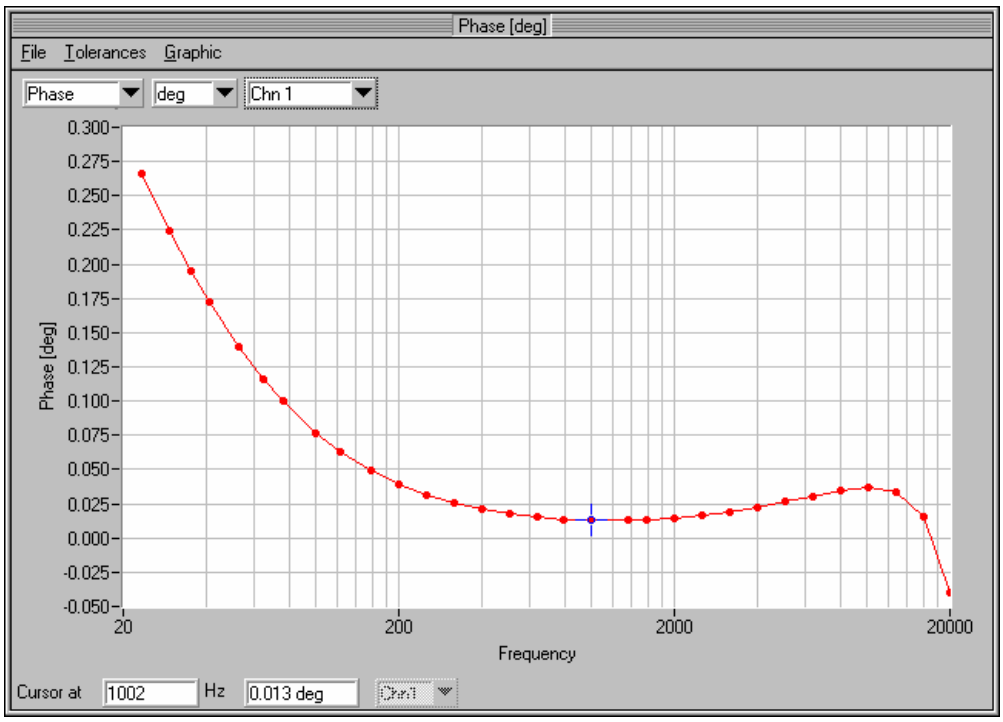


Fig 30 Phase Plot (RT-EVAL Screenshot)

The phase function can be used for two applications:

1. To measure the *phase difference* between the two channels of a multitone signal that has been transmitted e.g. through a stereo device or through two devices. For this application, both channels of *RT-2M* must be fed through the DUT(s).
2. To measure the *absolute phase shift* of a single-channel device. For this application, the output & input of one *RT-2M* channel must be connected directly (e.g. by using the command ***INPut[1¦2]:LINK ON***), whereby the alternate channel is fed through the DUT. Keep in mind that this measurement is restricted to a maximum of 360° degrees (2π)

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RSS Selective Level

RT-2M allows measuring the total received energy (level + total distortion + noise) in a user-defined band (***Equation 5***, p. ***136***).

- ***MEASurement[1¦2]:SELectiverss:UNIT [DBV¦V¦DBSPL¦DBPA¦DBM]*** defines the unit, in which the result is expressed.
- ***MEASurement[1¦2]:SELectiverss?*** <***Binstart***> <***Binstop***> queries the total energy in the band between <***binstart***> and <***binstop***>. The two borders can be set freely and do not have to be identical to the signal bins of the transmitted multitone signal.

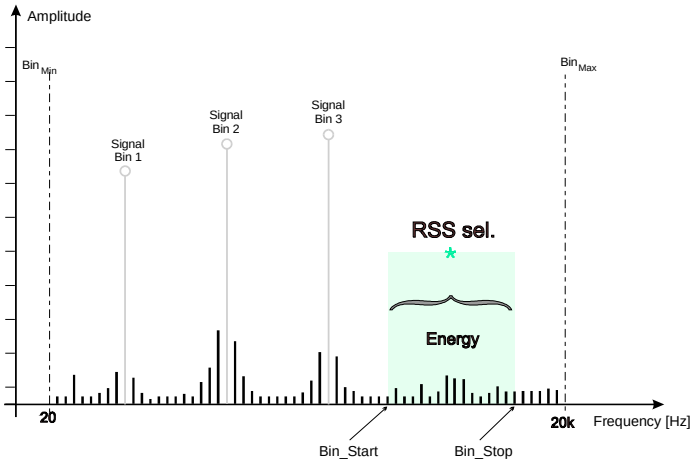


Fig 31 RSS Selective Measurement

NOTE **The RSS selective measurement queries the total energy that was received in the specified band, i.e. *level + distortion + noise*.**

The RSS selective analysis can also be executed on an *externally* generated signal. Thus, it becomes possible to measure specific signal components of any received signal.

Sound Pressure Level (SPL)

Proceed as follows to measure the sound pressure level in dB_{SPL}:

- Connect a microphone to the *RT-2M* input and activate the internal microphone power supply if required (***INPut[1¦2]:IMPedance PHANTOM***). Make sure that *RT-2M* is switched to the correct Phantom power (15 V or 48 V).
- Enter the microphone sensitivity, expressed in [mV/Pa] with ***INPut[1¦2]:MICSensitivity*** <***Sensitivity***>
- ***MEASurement[1¦2]:SELectiverss:UNIT DBSPL*** selects the unit [dB_{SPL}] for the SPL query.
- ***MEASurement[1¦2]:SELectiverss?*** <***binstart***> <***binstop***> queries the sound pressure level after the data acquisition. Normally, the band between <***binstart***> and <***binstop***> covers the frequency range from 20 Hz – 20 kHz. However, this range can also be limited to a narrower band, e.g. if the sound to be measured has a predictable, fixed frequency.

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Multitone Pretrigger

Some devices (e.g. amplifiers with automated gain control, AGC) require a certain time to stabilize themselves to an incoming signal. This settling process can affect the RT-2M trigger in a way that the analyzing unit cannot recognize the trigger any more.

To overcome this effect, RT-2M allows inserting a neutral *pretrigger* signal in front of the proprietary trigger. Use the command ***OUTPut:MTONe:PRETriggerlength*** <***Length***> to let the DUT stabilize.

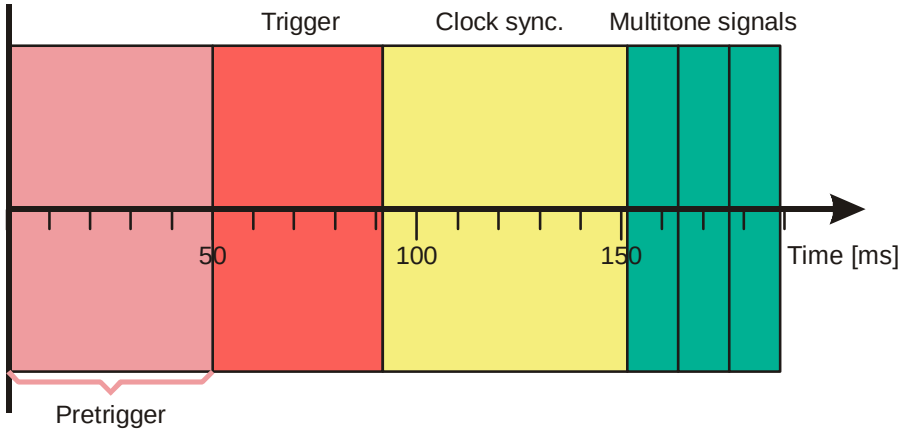


Fig 32 Pretrigger (example)

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Multitone (Signal) Bins

The frequencies that are available for the multitone signal definition are called *bins*. For a better understanding, three types of bins are differentiated.

- *Signal bins* are those bins (frequencies) that are actually selected by the user to build the multitone signal.
- *Even bins* are the bins (frequencies) that emerge from ***Equation 2*** (p. ***132***), i.e. the frequencies that can be used as signal bins in a multitone signal.
- *Odd bins* are an effect of the internal FFT computation of ***RT-2M***. They represent all bins halfway between the even bins, i.e. as if the frequency spacing would be Δf/2.

NOTE **The *RT-2M* analyzer always samples 2 signal bocks, i.e. it operates at twice the blocklength of the defined multitone signal.**
Thus, the frequency resolution of the *RT-2M* analyzer is *Δf/2*.

Example

Given Blocklength = 512

⇒ Generator Δf = 93.75 Hz, i.e. available frequencies = *n* * 93.75 Hz (*n* = integer)

⇒ Analyzer frequency resolution = Δf/2 = 46.88 Hz

Number of Signal Bins

The maximum allowed number of signal bins (i.e. frequencies) in a ***RT-2M*** multitone signal is 31. All bins that are between $\boldsymbol{Bin_{Min}}$ and $\boldsymbol{Bin_{Max}}$ (***Equation 14*** and ***Equation 15***) can be made a signal bin. The distribution of the signal bins in a multitone signal is up to the user.

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Multitone Signal Bin Number

For the definition of a multitone signal it is necessary to convert the required frequencies to the corresponding signal bin numbers as shown in ***Equation 13***:

$$SignalBin_n = Round\left(\frac{f_n}{\Delta f}\right)$$

Equation 13 Calculation of Signal Bin Numbers

whereby f_n = required frequency
Δf = frequency spacing (***Equation 2***, p. ***132***)

Example

Required Multitone signal with three signal bins f_n = 300 Hz, 1 kHz, 3 kHz

Given blocklength = 1024 ($\Rightarrow \Delta f$ = 46.875 Hz)

Calculation $Bin_n = Round\left(\frac{f_n}{\Delta f}\right) = \frac{f_n[Hz]}{46.875[Hz]}$ $\Rightarrow$ Signal bin numbers: 6, 21, 64

Bin_{Min} and Bin_{Max}

The minimum and the maximum available frequencies (Bin_{Min} and Bin_{Max}) of RT-2M are given by following formulas:

$$f_{Bin_Min} \geq 20\ [Hz] \quad \text{thus} \quad Bin_{Min} = ceil\left(\frac{Blocklength}{48000} * 20[Hz]\right)$$

Equation 14 Bin_{min}: Minimum Signal Bin Frequency [2]

$$f_{Bin_Max} \leq 20\ kHz \quad \text{thus} \quad Bin_{Max} = floor\left(\frac{Blocklength}{48000} * f_{\max}[Hz]\right)$$

Equation 15 Bin_{max}: Maximum Signal Bin Frequencies [3]

[2] "*ceil*()" = round to the next higher integer
[3] "*floor* ()" = round to the next lower integer

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Multitone Signal Definition

RT-2M can store 4 user-defined multitone signals in its non-volatile memory. Each signal comprises a fully independent signal bin (frequencies) definition for both channels, whereby a maximum of 31 signal bins can be defined per channel.

OUTPut:MTONe:PARameter ... (p. ***39***) defines a new multitone signal. This command comprises of the following information:

- *Memory location* of the signal: 1 to 4.
- *Name* of the signal, i.e. a user-defined ASCII string with up to 8 characters.
- *Blocklength* (number of samples). Available values are shown in ***Table 12*** (p. ***156***).
- *Number of signal* bins for channel *1* defines the number of frequencies that build the multitone signal of channel 1; the minimum is 1, the maximum is 31.
- *Number of signal* bins for channel *2* defines the number of frequencies that build the multitone signal of channel 2; the minimum is 1, the maximum is 31.
- *Signal bin numbers* of channel *1* (to be calculated according to the equation below).
- *Signal bin numbers* of channel *2* (to be calculated according to the equation below).
- *Phases* of the signal bins for channel *1*
- *Phases* of the signal bins for channel *2*

Example

Required Multitone signal parameters

Given
Memory location #3
Signal name: 'Test'
blocklength = 1024
3 signal bins on channel 1: No. 6, 21, 64
5 signal bins on channel 2: No. 3, 12, 36, 48, 72
Signal bin phases of chn. 1: $-\pi$, 1.234, $^1/_{\sqrt{2}}$
Signal bin phases of chn. 2: 0, 2.456, 0.819, 1.414, 0.111

Result

```
OUTP:MTON:PAR 3,"Test",1024,3,5,6,21,64,3,12,36,,48,72,
-3.141,1.234,0.707,0,2.456,0.819,1.414,0.111
```

HINT *Optimize the signal bin phases with the Crest factor optimizer of RT-EVAL.*

NOTE **The multitone burst can be prolonged artificially with a pretrigger or the repeated transmission of the multitone signal (p. *136*).**

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Multitone Signal Duration

The duration of the *multitone signal* depends on the current blocklength and sampling rate:

$$t_{MT}[\text{sec}] = \frac{blocklength}{48000}$$

Equation 16 Multitone Signal Duration

However, as shown in chapter ***Multitone Burst Structure*** (p. ***130***) every *RT-2M* multitone burst comprises of several multitone signal blocks. Consequently, the actual multitone *burst* duration will always be longer than the multitone signal duration (***Table 12***, p. ***156***)).

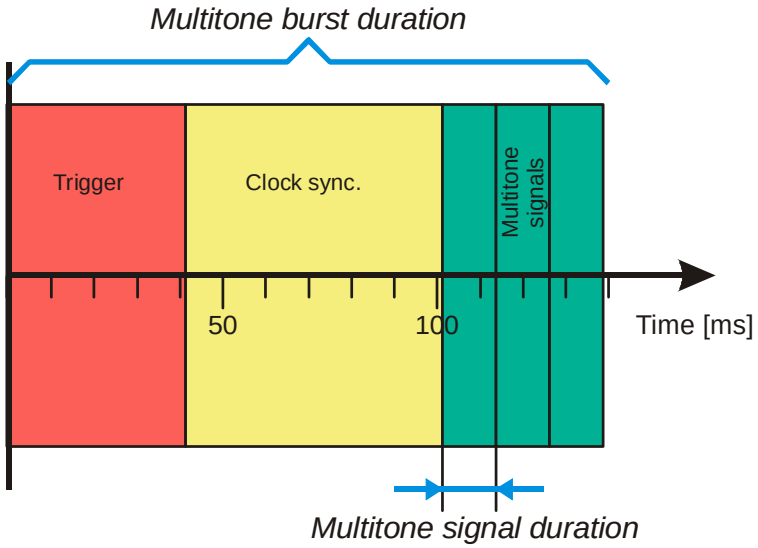


Fig 33 Multitone Signal Duration vs. Burst Duration

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Multitone Signal Recording Duration

The signal acquisition time of *RT-2M* depends on the selected trigger mode and of the blocklength of the active multitone signal.

In the ***INTernal***, ***INTNoheader***, ***EXTernal*** and ***EXTNoheader*** trigger mode, the sampling time of the *RT-2M* analyzer is optimized to the transmitted multitone signal.

In the ***THReshold*** triggering mode, the signal acquisition time t_{Acq} is given by:

$$t_{Acq}[s] = \frac{Blocklength}{48000} * 2$$

Equation 17 Acquisition Duration

Consequently, if an externally generated signal shall be analyzed by *RT-2M*, it must have a minimum duration of:

$$t_{ExtMin} = t_{Delay} + t_{Acq}$$

Equation 18 Minimum Signal Duration for External Signal Analysis

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Multitone Signal Table

The following table provides an overview on the most important multitone signal parameters:

- Blocklength
- Multitone signal duration
- Frequency resolution (spacing)
- Bin_{Min} and Bin_{Max}

Generator Blocklength	*Analyzer Blocklength*	*Min. Burst Duration (w/o Header)*	*Typical Burst Duration*	*Frequency Resolution Δf*	*Analyzer Resolution Δf/2*	*Bin_Min / f_{min}*	*Bin_Max / f_{max}*
512	1024	**154 ms**	260 ms	**93.75 Hz**	46.88 Hz	**1 / 93.8 Hz**	**213 / 19.97 kHz**
1024	2048	**284 ms**	390 ms	**46.88 Hz**	23.44 Hz	**1 / 46.9 Hz**	**426 / 19.97 kHz**
2048	4096	**344 ms**	450 ms	**23.44 Hz**	11.72 Hz	**1 / 23.4 Hz**	**853 / 19.99 kHz**
4096	8192	**684 ms**	790 ms	**11.72 Hz**	5.86 Hz	**2 / 23.4 Hz**	**1706 / 19.99 kHz**
8192	16384	**854 ms**	960 ms	**5.86 Hz**	2.93 Hz	**4 / 23.4 Hz**	**3413 / 19.99 kHz**

Table 12 Blocklength and Multitone Burst Characteristics

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Normal Mode

In the *Normal mode*, ***RT-2M*** supports multitone and stepped sweep testing.

NOTE **Some commands are not available if the analyzer has been armed, i.e. after the command *INPut:TRIGger:ARMed*.**

- Connect the unit to the DUT as shown in ***Fig 34***.

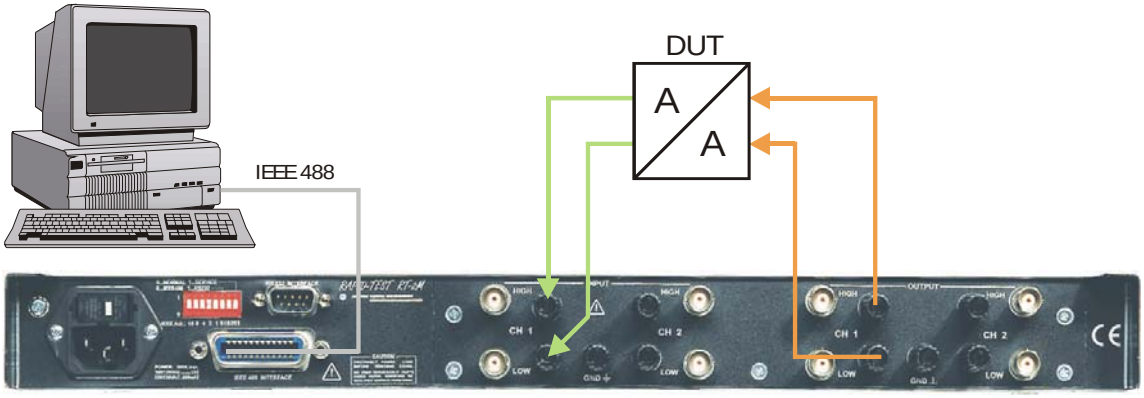


Fig 34 Normal Mode

- Activate one of the multitone signals that are stored in the internal memory with command ***OUTPut:MTONe:ACTive [1¦2¦3¦4]***.
- Select the appropriate trigger mode (chapter ***Triggering & Signal Acquisition***).
- Adjust the ***RT-2M*** output level (p. ***158f***) and the input range (p. ***125***).
- Transmit the multitone signal or the stepped sweep (commands ***OUTPut:MTONe:STARt***, ***OUTPut:STEPpedsweep:STARt***).
- Query the required measurement results.

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Output Level

The user must define the output level – i.e. the amplitude – of the test signal (e.g. multitone burst, stepped sweep or chirp) before the unit generates the signal. *RT-2M* offers three alternatives to set this value:

- The *MT Level* defines the amplitude of the active multitone signal.
- The *BinLevel* defines the reference amplitude for the signal bins of the active multitone signal.
- The *SineLevel* defines the reference amplitude for the stepped or gliding sweep ('chirp').

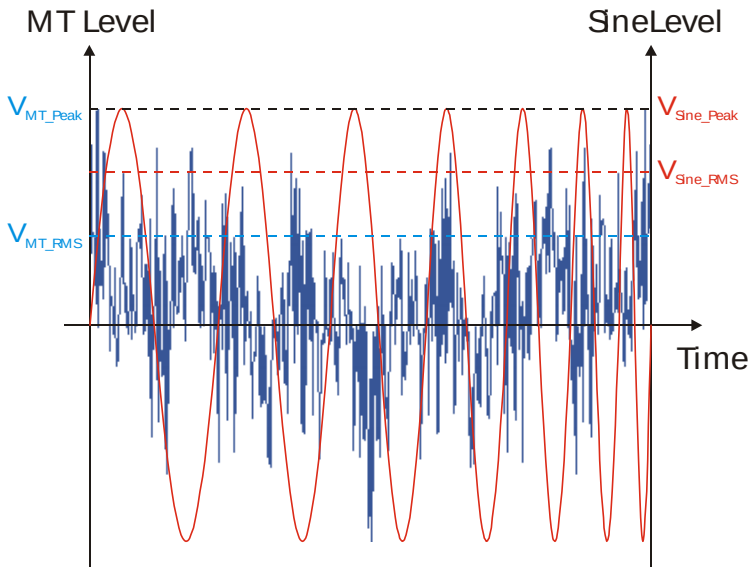


Fig 35 MT Level vs. SineLevel

Fig 35 shows the time plot of a multitone & sweep signal and visualizes their Peak & RMS levels. The mathematical correlation between V_{MT_Peak} and V_{MT_RMS} as well as V_{Sine_Peak} and V_{Sine_RMS} is given by following formulas:

$$V_{MT_RMS} = \frac{V_{MT_Peak}}{C_f}$$

$$V_{Sine_RMS} = \frac{V_{Sine_Peak}}{\sqrt{2}}$$

Equation 19 MT Level and SineLevel

In the case of $V_{MT_Peak} = V_{Sine_Peak}$, a direct correlation between V_{MT_RMS} and V_{Sine_RMS} can be established:

$$V_{MT_RMS} = V_{Sine_RMS} \frac{\sqrt{2}}{C_f}$$

Equation 20 MT Level vs. SineLevel

NOTE **It is possible to apply a custom-defined *weighting* or *amplitude shape* to multitone signal or stepped sweep respectively.**

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MT Level

Define the *MT Level* with command ***OUTPut[1¦2]:LEVel <Level> [V¦VP¦DBV¦DBVP¦DBM]***. Note that it can be expressed as *peak* or as *RMS* level in *linear* or *logarithmic* units.
In practice, the use of a peak unit is advantageous for those setups where the dynamic range of the DUT & transmission line is known.

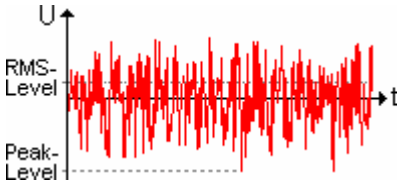


Fig 36 Overall Output Level

Binlevel

The *BinLevel* reflects the amplitue of the signal bins in a multitone signal. By default, all signal bins of a multitone signal have identical BinLevels that can be defined by ***OUTPut[1¦2]:BINlevel <BinLevel> …***.

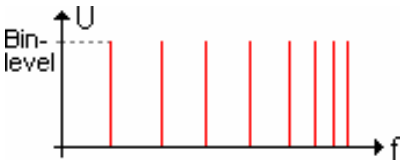


Fig 37 Binlevel

NOTE **When adjusting the BinLevel of a multitone burst, keep in mind that its overall output level will be higher by $\sqrt{n}$. Therefore, never set the BinLevel to a value that corresponds to the full dynamic range of your DUT.**

SineLevel

OUTPut[1¦2]:SINelevel <SineLevel> [DBVP¦VP¦DBV¦V¦DBM] defines the *SineLevel*, i.e. the RMS level of a generated sine signal. This command is normally used to adjust the output level of a stepped sweep, chirp, arbitrary sine signal or a multitone signal with only one signal bin.

If the command is applied on a multitone burst with several signal bins, <***SineLevel***> defines the multitone level that is equivalent to the level of a sine signal.

Please refer to ***Fig 35*** (p. ***158***) to understand how the MT Level and the SineLevel relate to each other, depending on the selected level unit (Peak or RMS).

Correlation Formulas

Following formulas summarize the correlation between the MT Level (U_{MT_Level}), Binlevel ($U_{BinLevel}$) and SineLevel ($U_{SineLevel}$).

$$U_{MT_Level}\ [Vp] = U_{SineLevel}\ [Vp] = U_{MT_Level}\ [V] * Cf = U_{SineLevel}\ [V] * \sqrt{2}$$

$$U_{BinLevel}\ [V] = (U_{MT_Level}\ [V])\ \sqrt{n}$$

Equation 21 Output Level Correlations

whereby *Cf* = Crest factor
n = number of signal bins

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Multitone Binlevel Weighting (Individual Binlevel)

RT-2M allows weighting the BinLevels of the signal bins. In other words, the operator can individually attenuate the signal bin levels of a multitone signal.

This feature is used to compensate for the frequency response of a test setup, e.g. of a reference speaker. Thus, it becomes possible to stimulate the DUT with a constant level at every signal bin.

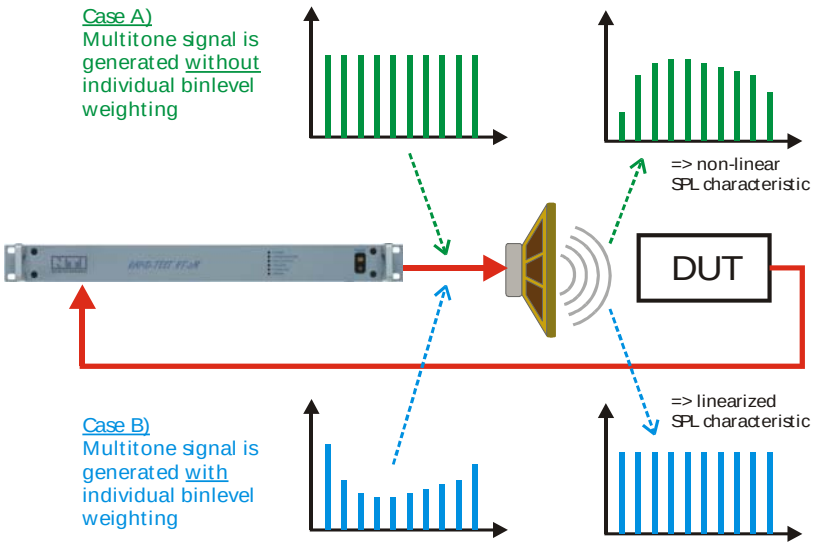


Fig 38 Multitone Binlevel Weighting Example

- Insert "WTD" to ***OUTPut:MTONe:PARameter*** ***<SigNo>,<SigName>,<Blocklength>,WTD,…*** and append the individual attenuation factors to introduce an individual BinLevel weighting to the active multitone signal (p. ***41***).
- Alternatively, use command ***OUTPut[1¦2]:MTONe:EQUalize*** to let RT-2M automatically apply a BinLevel weighting that compensates for the frequency response of the DUT.
- Clear the individial BinLevel weighting with command ***OUTPut:MTONe:CLEarweightings***.

NOTE **At least one signal bin must be left unweighted, i.e. with an attenuation of 0 dB. The BinLevel of this signal bin is the reference for the output level (defined by command *OUTPut[1¦2]:SINelevel* … or *OUTP[1¦2]ut:BINlevel* …), whereby the attenuation of the weighted signal bins are referred to the unweighted signal bin(s).**

Example

Given A multitone signal with three signal bins (#3, #11, #32 @ f_s = 48 kHz, blocklength = 512, i.e. frequencies 281.25 Hz, 1031.25 Hz and 3 kHz) has to be transmitted through a reference speaker. A level measurement shows that the speaker attenuates the signal with –6 dB @ 281 Hz and with –3 dB @ 3 kHz (level result e.g.: `3/0.4000E+01 dBV,11/0.7000E+01 dBV,32/1.0000E+01 dBV`)

Required The signal bin levels of the multitone signal shall be equalized in a way that the speaker generates a constant sound pressure vs. frequency.

⇒ The BinLevels of the multitone signal have to be weighted on channel 1 with +6 dB @ #3 and with +3 dB @ #32. The BinLevel of #11 (i.e. 1 kHz) of channel 1 as well as all BinLevels of channel 2 are not weighted.
The string below shows the RT-2M command that defines such a multitone signal with an individual BinLevel weighting on channel 1:

Result

```
OUTPUT:MTONE:PAR 4,"3tone",512,WTD,3,3,3,11,32,3,11,32,
-0.35254506, 2.43579567,2.64434581,-0.35254506,2.43579567,
2.64434581,3.00000,0.00000,6.00000,0.00000,0.00000,0.00000
```


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Stepped Sweep Amplitude Shaping

RT-2M allows shaping the output level vs. frequency of a stepped sweep. In other words, the operator can individually attenuate every level of a stepped sweep.

This feature is used to compensate for the frequency response of a test setup, e.g. of a reference speaker. Thus, it becomes possible to stimulate the DUT with a constant level at every frequency.

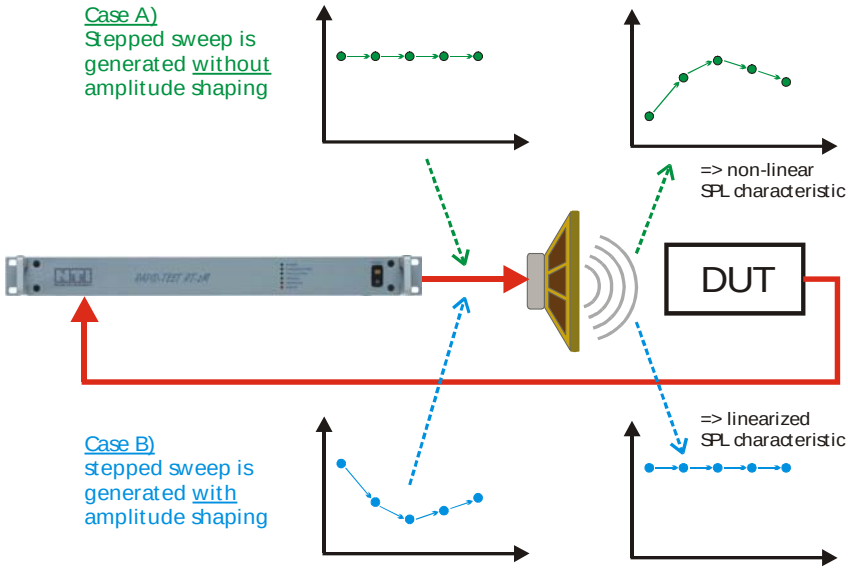


Fig 39 Stepped Sweep Amplitude Shaping Example

OUTPut:STEPpedsweep:AMPLitudeshape:SET ***<Shape1>,<Shape2>,…,<Shape#Steps+1>*** defines the individual shapes of the stepped sweep levels as attenuation factors, expressed in [dB].

NOTE **At least one frequency must not be attenuated (i.e. <$Shape_x$> =0). This frequency is the reference for the output level definition.**

Example

Given A stepped sweep with four frequencies (f_{Start} = 20 Hz, f_{Stop} = 20 kHz ⇒ f_1 = 20 Hz, f_2 = 200 Hz, f_3 = 2 kHz, f_4 = 20 kHz) has to be transmitted through a reference speaker. A level measurement shows following results: –1.5 dBV @ 20 Hz, –1.0 dBV @ 200 Hz, 0 dBV @ 2 kHz and –0.5 dBV @ 20 kHz (returned result vector: `2.00000E+01/-1.51249E+00 dBV,2.00000E+02/-0.97894E+00 dBV, 2.00000E+03/+0.13587E-01 dBV,2.00000E+04/-0.49761E+00 dBV`).

Required The stepped sweep shall be equalized in a way that the speaker has a constant sound pressure level vs. frequency.

⇒ The levels of the stepped sweep have to be attenuated with 0 dB @ 20 Hz (reference level), –0.5 dB @ 200 Hz, –1.5 dB @ 2 kHz and –1.0 dB @ 20 kHz.
The string below shows the *RT-2M* command that defines the attenuation on chn. 1 of the stepped sweep:

Result `OUTPUT:STEPPEDSWEEP:AMPLITUDESHAPE:SET 0,-0.5,-1.5,-1`

NOTE **The <$Shape_n$> values refer to the reference (i.e. not attenuated) level. The output level of this reference frequency is defined by the command *OUTPut[1¦2]:SINelevel <SineLevel> [DBVP¦VP¦DBV¦V¦DBM].***

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Output Level Query

Use the following commands to query the current output level:

- ***OUTPut[1¦2]:LEVel? [V¦VP¦DBV¦DBVP¦DBM*** for the *MT Level*.
- ***OUTPut[1¦2]:BINlevel? [V¦VP¦DBV¦DBVP¦DBM]*** for the *BinLevel*.
- ***OUTPut[1¦2]:SINelevel? [V¦VP¦DBV¦DBVP¦DBM]*** for the *SineLevel*.
- ***OUTPut:MTONe:PARameter?*** returns the attenuation factors of the weighted multitone signal bins, referred to the unweighted reference signal bin.
- ***OUTPut:STEPpedsweep:AMPLitudeshape:SET?*** returns the attenuation factors of the shaped stepped sweep levels, referred to the reference frequency.

These commands can be used regardless whether the output level has been defined as *MT Level* , as *BinLevel* or a s *SineLevel*.

Obviously, the commands allow expressing the current output level in another unit. For instance, if the MT Level of a multitone signal has been defined in dBV, the amplitude of the signal bins can be queried in dBm etc.

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PureSound™ Chirp (Gliding Sweep) Parameters

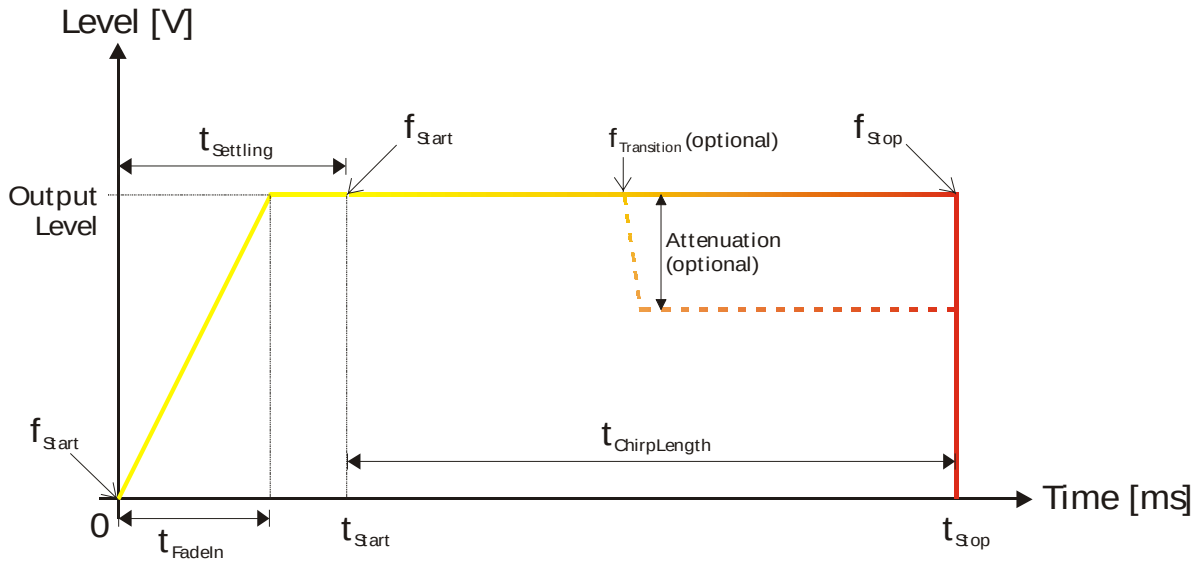


Fig 40 Chirp Parameters

Fig 40 visualizes the parameters that define the chirp for a Rub & Buzz test.

- ***INOUT:PUResound:MODE RNB*** switches the unit to the PureSound™ Rub & Buzz mode.
- ***OUTPut:PUResound:CHIRp:FSTArt*** <***Frequency***> and ***OUTPut:PUResound:CHIRp:FSTOp*** <***Frequency***> define the start and stop frequencies f_{Start}, , f_{Stop} of the chirp. The start frequency can be lower or higher than the stop frequency (e.g. 20 Hz → 800 Hz or 800 Hz → 20 Hz).

NOTE **The generated chirp level is attenuated in the range 5 – 20 Hz as follows: 0 dB @ 20 Hz → –0.6 dB @ 10 Hz → –1.3 dB @ 5 Hz.**

- ***OUTPut:PUResound:CHIRp:SETTling*** <***Duration***> defines the *settling* time, i.e. the time during which *RT-2M* generates a sine signal with constant frequency f_{Start} before it starts transmitting the chirp. This allows the DUT settling to the test signal.
- ***OUTPut:PUResound:CHIRp:FADEin*** <***Duration***> defines the *fade in* time, i.e. the time during which the *RT-2M* output voltage is raised continuously from 0 V to the user-defined output level (refer to the commands ***OUTPut[1¦2]:LEVel …***, ***OUTPut[1¦2]:BINlevel …*** and ***OUTPut[1¦2]:SINelevel …***). A fade-in can be required to reduce initial transients. Normally, t_{FadeIn} is below or equal to $t_{Settling}$.
- ***OUTPut:PUResound:CHIRp:LENGth*** <***Duration***> defines the *chirp length*. This represents the duration of the core sweep, i.e. the time from t_{Start} to t_{Stop}. Consequently, the overall chirp duration $t_{Total} = t_{Settling} + t_{ChirpLength}$.
- ***OUTPut:PUResound:CHIRp:AMPLitudeshape*** <***Frequency***>,<***Attenuation***> allows damping the chirp level above an user-defined transition frequency. This optional feature is intended for woofer tests, where the operator must be protected from very loud sound levels at higher frequencies (e.g. > 100 Hz). However, please note that certain Rub & Buzz effects might disappear if the chirp level is not high enough.

Please refer to chapter ***PureSound™ Steepness Measurement*** (p.***169***) for further details about the analysis of the transmitted chirp.

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PureSound™ Correlation Analysis

The detailed analysis and verification of sound samples is one of the most demanding QC requirements in the industry. So far, there was no reliable test available for the

- Ringer melodies of mobile phones
- Music signals of MP3 players or other audio devices
- Speech signals of voice synthesizers etc.

The sound correlation analysis of *RT-2M* provides a 100% reliable solution for this task. It compares a reference signal ("golden sample") against the test signal and determines the similarity between these two signals.

Fig 41 gives an example of a good and a corrupted sample of the same signal. First, the signal of the good sample is recorded by *RT-2M* and stored in the internal memory as reference signal. Next, the signal is replayed by the device that has to be tested, whereby *RT-2M* compares the signal against the stored reference and provides three results:

- The *sound correlation* represents the similarity of the test signal versus the stored reference signal. The result is expressed in percent, ranging from 0 % (no correlation) to 100 % (signals are identical).
- The *level correction* indicates how much the test signal and the reference signal differ in RMS level. The result is expressed in %.
- The *RMS level* of the recorded sound sequence, expressed in dBV, V, dBSPL, dBPA or dBm.

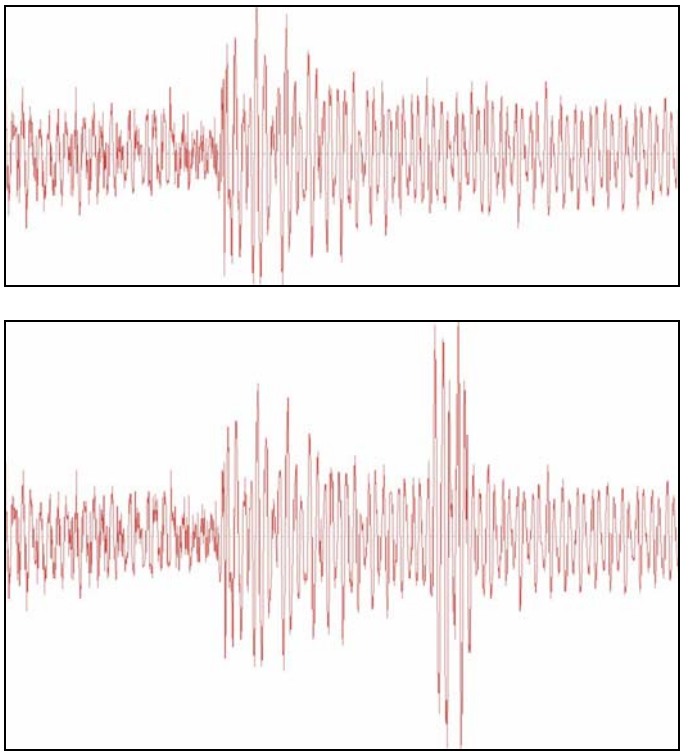


Fig 41 Sound Sequence, Correct and Corrupted

Fig 42 shows a sound correlation test setup. The sound sequence can be fed electrically or by an acoustical coupling to *RT-2M*.

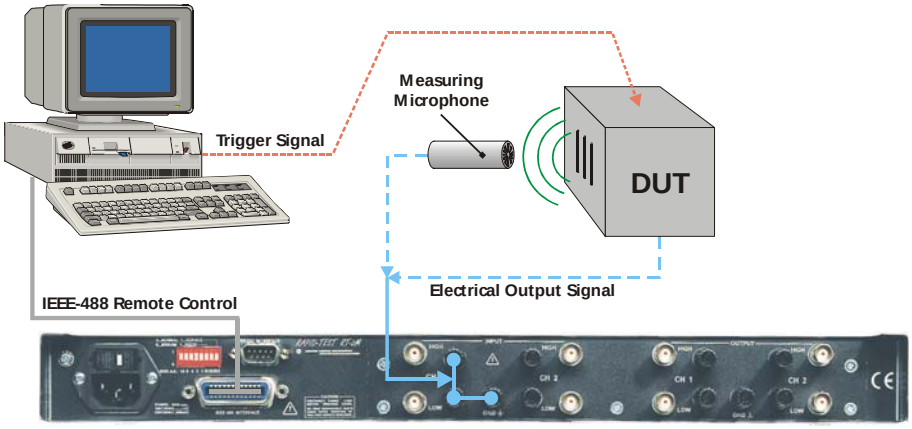


Fig 42 Sound Correlation Test Setup

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Reference Signal Acquisition

1. Define the active memory location (A or B) for the reference signal with the command ***MEASurement:PUResound:STEepness:REFerence:ACTive [A¦B]***.
2. Assign a user-defined name to the active reference signal (memory A or B) with the command ***MEASurement:PUResound:STEepness:REFerence:NAME*** <***RefName***>.
3. Define the period length, during which the analyzer has to sample the incoming signal after triggering with the command ***MEASurement:PUResound:LENGth*** <***Duration***>.
4. Transmit the signal from a golden sample and save it in the active *RT-2M* memory as the reference signal ***MEASurement:PUResound:STEepness:REFerence:USELastmeas***.
5. Optionally, you can transfer the recorded data of the active reference signal to the PC with command ***MEASurement:PUResound:STEepness:REFerence:GET?*** and back to *RT-2M* with command ***MEASurement:PUResound:STEepness:REFerence:SET …***.

Test Signal Analysis

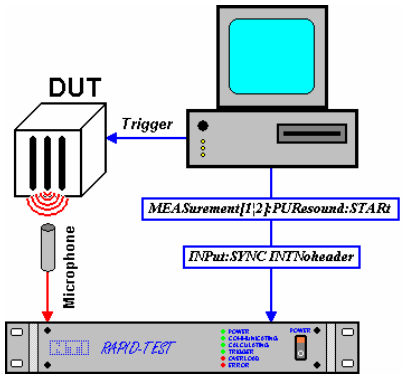
1. Select the reference signal with ***MEASurement:PUResound:STEepness:REFerence:ACTive [A¦B]*** (possibly, you first have to record the reference signal or transfer a previously stored reference signal from the PC to *RT-2M* as described above).
2. Transmit the test signal and make sure that the analyzer triggers & samples it correctly.
3. Query the *sound correlation* with ***MEASurement:PUResound:STEepness:CORRelation?***. The returned result indicates the trigger delay between the reference sequence and the sample, followed by the sound correlation result (0 to 100 %).
4. Query the *level correction* with ***MEASurement:PUResound:STEepness:LEVelcorrection?***. The returned data reflect the signal duration and the level correction result.
5. Query the RMS level of the test signal (***MEASurement:PUResound:STEepness:RMSLevel?***).

Triggering & Signal Acquisition

Case a) The PC triggers the DUT

The PC triggers the DUT to generate the sound sequence and simultaneously forces *RT-2M* to start the data acquisition.

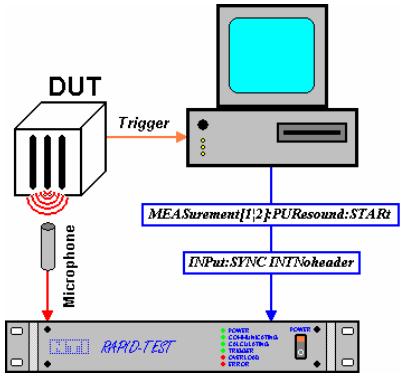
- Use the trigger mode ***INPut:SYNC INTNoheader***.
- Let the PC trigger the DUT to generate the sound sequence
- Simultaneously, start the signal acquisition with the command ***MEASurement[1¦2]:PUResound:STARt***.



Case b) The DUT triggers the PC

The DUT triggers the PC exactly at the time when it generates the sound sequence ⇒ the PC in return triggers *RT-2M* to start the data acquisition

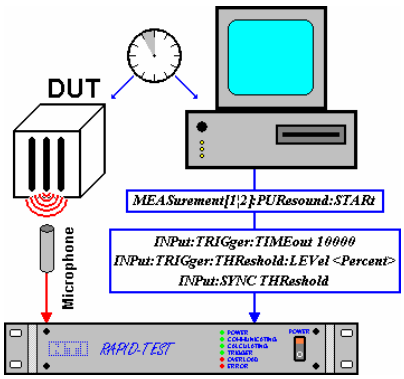
- Use the trigger mode ***INPut:SYNC INTNoheader***.
- As soon as the PC receives the trigger signal from the DUT, it has to start the signal acquisition with the command ***MEASurement[1¦2]:PUResound:STARt***.



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Case c) The DUT generates the sound at a predictable time

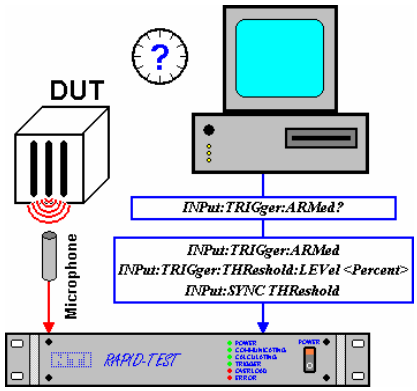
The DUT generates the sequence at a known time but with an uncertainty of few seconds ⇒ the PC triggers the *RT-2M* slightly in advance for the incoming sound sequence.



- Use the trigger mode ***INPut:SYNC THReshold*** (p. ***194***).
- Define an appropriate threshold level with command ***INPut:TRIGger:THReshold:LEVel <ThreshLevel>***.
- Set the trigger timeout to 10 seconds with command ***INPut:TRIGger:TIMEout 10000***.
- Prepare the *RT-2M* analyzer for the incoming signal with ***MEASurement[1|2]:PUResound:STARt*** few seconds before the signal comes in.

Case d) The DUT generates the sound at an unpredictable time

The time of the incoming signal is not known ⇒ *RT-2M* has to be armed in advance to wait for the incoming sound sequence.



- Use the trigger mode ***INPut:SYNC THReshold*** (p. ***194***).
- Define an appropriate threshold level with command ***INPut:TRIGger:THReshold:LEVel <ThreshLevel>***.
- Arm the analyzer (***INPut[1|2]:TRIGger:ARMed***, p. ***187***).
- Repeatedly query the *RT-2M* analyzer status with ***INPut:TRIGger:ARMed?***. As soon as the unit has triggered, it returns the string `"STOPPED"`, thus indicating that the sound correlation results can be queried by the PC.
- Re-arm the analyzer and repeat the status query for the next incoming sequence.

Sound Correlation Example

Fig 43 (p. ***167***) visualizes the different parameters and measurement results of a sound correlation analysis. Thus, it helps understanding the backgrounds and applying this feature properly.

HINT *The two sequences in the example are identical, except of their RMS level. Apart from that, the RT-2M analyzer has triggered to different peaks of the sequence.*

To simplify the understanding of the returned results, the two sequences have been placed in a way that the trigger event is located at the same point on the time-axis.

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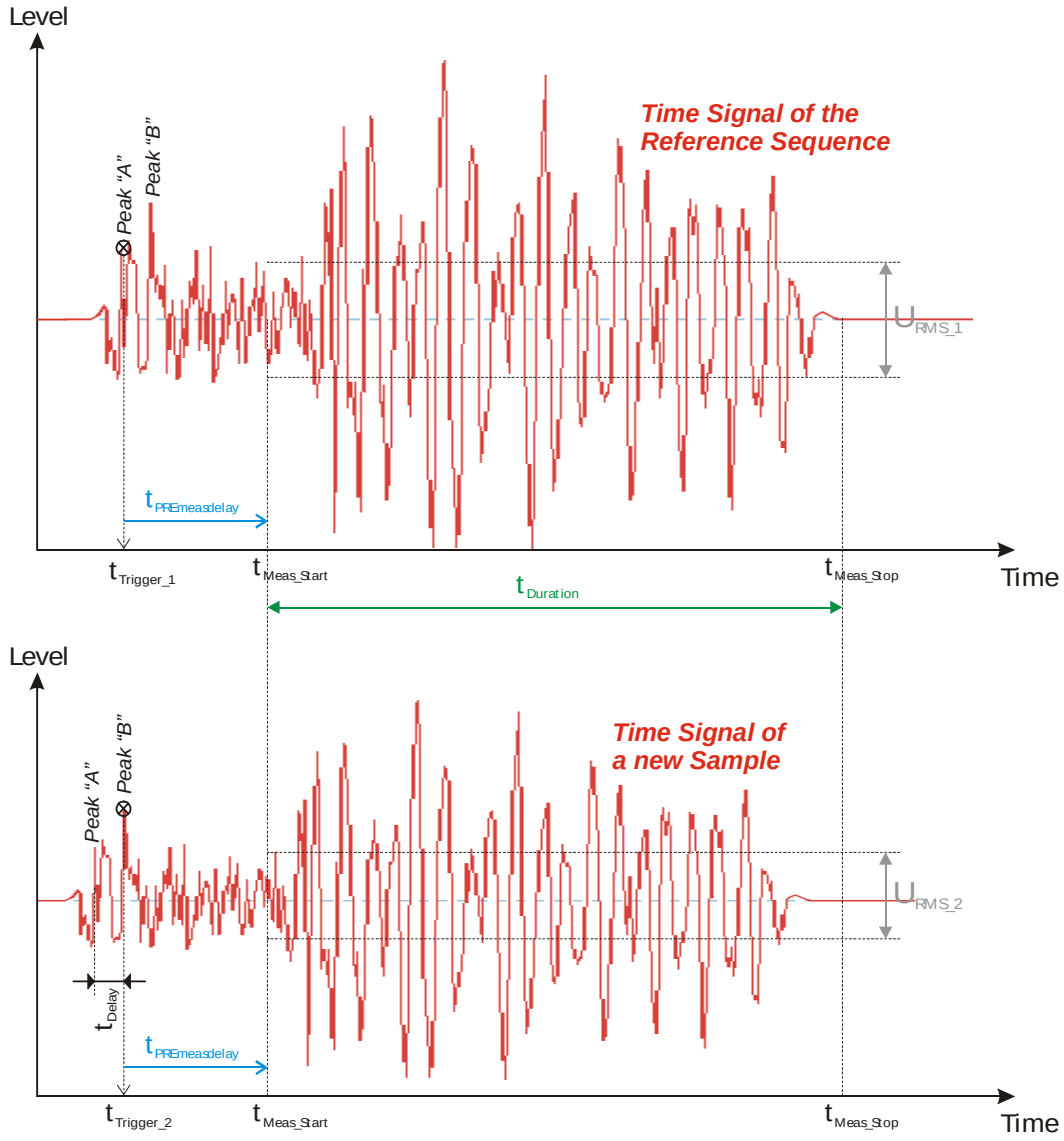


Fig 43 Sound Correlation Parameters

• $t_{Trigger_1}$ and $t_{Trigger_2}$ indicate the times when the analyzer has triggered to the incoming signal. In the example, this has happened at peak "A" of the reference sequence, but at a later point (peak "B") of the sample.
• t_{Delay} is the time difference between the trigger points of the reference sequence and the sample (peak "A" – "B"). *RT-2M* automatically recognizes & compensates this delay.
• $t_{PREmeasdelay}$ is the user-defined delay from the trigger point to the start of the data acquisition. This delay is only applied in the trigger mode ***THReshold*** (p. ***194***).
• $t_{Duration}$ is the user-defined duration of the signal acquisition. It is applied for the reference sequence and the sample.
• U_{RMS_1} and U_{RMS_2} represent the RMS level of the reference sequence and of the sample. Consequently, the level correction result in % = (U_{RMS_1} / U_{RMS_2}) * 100.

HINT RT-2M automatically compensates for the trigger delay and the level correction. Therefore, in the example, the sound correlation result would be close to 100 %.

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PureSound™ Mode

The PureSound™ option for *RT-2M* is a revolutionary approach for signal analysis in the *time domain*. It is based on the patented algorithm (No. EP 073751 and US 5,884,260) by Frank Leonhard and is best described as the *detection of changes in the instantaneous energy by means of transient analysis*.

NOTE **The PureSound™ option must be enabled with a license code. Please contact your NTI agent for further details.**

The applications of the PureSound™ option can be divided in two groups:

1. *Steepness measurement* of a transmitted chirp (i.e. gliding sweep) or an externally generated signal. The analysis provides an extremely accurate indication of audible defects such as *Rub & Buzz* of electroacoustic transducers.
2. *Sound correlation* analysis, whereby *RT-2M* compares the reference signal of a "golden sample" against the test signal, thus detecting discrepancies. This mode can be used to check for the quality of ringer melodies, music or speech signals etc.

NOTE **The PureSound™ mode allows analyzing internally as well as externally generated test signals.**

Activate the PureSound™ mode with ***INOUT:PUResound:MODE [RNB¦CORRELATION]***. Consequently, *RT-2M* allows executing all Rub & Buzz or sound correlation analysis commands as described in chapters ***PureSound™ Steepness Measurement*** (p. ***169***) and ***PureSound™ Correlation*** (p. ***164***).

HINT *If a test shall comprise of a PureSound™ analysis and of a multitone or stepped sweep measurement these tests have to be executed one after the other (i.e. not in parallel).*

NOTE **In the PureSound™ mode only a restricted number of *RT-2M* measurement functions are available. Please refer to the detailed command descriptions.**

Input Filter Characterstics

The PureSound™ analysis applies six bandpass filters on an incoming signal. These filters represent the psychoacoustic perception of the human hearing system and provide the six result blocks of a Rub & Buzz measurement.

Refer to ***Fig 44*** for the characteristics of the six PureSound™ bandpass filters.

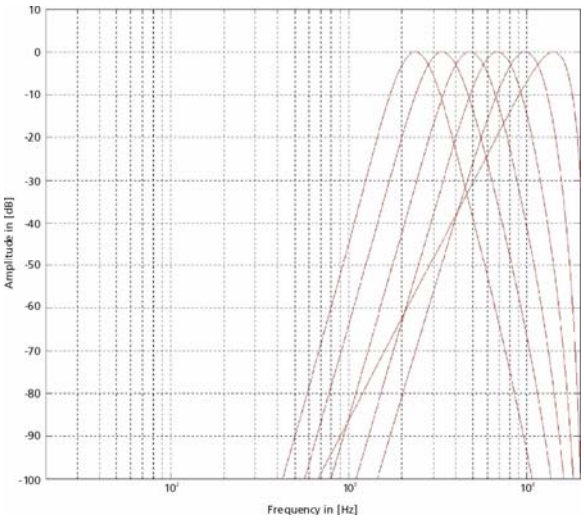


Fig 44 PureSound™ Input Filters

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PureSound™ Steepness Measurement

The PureSound™ steepness measurement allows detecting virtually all kinds of audible defects on the incoming signal. For instance, Rub & Buzz defects that are caused by faulty transducers or other mechanical devices can be detected with 100% reliability (refer to **NTI**'s application notes ***Transients & Steepness Analysis*** and ***PureSound™ for Rub & Buzz Detection***).

Steepness Measurement

- Activate the steepness analysis mode with ***INOUT:PUResound:MODE RNB***.
- Enter the signal duration with command ***MEASurement:PUResound:LENGth*** <***Duration***>. It is recommended to select the same <***Duration***> as of the test signal.
- ***MEASurement:PUResound:STEepness:UNIT [PA|S¦V|S]*** defines the unit, in which the acquired steepness results shall be expressed:
  - *Pa/S* (i.e. Pascal per second) for setups with a microphone with defined sensitivity.
  - *V/S* (i.e. Volt per second) is used for other electrical input signals.
- ***MEASurement:PUResound:NRESults*** <***#Results***> defines the number of returned steepness results (i.e. the resolution of the returned result vector).
- If required, define individual PASS/FAIL limits for the six bands (see next chapter) and activate these limits with ***MEASurement:PUResound:STEepness:VARLimit:ACTive[1¦2¦3¦4¦5¦6]***.
- Activate the noise cancellation if the test is executed in a noisy environment (p. ***171***).
- Use command ***INPut:SYNC …*** to select the trigger mode (p. ***188***): ***INTNoheader*** for the analysis of the *RT-2M* chirp or ***THReshold*** for the acquisition of an externally generated signal.
- Start the signal acquisition with ***OUTPut[1¦2]:PUResound:CHIRp:STARt*** (analysis of *RT-2M* chirp) or ***MEASurement[1¦2]:PUResound:STARt*** (analysis of externally generated signal).
- Query the steepness vaues of a band (***MEASurement:PUResound:STEepness[1¦2¦3¦4¦5¦6]?***) or the PASSED / FAILED result (***MEASurement:PUResound:STEepness:OK?***, see below).

NOTE ***RT-2M* is also able to execute a Rub & Buzz test with an externally generated chirp, supposed that the latter is a linear, gliding frequency sweep with constant amplitude.**

Steepness Limits for PASS/FAIL Test (Rub & Buzz Detection)

The PureSound™ option allows checking steepness results against user-defined PASS/FAIL limits. The individual limits for each of the six bands are stored in the non-volatile *RT-2M* memory. As soon as a steepness measurement is recorded, the unit checks it against the corresponding limits and returns the PASSED / FAILED result upon request.
Define the individual band limits with ***MEASurement:PUResound:STEepness:VARLimit SET [1¦2¦3¦4¦5¦6] <NoOfPoints> [PA|S¦V|S] <X_Interval$_1$>,<X_Interval$_2$>,…,<X_Interval$_{NoOfPoints}$>, <Y_Limit$_1$>,<Y_Limit$_2$>,…,<Y_Limit$_{NoOfPoints}$>***.

- ***[1¦2¦3¦4¦5¦6]*** selects the active band, i.e. the steepness band on which the limits are applied.
- <***NoOfPoints***> defines the number of points that build the limit.
- ***[PA|S¦V|S]*** selects the unit, in which the steepness band limits are expressed (Pascal per second or Volt per second).
- <***X_Interval$_n$***> defines the position of a point on the X-axis (i.e. time axis), relative to the total duration of the signal acquisition (= 100%).
- <***Y_Limit$_n$***> defines the absolute steepness limit for every point, expressed in the active unit. The limits between two neighboured points are interpolated linearly.

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NOTE **The positions of the points are defined relative to the total signal duration. Therefore, if the user enters another duration, the absolute positions of the points change as well.**

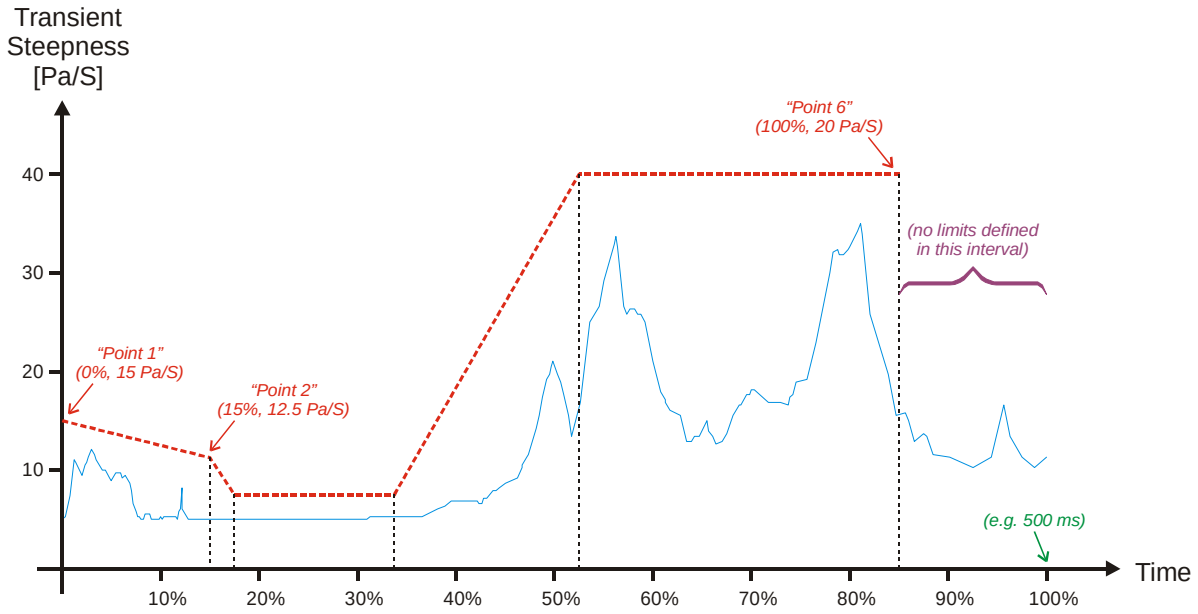


Fig 45 Variable Limits Definition

Fig 45 shows an example of a recorded steepness graph (only one band displayed) with its individual limits.

- <***NoOfPoints***> = 6; therefore, the limits band consists of five intervals.
- The steepness results are expressed in the unit Pa/S.
- The positions of the six points are 0%, 15%, 17.5%, 20%, 33%, 52.5% and 85% of the total signal duration. Under the assumption that the signal duration is 500 ms, these values equal 0 ms, 75 ms, 87.5 ms, 100 ms, 166.7 ms, 262.5 ms and 425 ms.
- The corresponding limits are 15 Pa/S, 12.5 Pa/S, 7.5 Pa/S, 7.5 Pa/S, 40 Pa/s and 40 Pa/S.
- The interval between 85% and 100% of the test signal has no limit and is therefore not checked.

The limit definition command for the shown example would be the following (refer to p. ***87***):

```
MEASurement:PUResound:STEepness:VARLimit SET 3 6 PA|S 0.00E00,
1.50E+01,1.75E+01,2.00E+01,3.33E+01,5.25E+01,0.85E+02,
1.50E+01,1.25E+01,0.75E+01,0.75E+01,0.40E+02,0.40E+02
```

The application of individual steepness limits is an extremely powerful tool to execute a concise, yet fast and reliable signal analysis as e.g. Rub & Buzz detection.

- Activate the individual transient steepness limit test (Rub & Buzz detection) with the command ***MEASurement:PUResound:STEepness:VARLimit:ACTive[1¦2¦3¦4¦5¦6]***.
- Adjust the ***INPut:SYNC*** mode to ***INTNoheader*** or ***THReshold*** (refer to p. ***188***).
- Start the signal acquisition with ***OUTPut[1¦2]:PUResound:CHIRp:STARt*** (analysis of ***RT-2M*** chirp) or ***MEASurement[1¦2]:PUResound:STARt*** (analysis of externally generated signal).
- Query the PASSED / FAILED result with ***MEASurement:PUResound:STEepness:OK?***.

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Noise Cancellation

RT-2M provides a sophisticated, patented feature to cancel out the effects of ambient noise. In practice, the test system repeats every measurement that has exceeded the currently active steepness limits. Next, it verifies whether the results of the repeated measurement show the same kind of "noise" than the previous run (systematic error) or not (random noise). If a systematic error (same kind of defect at all runs) has occurred, *RT-2M* returns a "FAILED". Otherwise, i.e. in case of random noise (limits have been exceeded at different points), the unit cancels out the recorded transients and returns a "PASSED". This way, *RT-2M* can be operated even in noise environments without compromising on the accuracy or reliability of the test results.

Enter the maximum number of runs that can be executed in case of a recorded defect with the command ***MEASurement:PUResound:NRESults*** <***#Results***>. Consequently, *RT-2M* repeats the test for the defined number of cycles (= <***#Results***>) if the user-defined limits are exceeded (i.e. if the test = FAILED).

Rub & Buzz Test

RT-2M stimulates the DUT with a chirp, i.e. a *gliding* sweep from 20 – 6'000 Hz. This test signal excites all possible Rub & Buzz defects of subwoofers, speakers or even tweeters (in case of the latter, the stimulus might need to be introduced after the crossover). Simultaneously, the analyzer measures the transient steepness of the input signal in 6 bands between 2 – 20 kHz, representing the human hearing perception. Thus, the PureSound™ analysis detects all audible Rub & Buzz defects and provides a clear indication of this.

In addition to the chirp, a stepped sweep is transmitted to measure the frequency and impedance response, resonance frequency f_0, sound pressure level (SPL) and polarity of the transducer. Refer to chapter ***Stepped Sweep Generation*** (p. ***173***) and ***Stepped Sweep*** (p. ***175***) for further details.

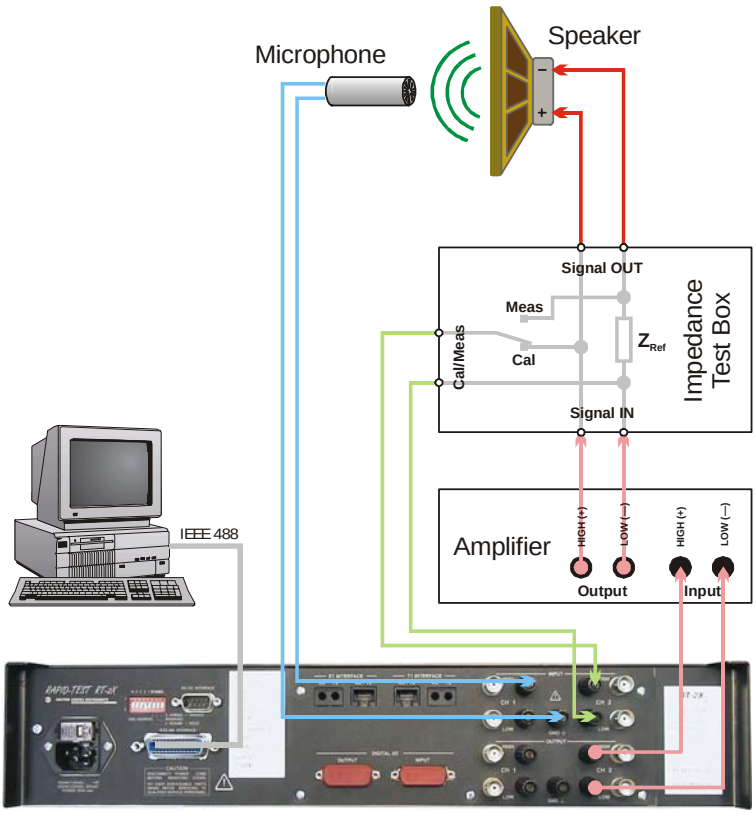


Fig 46 Transducer Test Setup

NOTE **A shunt resistor is required to measure the impedance vs. frequency. Please ask your agent for the NTI impedance test box *RT-IB*.**

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RS232 Serial Interface

By connecting a Nullmodem-cable between the PC and the *RT-2M* standard RS232 interface (D-Sub 9pin connector) a serial communication can be established, supporting virtually all *RT-2M* instructions and queries, described in chapter ***Commands*** (p. ***22***).

Baudrate	38400
Databits	8
Stopbits	1
Parity	None
Protocol	Hardware

Termination of transmitted commands PC → RT-2M	CR LF (Carriage Return Line Feed)
Answers from RT-2M → PC	LF (Line Feed)

Table 13 RS232 Setup Parameters

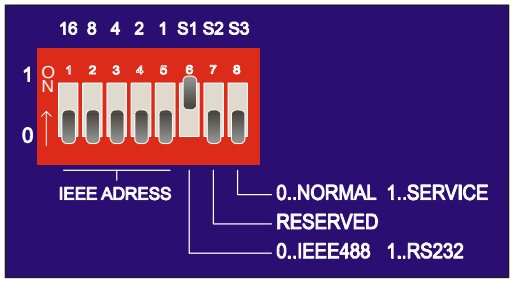


Fig 47 DIP-switch Settings for RS232 Operation

NOTE **Activate the RS232 interface by setting the DIP-switch on the *RT-2M* rear panel labeled 'S1' (6th switch from left) to '1' (upper position).**

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Sine Signal Generation (Arbitrary)

OUTPut:ARBSIN ***<Frequency>,<Time>*** lets *RT-2M* generate a sinusoidal tone with an user-defined frequency [Hz] and duration [ms]. The parameters ***<Frequency>*** and ***<Time>*** are fully independent from the current multitone signal parameters (i.e. blocklength, sampling rate etc.).

- The available frequency band for the arbitrary sine generation is 1 Hz – 22 kHz, whereby the frequency can be defined with a resolution of 0.01 Hz.
- The available signal duration ranges from 0 ms to 30'000 ms and can be defined with a resolution of 1 ms.

OUTPut:ARBSIN BREAK immediately stops the arbitrary sine wave generation.

Use command ***OUTPut[1¦2]:LEVel <Level> [V¦VP¦DBV¦DBVP¦DBM]*** or ***OUTPut[1¦2]:SINelevel <SineLevel> [DBVP¦VP¦DBV¦V¦DBM]*** to adjust the output level of the sine wave.

NOTE **The actual output level of the arbitrary sine generator differs from the selected value below 20 Hz and above 20 kHz as follows (refer to *Fig 48*):**

- **–4 dB @ 1 Hz to 0 dB @ 20 Hz**
- **0 dB @ 20 Hz to –0.5 dB @ 22 kHz.**

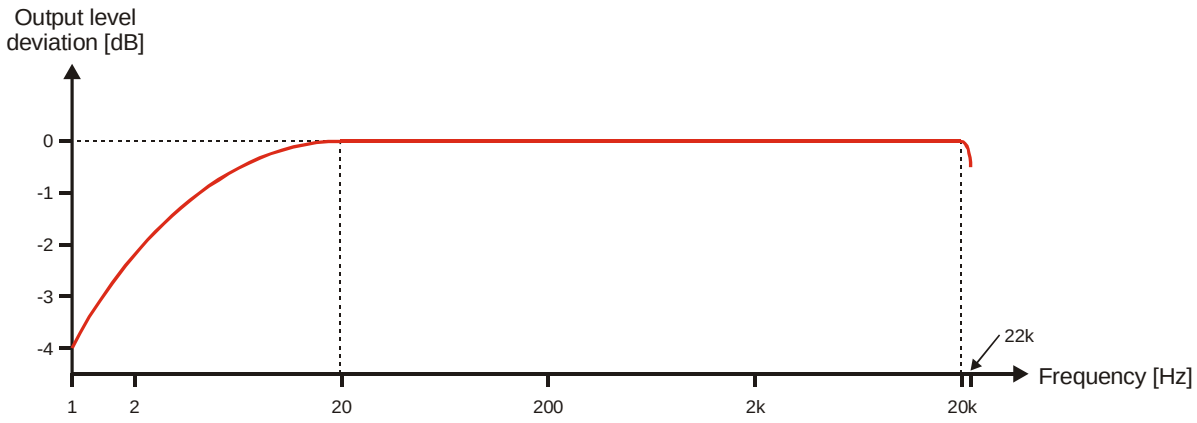


Fig 48 Arbitrary Sine Output Level Deviation

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Stepped Sweep Generation

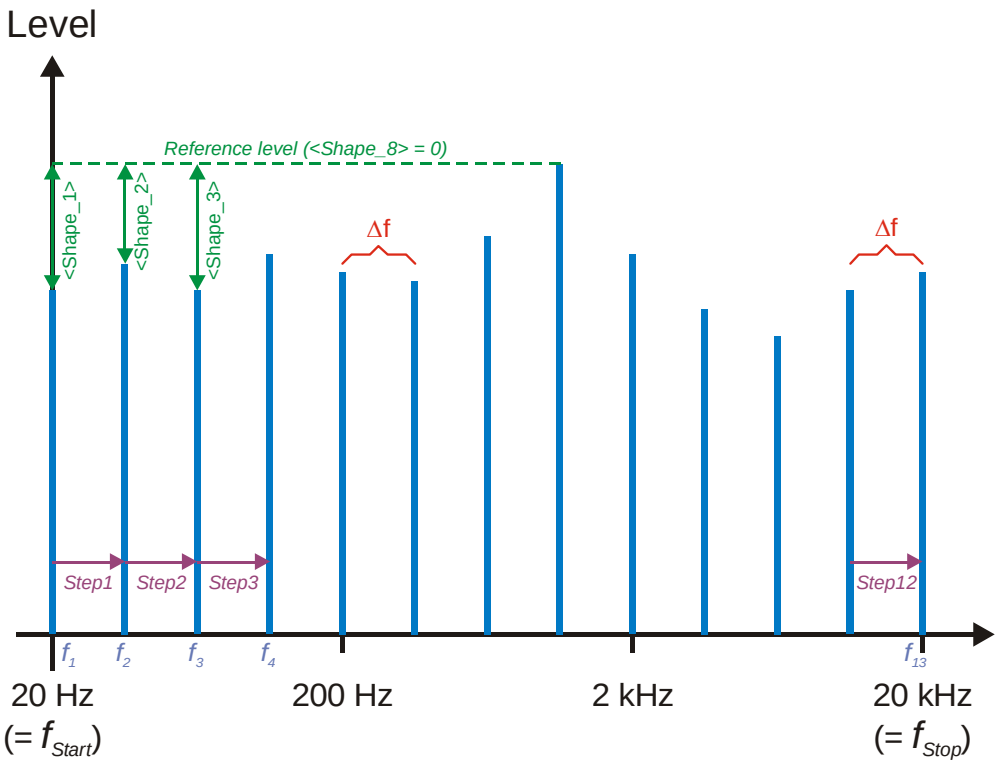


Fig 49 Sweep Generator Parameters

- ***OUTPut:STEPpedsweep:FSTArt*** **<*StartFrequency*>** defines the sweep's *start frequency* f_{Start} that can be lower or higher than f_{Stop}.
- ***OUTPut:STEPpedsweep:FSTOp*** **<*StopFrequency*>** defines the sweep's *stop frequency* f_{Stop} that can be higher or lower than f_{Start}.
- ***OUTPut:STEPpedsweep:NSTeps*** **<*#Steps*>** defines the number of *steps* between f_{Start} and f_{Stop} (i.e. the frequency resolution of the stepped sweep). Please note that the *number of frequencies* = **<*#Steps*>** + 1.
- ***OUTPut[1¦2]:SINelevel*** **<*SineLevel*>** ***[DBVP¦VP¦DBV¦V¦DBM]*** defines the reference *output level* for the stepped sweep.
- ***OUTPut:STEPpedsweep:AMPLitudeshape:SET*** **<*Shape1*>,<*Shape2*>,…,<*Shape#Steps+1*>** allows attenuating the individual output levels of the sweep frequencies, whereby the number of **<*Shape_n*>** values must equal the number of steps and at least one level must not be attenuated (i.e. **<*Shape_x*>** = 0).
- ***OUTPut:STEPpedsweep:AMPLitudeshape:ACTive [ENABle¦DISable]*** activates or disables the last defined amplitude shaping for the active sweep (supposed that the listed conditions are met).
- ***OUTPut:STEPpedsweep:STATus?*** queries the values of the parameters **<*StartFrequency*>**, **<*StopFrequency*>** and **<*#Steps*>** of the active sweep.
- ***OUTPut:STEPpedsweep:AMPLitudeshape:SET?*** queries the **<*Shape_n*>** values that were defined with the last ***OUTPut:STEPpedsweep:AMPLitudeshape:SET …*** command.

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Stepped Sweep Setup Parameters

Delays

There are two ways to delay the start of the analyzer's data acquisition. If both delays are active, they will be applied one after the other (refer to ***Fig 51***).

- ***MEASurement:STEPpedsweep:SETTling:CYCLes*** <***Cycles***> defines a frequency-dependent delay for the start of the signal acquisition. This may be necessary to allow the DUT settling at the beginning of a new generator frequency.
- ***MEASurement:STEPpedsweep:SETTling:DELay*** <***Delay***> defines a fixed delay between the start of the frequency generation and the start of the signal acquisition. This delay can be used to compensate for the propagation time of the signal, e.g. caused by an acoustical transmission.

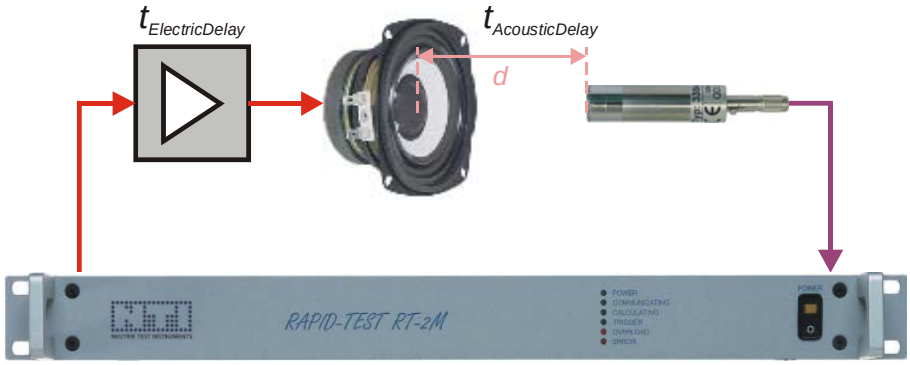


Fig 50 Signal Propagation Delay

Fig 50 visualizes the signal propagation delay that can be caused by electrical devices (e.g. a codec) or the acoustical signal path. The overall propagation delay can be calculated with following formulas (***d*** = distance membrane – microphone; v_{Sound} = speed of sound):

$$t_{PropagationDelay} = t_{ElectricDelay} + t_{AcousticDelay}$$
$$= t_{ElectricDelay} + \frac{d}{v_{Sound}}$$

Equation 22 Signal propagation delay

Example

Given ***d*** = 0.5 m; v_{Sound} = 340 m/s; $t_{ElectricDelay}$ = 1 ms = 0.001 s

$$\Rightarrow \quad t_{PropagationDelay} = 0.001 + \frac{0.5}{340} = 0.0025\,[s] = 2.5\,[ms]$$

In this case it would be recommended to apply a <***Delay***> of 3 or 4 ms

Noise Immunity

A noisy environment can affect the accuracy of acoustical measurements. Therefore, ***RT-2M*** allows enabling an internal filter that rejects signal components that have a different frequency from the actually present sweep frequency.
Activate the internal noise filter with ***MEASurement:STEPpedsweep:NOISeimmunity [OFF¦ON]***.

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High Precision Mode

In most applications, *RT-2M* requires only half a signal period for an accurate level measurement. However, certain drivers (e.g speakers, transducers, capsules) create highly asymmetric non-linear distortions, thus downgrading the level measurement accuracy (typ. ~0.5 dB).
Therefore, *RT-2M* supports a special mode, wherein the full signal period is acquired and analyzed to ensure maximum measuring accuracy (deviation < 0.5 dB). Activate this mode with the command ***MEASurement:STEPpedsweep:HIPRecision ON*** in following cases:

- The stepped sweep output level is close to the maximum allowed input level of the driver.
- A high measuring resolution (< 0.5 dB) is required at low frequencies.
- The driver's resonance impedance R_0 is close to its DC resistance R_{DC}: $\frac{R_0}{R_{DC}} \leq 1.5$
- High-end wideband drivers (e.g. headphones, car speakers).

NOTE **The high precision mode makes the stepped sweep measurement slower.**

Settling

When measuring an audio device with unknown transient behaviour it is sometimes required to monitor the acquired measurement result at the current frequency for a while until it has settled. For this purpose *RT-2M* supports an automated settling algorithm.
If the settling is active, *RT-2M* checks every incoming sample before it is accepted as a valid measurement result. Furthermore, the unit does not start generating the next sweep frequency before this condition is met, unless that a timeout expires.

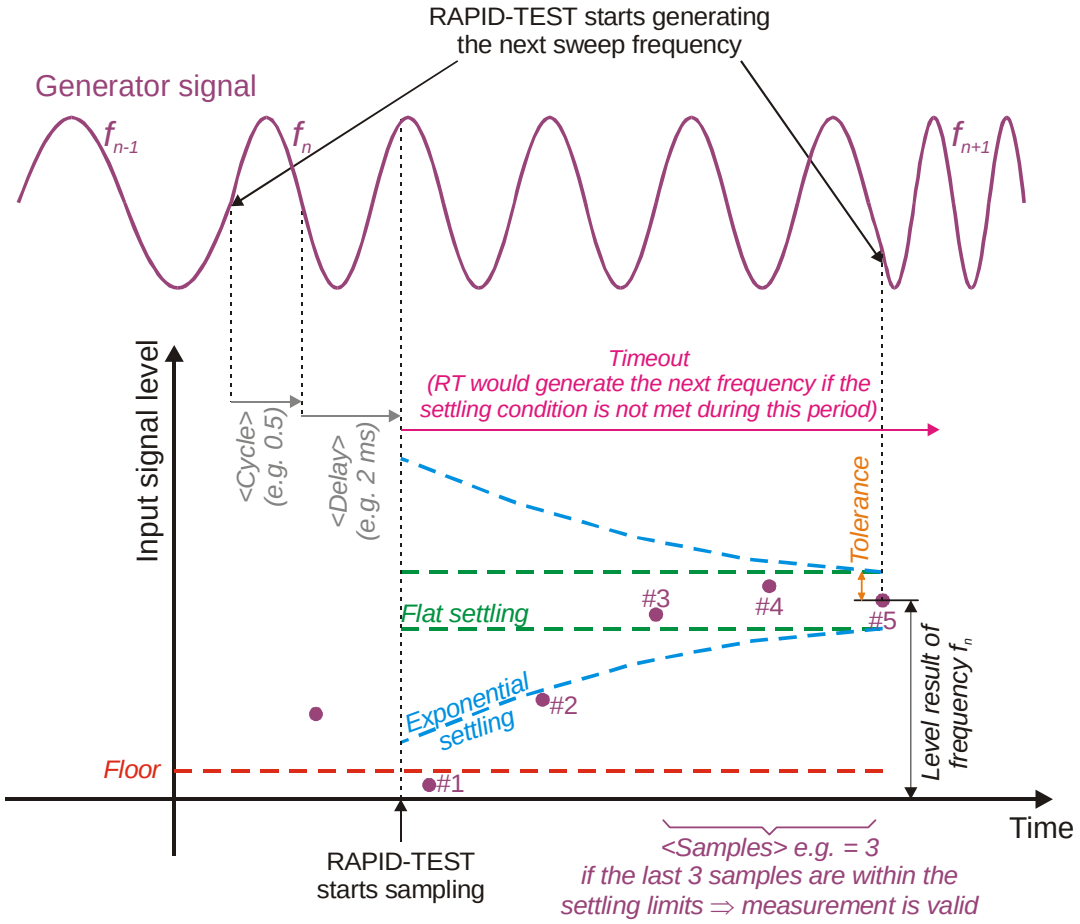


Fig 51 Sweep Settling Parameters

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NOTE ***RT-2M*** **applies pre-defined settling parameters depending on the acquistion mode (*RMSLEVEL* or *DISTORTION*, p. *180*). Amending the default setting is only recommended if truly required and if you feel safe with the settling parameter definition.**
Improper settling noticeably slows down the stepped sweep transmission.

- Select the settling type with the command ***MEASurement:STEPpedsweep:SETTling:TYPE [RMSLEVEL¦HARMONIC2¦ HARMONIC3¦HARMONIC4¦HARMONIC5¦THD¦THDN]***, with regard to the measurement to be executed (Level / Phase or 2nd, 3rd, 4th, 5th Harmonic or THD or THD+N).
- ***MEASurement:STEPpedsweep:SETTling:MODE [OFF¦NORMAL¦SELECTIVE]*** applies the settling on the full frequency band (***NORMAL***) or an user-defined band (***SELECTIVE***).
- In the selective settling mode, commands ***MEASurement:STEPpedsweep:SETTling:FBEGin <Frequency1>*** and ***MEASurement:STEPpedsweep:SETTling:FENd <Frequency2>*** define the frequency band, wherein the settling is active. Typically, ***<Frequency1>*** and ***<Frequency2>*** are defined around the resonance frequency f0 of the DUT. The benefit of this mode is that it provides fast and accurate measurement results around the resonance frequency of samples with a high Qms (mechanical quality factor).
- ***MEASurement:STEPpedsweep:SETTling:ACTive [CHANNEL1¦CHANNEL2¦BOTHCHANNELS]*** defines the input channel(s) where the settling is applied.
- ***MEASurement:STEPpedsweep:SETTling:ALGorithm [EXPonential¦FLAT]*** selects the settling algorithm. ***FLAT*** represents a band of constant width, i.e. the last samples must be within the user-defined limits to be accepted. ***EXPONENTIAL*** represents a tolerance mask that is exponentially less restrictive for older samples.
- ***MEASurement:STEPpedsweep:SETTling:FLOor <Floor> [V¦DBV]*** defines the minimum input level that must be exceeded by a sample to be accepted for the settling procedure. Consequently, this command is used to neglect noise during the settling process.
- ***MEASurement:STEPpedsweep:SETTling:NOISe <Level> [V¦dBV¦dBSPL¦dBPa]*** defines a relative acceptance band for the settling. If e.g. the input signal is stable, but a little noisy, it might not meet the ***EXPONENTIAL*** settling condition. In this case, the command allows to widen the acceptance condition a little.

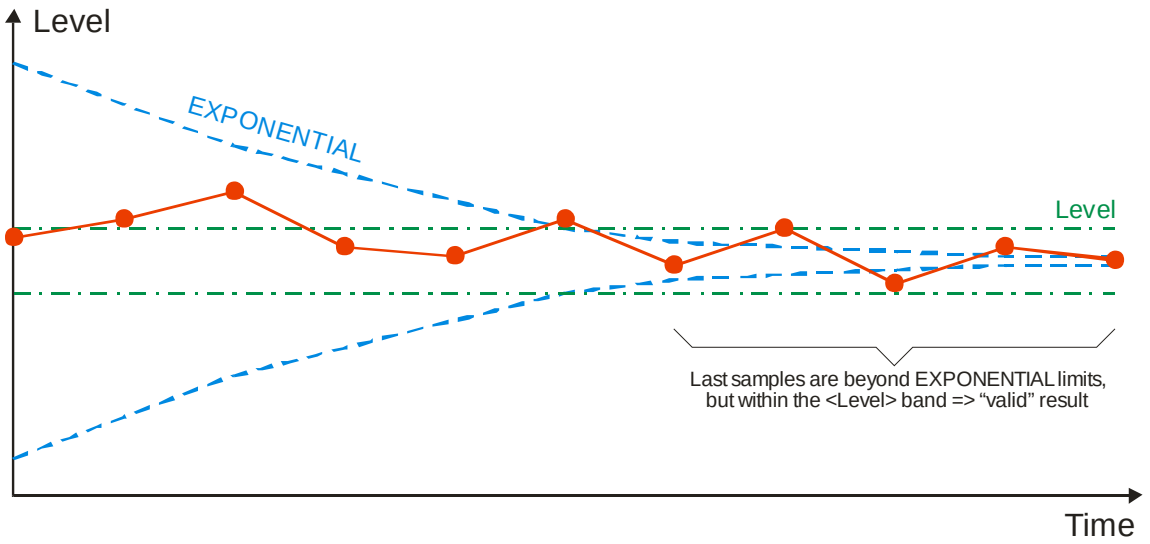


Fig 52 Example of Settling with User-defined "Noise Level"

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- ***MEASurement:STEPpedsweep:SETTling:TOLerance*** <***Tolerance***> ***[%¦DB]*** defines the width of the active settling tolerance. Every sample that meets the continuosly calculated tolerance limits is accepted as "valid".
- ***MEASurement:STEPpedsweep:SETTling:SAMple*** <***Samples***> defines how many samples in a row must be valid (i.e. within the tolerance limits) to become a valid measurement result.
- ***MEASurement:STEPpedsweep:SETTling:TIMEout*** <***Timeout***> gives the time, after which the measurement is aborted for the current frequency in case that the unit was not able to acquire a valid sample.
- ***MEASurement:STEPpedsweep:DISTortion:ACQUisitionlength*** <***Length***> allows defining the acquisition length for distortion measurements, e.g. to filter out hum.
- ***MEASurement:STEPpedsweep:SETTling:STATus?*** queries the settling parameters.

NOTE **The following rules allow optimizing the sweep settling for distortion measurements:**

- **Apply an anechoic test box (i.e. acoustical shielding).**
- **Adjust the driving level for the DUT to a rather high voltage.**
- **Select the settling mode OFF and carefully optimize the RT-2M input range.**
- **Enter the stepped sweep start & stop frequencies, whereby the latter should be below the start frequency (e.g. 20 kHz → 20 Hz).**
- **Activate the settling (mode NORMAL) only on the active input channel.**
- **Use the settling "RMSLEVEL" or "HARMONICx" rather than "THD+N".**
- **Increase the "Tolerance" or enter a longer "Timeout" if the DUT does not settle properly.**
- **Amend the "Acquisition length" to filter out low-frequency hum.**

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Smoothing

The command ***MEASurement:STEPpedsweep:SMOothing:MODe [OFF¦AVERAGE]*** activates the data smoothing, whereby the measured level results are averaged in a user-defined frequency window.

- ***MEASurement:STEPpedsweep:SMOothing:ACTive …*** defines the active channel(s).
- ***MEASurement:STEPpedsweep:SMOothing:RESolution <Percent>*** defines the lower and the upper limit of the frequency window.

$$LowerLimit = \frac{f_{current}}{2^{\frac{<Percent>}{100}}}$$

$$UpperLimit = f_{current} * 2^{\frac{<Percent>}{100}}$$

Equation 23 Calculation of Frequency Window Limits

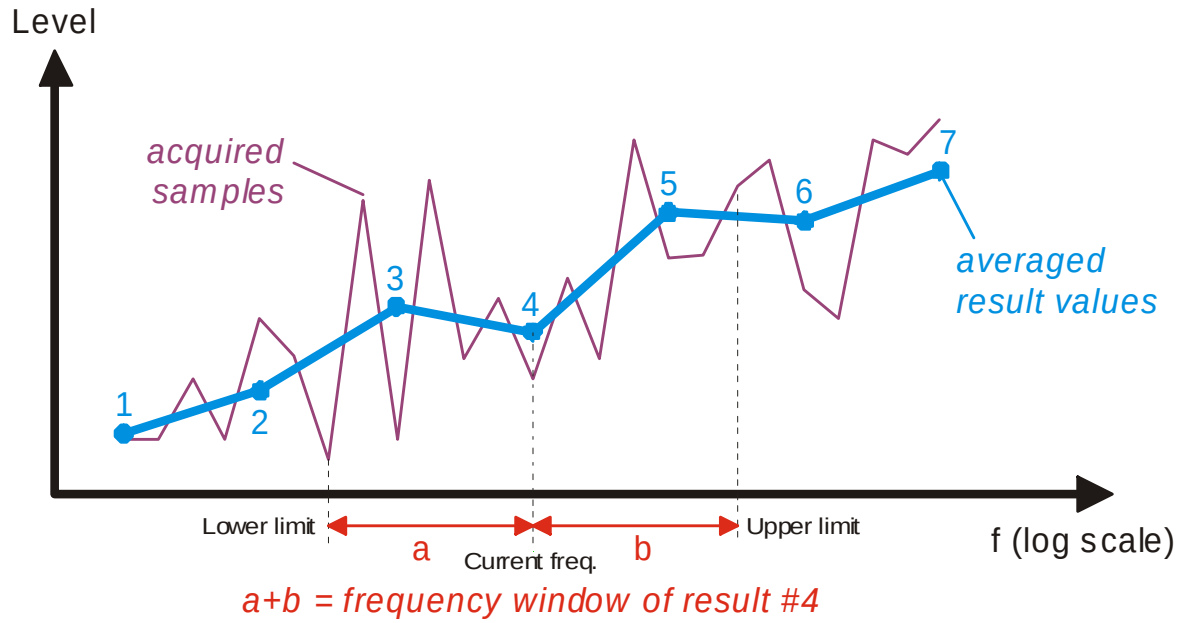


Fig 53 Data Smoothing Principle

Fig 53 explains the data smoothing frequency window that is defined in percent of the octave of the current frequency.

Example

Given: Current frequency = 1'500 Hz; width of the frequency window = 33.33%

⇒ lower limit of frequency window: 1500 / $2^{0.33}$ = 1193 Hz
*⇒ upper limit of frequency window: 1500 * $2^{0.33}$ = 1886 Hz*

Result: The measurement result at 1'500 Hz is calculated by averaging all samples that are acquired in the band from 1'193 Hz to 1'886 Hz

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Stepped Sweep Transmission

Acquisiton Mode

Prior to the signal transmission, the stepped sweep acquisition mode must be adjusted properly (commands ***MEASurement:STEPpedsweep:ACQUisition [RMSLEVEL¦DISTORTION]*** and ***MEASurement:STEPpedsweep:DISTortion:ACQUisitionlength*** <***Length***>, p. ***90***), depending on the measurement function:

- ***RMSLEVEL*** for Level or Phase measurements.
- ***DISTORTION*** for 2nd, 3rd, 4th or 5th harmonic, THD or THD+N analysis.

Test Execution & Triggering

RT-2M always applies the ***INTNoheader*** trigger mode for a stepped sweep analysis, regardless of the last ***INPut:SYNC …*** command. During the test, the *RT-2M* generator & analyzer are synchronized so that the sweep speed is automatically adjusted to the actual setup. The analysis of an externally generated sweep is not possible.

- Optimize the *RT-2M* input range as described in chapter ***Input Range*** (p. ***125***).
- Iinitiate the sweep transmission & acquisition with command ***OUTPut:STEPpedsweep:STARt***.

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Stepped Sweep Measurements

NOTE **Make sure that following modes are adjusted properly before executing a stepped sweep measurement:**
- **Acquisition mode (p. *180*).**
- **Settling (p. *176f*).**

Distortion

RT-2M supports three different stepped sweep distortion measurements:
- 2nd, 3rd, 4th, 5th harmonic (***MEASurement[1¦2]:STEPpedsweep:DISTortion:HARMONIC:UNIT [DB¦%¦DBV¦V¦DBM]***, ***MEASurement[1¦2]:STEPpedsweep:DISTortion:HARMonic? [2¦3¦4¦5]***).
- THD (commands ***MEASurement[1¦2]:STEPpedsweep:DISTortion:THD:UNIT [DB¦%]*** and ***MEASurement[1¦2]:STEPpedsweep:DISTortion:THD?***)
- THD+N (commands ***MEASurement[1¦2]:STEPpedsweep:DISTortion:THDN:UNIT [DB¦%]*** and ***MEASurement[1¦2]:STEPpedsweep:DISTortion:THDN?***).

NOTE **The speed and accuracy of a distortion measurement depends directly from the thorough adjustment of the settling parameters. Please refer to the corresponding chapter (p. *176f*).**

Level Measurement

- ***MEASurement[1¦2]:STEPpedsweep:RMSLevel:UNIT [DBV¦V¦DBSPL¦DBPA¦DBM]*** defines the unit for the level result.
- ***MEASurement[1¦2]:STEPpedsweep:RMSLevel?*** queries the level results of the last successful sweep acquisition.

Phase Measurement

- Define the phase unit with ***MEASurement:STEPpedsweep:PHASe:UNIT [RAD¦DEG]***.
- Query the phase result at a single frequency or the phase results of all sweep frequencies with the command ***MEASurement[1¦2]:STEPpedsweep:PHASe?*** <***MeasFrequency***>, whereby the optional parameter <***MeasFrequency***> defines the single frequency.

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Test Setups

Start Commands

OUTPut:MTONe:STARt

- The generator immediately starts transmitting the multitone burst.
- The analyzer starts sampling immediately after the start command ***OUTPut:MTONe:STARt*** (trigger mode ***INTNoheader***) or as soon as the trigger condition is met (trigger modes ***INTernal***, ***EXTernal*** or ***THReshold***).
- In the trigger modes ***INTernal***, ***EXTernal*** and ***THReshold***, the maximum allowed time delay between the test signal generation (initiated by the start command) and the triggering of the analyzer is 10 seconds (default = 500 ms) This timeout can be adjusted with the command ***INPut:TRIGger:TIMEout*** <***Timeout***>.

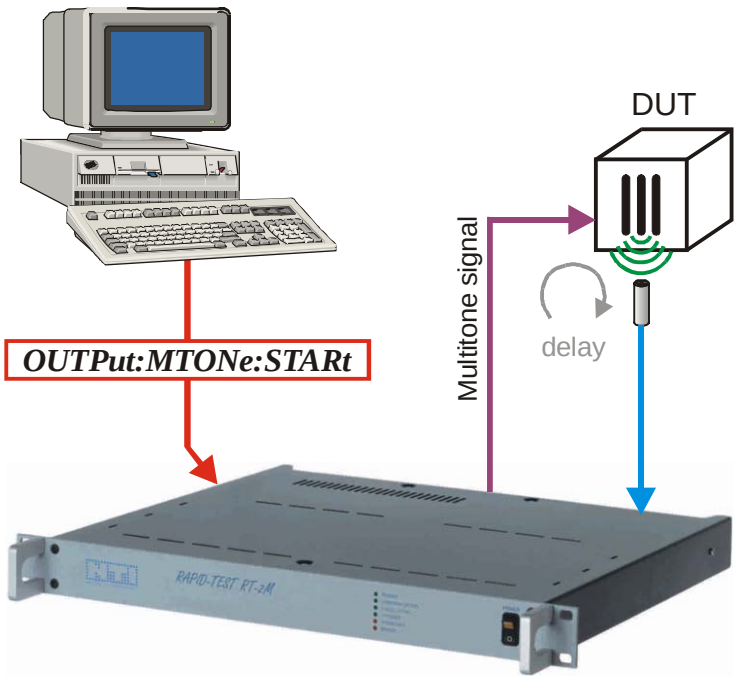


Fig 54 Command OUTPut:MTONe:STARt

Typical applications:

- *Internal* multitone analysis, i.e. the test signal is transmitted from the RT-2M generator through the DUT to the analyzer of the same RT-2M unit. Thereby, the maximum allowed delay is 10 seconds.
- *External* signal analysis, whereby the 'arrival' time of the incoming signal is predictable within few seconds (please refer also to p. ***155***).

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OUTPut:STEPpedsweep:STARt

- The generator immediately starts transmitting the stepped sweep.
- The analyzer starts sampling immediately after the command ***OUTPut:STEPpedsweep:STARt***.
- Optionally, a delay between the start command and the beginning of the settling procedure can be applied (refer to chapter ***Stepped Sweep Noise Immunity***, p. ***175***).

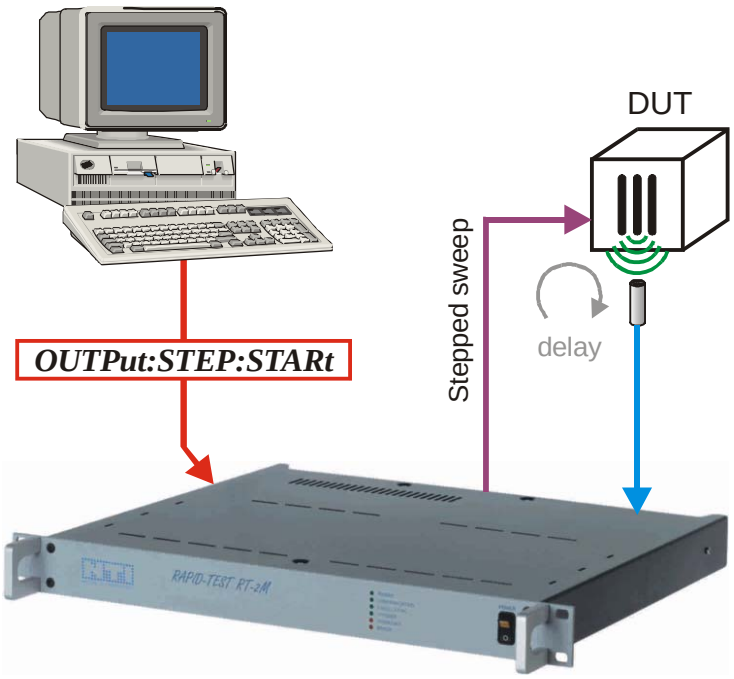


Fig 55 Command OUTPut:STEPpedsweep:STARt

NOTE The RT-2M unit that generates the stepped sweep must analyze it as well.

Typical applications of the stepped sweep analysis are frequency response measurements of electroacoustic transducers (tweeters, drivers, woofers etc.)

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OUTPut[1¦2]:PUResound:CHIRp:STARt

NOTE **This command is only available if the PureSound™ option is enabled.**

- The generator immediately starts transmitting the chirp (i.e. gliding sweep).
- In the trigger mode ***INTNoheader***, the analyzer starts sampling immediately after command ***OUTPut[1¦2]:PUResound:CHIRp:STARt***.
- Alternatively, in the trigger mode ***THReshold***, the analyzer starts sampling as soon as the trigger condition is met. In this case a maximum timeout of 10 seconds can be applied with command ***INPut:TRIGger:TIMEout*** <***Timeout***>.

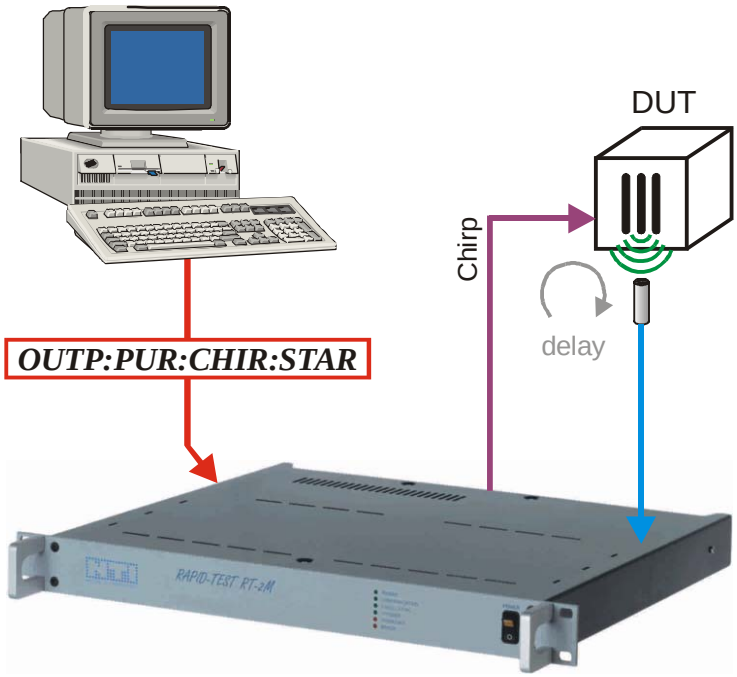


Fig 56 Command OUTPut[1¦2]:PUResound:CHIRp:STARt

This command is used for Rub & Buzz transducer tests, whereby the chirp can be generated by the same RT-2M unit that analyzes the transmitted test signal *or* by an external device, supposed that the latter is able to provide a linear + gliding sweep and that the 'arrival' time of the chirp is predictable within few seconds.

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MEASurement[1¦2]:PUResound:STARt

NOTE This command is only available if the PureSound™ option is enabled.

- The analyzer starts sampling immediately (trigger mode ***INTNoheader***) *or* as soon as the ***THReshold*** trigger condition is met, whereby this must happen within a maximum timeout of 10 seconds after the command ***MEASurement[1¦2]:PUResound:STARt***.
- The generator does not send out any test signal.

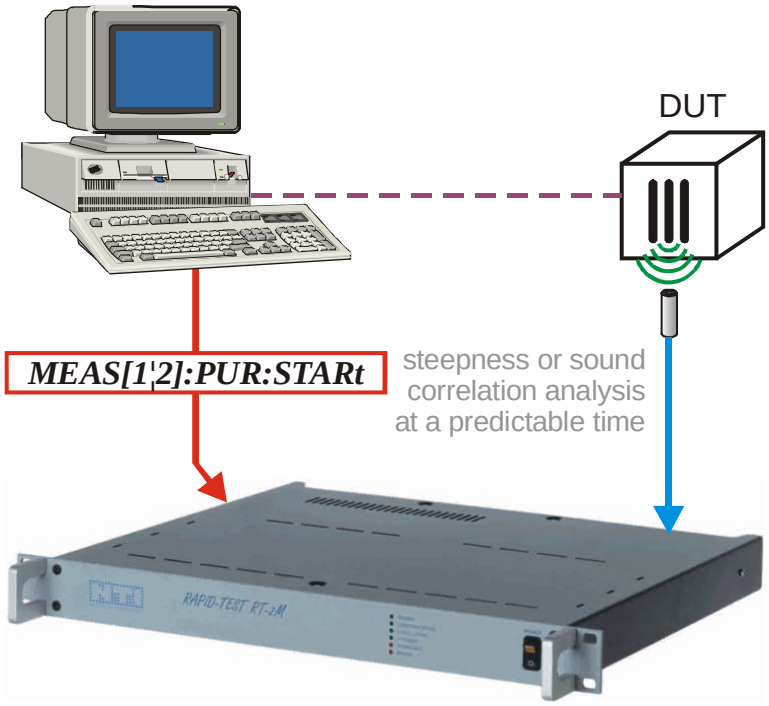


Fig 57 Command MEASurement[1¦2]:PUResound:STARt

This command is typically used for *steepness* measurements or the *sound correlation* analysis of an *externally generated sound sequence*, whereby the 'arrival' time of the signal is *predictable* within few seconds.

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INPut:TRIGger:ARMed

- The analyzer is armed, i.e. it waits until the trigger condition (***INTernal***, ***EXTernal*** or ***THReshold***) is met before it starts sampling.
- The generator does not send out any test signal.
- Please note that the command is only available in the ***Normal Mode*** (p. ***157***).

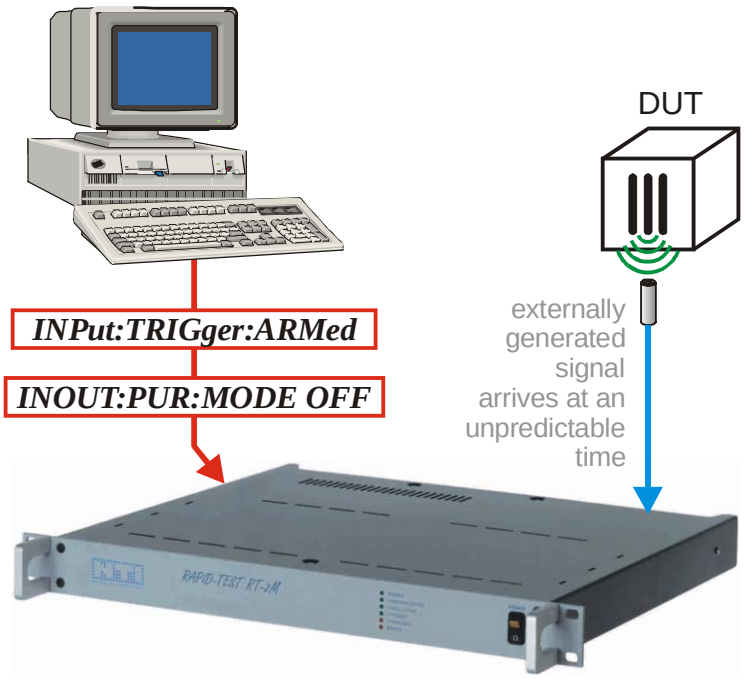


Fig 58 Command INPut:TRIGger:ARMed

Typical applications of an armed analyzer in the Normal mode:

- *Analysis* (e.g. RSS Selective Level, Frequency etc.) of an *externally generated audio signal*, whereby the 'arrival' time of the signal is not predictable (please refer also to p. ***155***).
- *Transmission line testing* (e.g. a broadcast network, a satellite link etc.), whereby the sending unit (e.g. a remote ***RT-2M***) is *physically separated* from the analyzer.

NOTE **After the *INPut:TRIGger:ARMed* command, not all measurement functions of *RT-2M* are available. Please refer to the command descriptions.**
Reset the analyzer – if required – with command *INPut:TRIGger:BREak*

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INPut[1¦2]:TRIGger:ARMed

NOTE **This command is only available if the PureSound™ option is enabled.**

- The analyzer is armed, i.e. it waits until the ***THReshold*** trigger condition is met before it starts sampling.
- The generator does not send out any test signal.
- Please note that the commmand is only available in the ***PureSound™ Mode***, (p ***168***).

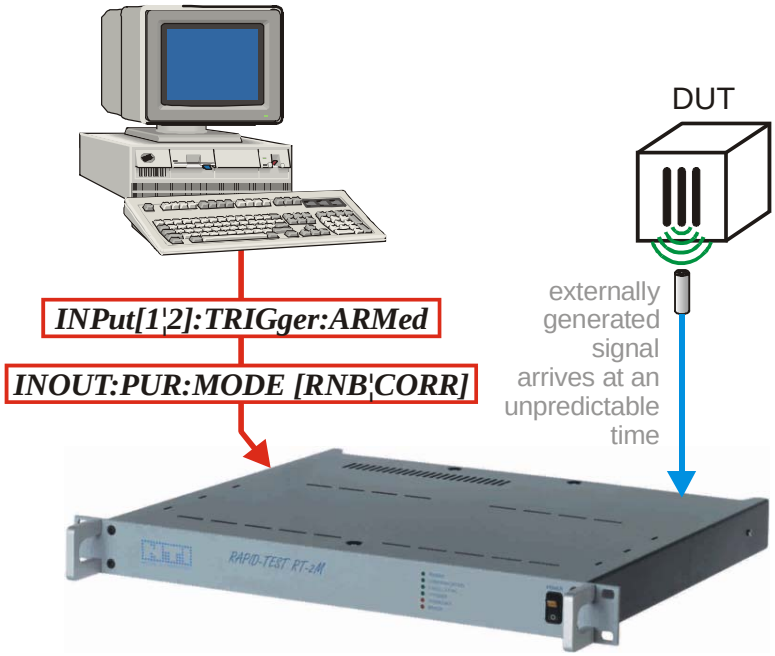


Fig 59 Command INPut[1¦2]:TRIGger:ARMed

Typically it is used to arm the analyzer in the PureSound™ mode to analyze the steepness or sound correlation of an *externally generated signal*, whereby the 'arrival' time of the signal is not predictable.

NOTE **After the *INPut:TRIGger:ARMed* command, not all measurement functions of *RT-2M* are available. Please refer to the command descriptions.**
Reset the analyzer – if required – with command *INPut:TRIGger:BREak*

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Triggering & Signal Acquisition

A core requirement for the correct signal analysis is to properly trigger the *RT-2M* analyzer to the incoming signal. *RT-2M* supports three alternatives:

1. Transmission of a proprietary *header* (i.e. trigger signal) that 'announces' the incoming multitone burst (chapter ***Multitone Burst Structure***, p. ***130***). The analyzer starts sampling the incoming signal as soon as this header is recognized.
2. Transmission of the multitone burst *without* the proprietary header. In this case the analyzer must be triggered to start the data acquisition with the command ***OUTPut:MTONe:STARt***.
3. Definition of a *threshold level* in the analyzer. As soon as the level of the incoming signal exceeds this threshold, the analyzer triggers and starts sampling the signal (similar to a scope trigger).

The 1st method is applied in most cases, supposed that:

- The multitone signal is generated & analyzed by a *RT-2M* unit.
- No major ambient noise is present.
- The time delay on the signal path is < 10 seconds.
- The DUT does not change the frequencies of the transmitted signal.
- A transmission line shall be tested with two or more remote *RT-2M* units (p. ***196***).

The 2nd approach is mainly used if:

- The test is located in a noisy environment.
- The frequencies of the multitone signal are changed on the transmission path.

The 3rd alternative is used:

- For the analysis of externally generated signals.
- For transmission line testing with two or more remote *RT-2M* units (p. ***196***).

NOTE **Refer to pages *182 – 187* for further information about test setups, trigger modes and start commands.**

Trigger Modes

The command ***INPut:SYNC [INTernal¦INTNoheader¦EXTernal¦EXTNoheader¦THReshold]*** defines, whether:

- The multitone burst must comprise of the proprietary header (***INT***, ***EXT***) or not (***INTN***, ***EXTN***, ***THR***).
- The *RT-2M* analyzer synchronizes its sampling clock to the generator of the same instrument (***INT***, ***INTN***, ***THR***) or to the incoming multitone burst (***EXT***, ***EXTN***).
- The *RT-2M* analyzer triggers (i.e. starts sampling) to the command ***OUTPut:MTONe:STARt*** (***INTN***, ***EXTN***) or to the prorietary header of an incoming multitone burst (***INT***, ***EXT***) or to a threshold level (***THR***).

Table 14 provides an overview on the trigger modes and their applications in respect to the two test initialization commands of *RT-2M*.

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Trigger Mode	Test Initialization Command	
	OUTPut:MTONe:STARt	INPut:TRIGger:ARMed
INTernal	Generator transmits multitone burst with proprietary header. Analyzer triggers only to a proprietary header. Timeout = 50 – 10'000 ms (selectable). Analyzer sampling clock is synchronized to the internal generator.	Generator is deactivated. Analyzer triggers only to a proprietary header. No timeout. Analyzer waits, until the trigger condition is met. Analyzer sampling clock is synchronized to the internal generator.
INTNoheader	Generator transmits multitone burst without proprietary header. Analyzer starts sampling directly after the initialization command. Analyzer sampling clock is synchronized to the internal generator.	Generator is deactivated. Analyzer starts sampling directly after the initialization command. Analyzer sampling clock is synchronized to the internal generator.
EXTernal [4]	Generator transmits multitone burst with proprietary header. Analyzer triggers only to a proprietary header. Timeout = 50 – 10'000 ms (selectable). Analyzer sampling clock is synchronized to 'clock sync' block of incoming burst.	Generator is deactivated. Analyzer triggers only to a proprietary header. No timeout. Analyzer waits, until the trigger condition is met. Analyzer sampling clock is synchronized to 'clock sync' block of incoming burst.
EXTNoheader [4]	Generator transmits multitone burst without proprietary header. Analyzer starts sampling directly after the initialization command. Analyzer sampling clock is taken from the previous burst transmission in the EXT mode.	Generator is deactivated. Analyzer starts sampling directly after the initialization command. Analyzer sampling clock is taken from the previous burst transmission in the EXT mode.
THReshold	Generator transmits multitone burst without proprietary header. Analyzer triggers as soon as the input signal exceeds the threshold level, whereby the corresponding delay of ***Table 15*** applies. Timeout = 50 – 10'000 ms (selectable). Analyzer sampling clock is synchronized to the internal generator.	Generator is deactivated. Analyzer triggers as soon as the input signal exceeds the threshold level. No timeout. Analyzer waits, until the trigger condition is met. Analyzer sampling clock is synchronized to the internal generator.

Table 14 Test Initialization vs. Trigger Modes

NOTE **In the case of a dual-channel burst transmission, the RT-2M analyzer will start sampling on *both channels simultaneously*, as soon as the trigger condition has been met on either channel.**
After command *INPut:TRIGger:ARMed* the analyzer is reset by a successful triggering or with command *INPut:TRIGger:BREak*.

[4] Only available in the normal mode for A-A devices!

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INTernal

Command: ***INPut:SYNC INT*** (default status).

- The generated multitone burst comprises of a proprietary header (trigger + 'Sync Block') and the user-defined multitone signal.
- The analyzer only triggers (i.e. starts sampling) to an incoming multitone burst with proprietary header.
- The analyzer is synchronized to the internal clock.

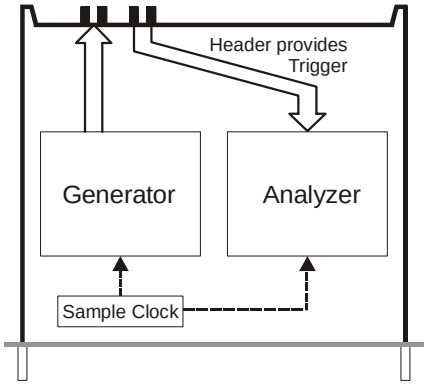


Fig 60 INT Mode

Applications of the trigger mode "INTernal":

- The *RT-2M* unit generates & analyzes the user-defined multitone burst after the initialization command, whereby the ambient noise level must be low and no frequency shifts occur in the DUT.
- An external unit (e.g. a remote *RT-2M* or a replay-device) generates a multitone burst with proprietary header that shall be analyzed by *RT-2M*, whereby the burst must arrive at a known time (± 4 seconds) and no frequency shifts occur in the DUT.

Initialization commands:

a) ***OUTPut:MTONe:STARt***

- The *RT-2M* generator immediately transmits the burst.
- The *RT-2M* analyzer immediately starts waiting for an incoming multitone burst with proprietary header during a user-defined timeout period (***INPut:TRIGger:TIMEout*** <***Timeout***>).

b) ***INPut:TRIGger:ARMed***

- No multitone burst is generated.
- The analyzer immediately starts waiting for an incoming multitone burst with proprietary header (no timeout) *or* until it is reset with command ***INPut:TRIGger:BREak***.

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INTNoheader

Command: ***INPut:SYNC INTN***.

- The generated multitone burst comprises only of the user-defined multitone signal (no proprietary header).
- The analyzer only triggers (i.e. starts sampling) to the initialization command.
- The analyzer is synchronized to the internal clock.

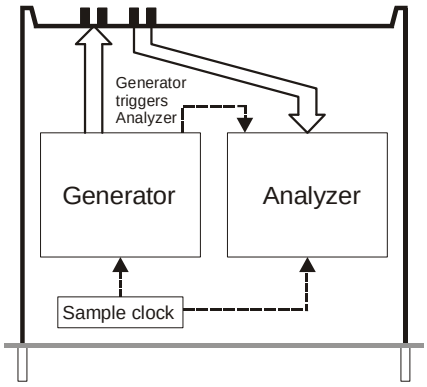


Fig 61 INTN Mode

Applications of the trigger mode "INTNoheader":

- The *RT-2M* unit generates the user-defined multitone burst and starts sampling the incoming signal after the initialization command, independent of ambient noise or muted generator output connectors.
- The *RT-2M* unit shall start sampling at a user-defined time, regardless whether the incoming signal is a multitone burst or another signal.

Initialization command: ***OUTPut:MTONe:STARt***

- The *RT-2M* generator immediately transmits the burst.
- The *RT-2M* analyzer immediately starts sampling the incoming signal.

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EXTernal

Command: ***INPut:SYNC EXT***.

- The generated multitone burst comprises of a proprietary header (trigger + 'Sync Block') and the user-defined multitone signal.
- The analyzer only triggers (i.e. starts sampling) to an incoming multitone burst with proprietary header.
- The analyzer is synchronized to the 'clock sync' block of the proprietary header of an incoming multitone burst to compensate for frequency shifts.

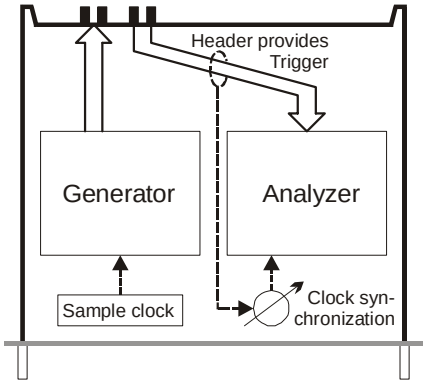


Fig 62 EXT Mode

Applications of the trigger mode "EXTernal":

- The *RT-2M* unit generates & analyzes the user-defined multitone burst after the initialization command, whereby the ambient noise level must be low and frequency shifts are allowed.
- An external unit (e.g. a remote *RT-2M* or a replay-device) generates a multitone burst with proprietary header that shall be analyzed by *RT-2M*, whereby the burst must arrive at a known time (± 4 seconds).

Initialization commands:

a) ***OUTPut:MTONe:STARt***
   - The *RT-2M* generator immediately transmits the burst.
   - The *RT-2M* analyzer immediately starts waiting for an incoming multitone burst with proprietary header during a user-defined timeout period (***INPut:TRIGger:TIMEout*** <***Timeout***>).

b) ***INPut:TRIGger:ARMed***
   - No multitone burst is generated.
   - The analyzer immediately starts waiting for an incoming multitone burst with proprietary header (no timeout) *or* until it is reset with command ***INPut:TRIGger:BREak***.

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EXTNoheader

Command: ***INPut:SYNC EXTN***.

- The generated multitone burst comprises only of the user-defined multitone signal (no proprietary header).
- The analyzer only triggers (i.e. starts sampling) to the initialization command.
- The analyzer is synchronized to the sampling clock of several previously received multitone bursts that had been transmitted in the EXT mode.

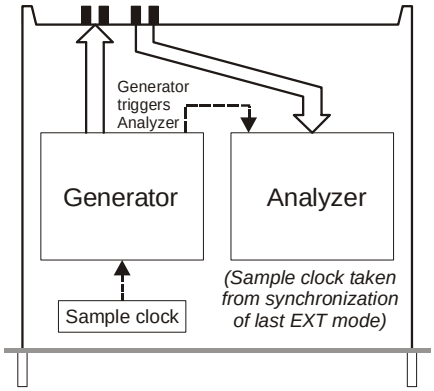


Fig 63 EXTN Mode

Initialization command: ***OUTPut:MTONe:STARt***

- The *RT-2M* generator immediately transmits the burst.
- The *RT-2M* analyzer immediately starts sampling the incoming signal.

NOTE **The EXT mode is only required for very specific applications and needs a very profund understanding of the setup.**

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THReshold

Command: ***INPut:SYNC THR***.

- The generated multitone burst comprises only of the user-defined multitone signal (no proprietary header).
- The analyzer triggers (i.e. starts sampling) if the input level exceeds a user-defined threshold level (like a scope trigger).
- The analyzer is synchronized to the internal clock.

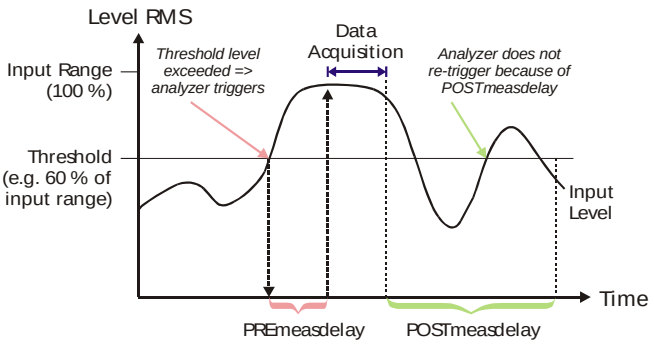


Fig 64 Example of Threshold Triggering with Delay

Adjust the threshold level for the active input channel by using the command ***INPut:TRIGger:THReshold:LEVel*** <***ThreshLevel***>. It defines the threshold in % of the current input range. In A-D or D-D operation, the reference level is 0 dBFSp = 100 %.

If required, let the analyzer wait with the data acquisition for a time delay $t_{PreMeasDelay}$ after the trigger condition has been met (***Fig 64***).
Define this delay with the command ***INPut:TRIGger:THReshold:PREmeasdelay*** <***PreMeasDelay***> after having completed the signal definition.
If no delay has been defined or after the commands ***OUTPut:MTONe:PARameter ...*** or ***OUTPut:MTONe:ACTive ...***, the default delays of ***Table 15*** apply.

f_s	*Blocklength*	*Default Delay*
8 kHz	*128*	128 ms
	256	256 ms
	512	256 ms
	1024	640 ms
	2048	512 ms
48 kHz	*512*	74 ms
	1024	170 ms
	2048	170 ms
	4096	426 ms
	8192	341 ms

Table 15 Default Delays of Threshold Trigger

Furthermore, it is possible to prevent the analyzer from re-triggering for a user-defined time delay $t_{PostMeasDelay}$ with the command ***INPut:TRIGger:THReshold:POSTmeasdelay*** <***PostMeasDelay***> after the data acquisition is completed (refer to ***Fig 64***).

ATTENTION **Define and activate the multitone signal before setting the time delays $t_{PreMeasDelay}$ and $t_{PostMeasDelay}$.**

The trigger mode "THReshold" is typically used for the analysis of externally generated signals.

Initialization commands:

a) ***OUTPut:MTONe:STARt***
   - The *RT-2M* generator immediately transmits the burst.
   - The *RT-2M* analyzer immediately starts waiting for an incoming signal that exceeds the threshold during a user-defined timeout period (***INPut:TRIGger:TIMEout*** <***Timeout***>).

b) ***INPut:TRIGger:ARMed***
   - No multitone burst is generated.
   - The analyzer immediately starts waiting for an incoming signal that exceeds the threshold level (no timeout) *or* until it is reset with command ***INPut:TRIGger:BREak***.

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Time Delay Measurement

Based on the measurement of the phase shift of a device, the *Signal Bin Delay* $T_{SignalBin}$ can be calculated according to the following equation.

$$T_{SignalBin}\,[\mathrm{sec}] = \frac{\varphi_{SignalBin}\,[\mathrm{deg}]}{f_{SignalBin}\,[Hz] * 360^{o}\,[\mathrm{deg}]}$$

Equation 24 Signal Bin Delay

The signal bin delay $T_{SignalBin}$ calculation refers to the phase $\varphi_{SignlaBin}$ and the frequency $f_{SignalBin}$ of a certain signal bin in a transmitted multitone signal.

The maximum signal bin delay that can be measured with RT-2M depends on the frequency of the signal bin. In practice, the signal bin should be defined at the lowest possible frequency, i.e. Bin_{Min} (p. **152**). In such a case, $T_{SignalBin}$ can equal up to 49.8 ms (if φ = 359° and $f_{SignalBin}$ = 20 Hz).

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Transmission Line Testing

RT-2M allows measuring the characteristics of transmission lines (e.g. broadcast network, satellite link etc.), whereby the sending unit (e.g. a remote *RT-2M*) is *physically separated* from the analyzer.

Set up the sending & receiving *RT-2M* units as follows:

1. Define the multitone test signal according to the specific demands of the test (available bandwidth, number of bins, signal duration etc.). Save exactly this multitone signal on all involved units. Set the trigger mode of the generator to ***INPut:SYNC INTernal***.
2. Adjust the output level of the sending *RT-2M* to a value that leaves enough headroom to the dynamic range of the transmission line (no clipping must occur!).
3. Adjust the input range of the analyzing *RT-2M* unit(s) (p. ***125***).
4. On the analyzing *RT-2M* unit(s), set the trigger mode to ***INPut:SYNC EXTernal***.
5. Initialize the analyzing *RT-2M* unit(s) with command ***INPut:TRIGger:ARMed*** (p. ***186***)
6. Transmit the test signal with ***OUTPut:MTONe:STARt*** (if a transmission line shall be measured, it is necessary to first interrupt the broadcast signal on this line).
7. Query the required measurement results from the analyzing unit(s).

HINT *The NTI software package RT-Eval allows saving a RAPID-TEST multitone signal as *.WAV (wavefile) or as PCM file. Thus, it is possible to feed such a file to a DUT that is able to replay or to convert it to the analog domain, where the signal is analyzed by a RT-2M unit.*

Trigger Configuration

The most important topic of transmission line measurements with *RT-2M* is the definition and application of an appropriate trigger. For this purpose, three trigger configurations are available:

- *LOOSE* - standard configuration for industrial applications (noisy signals with a poor dynamic range, or internal link between generator & analyzer). The trigger condition is met rather easily, i.e. a false triggering has to be expected if the multitone signal is introduced into an ordinary broadcast program etc.
- *TIGHT* - special configuration for broadcast applications. The trigger condition has been tightened by far vs. *LOOSE* to avoid false triggering. This requires an accurate setting of the generator output level and the analyzer input range.
- *USER* - this parameter allows defining the trigger condition. However, since this application requires a very thorough and detailed understanding of the whole triggering complex, this approach is only for very advanced users, who have a profound understanding of all possibilities and their consequences.

ATTENTION **Improper configuration of the USER trigger can result in an 'always' or 'never' condition, where the analyzer triggers on almost every incoming signal, or never recognizes any trigger, even if it is a correct one.**

The trigger signal of a *RT-2M* multitone burst comprises three signal bins at different frequencies and with individual levels. To avoid false triggering, the receiving *RT-2M* permanently monitors the input signal for this pattern. Furthermore, the analyzer checks whether two more, predefined signal bins are 'empty', i.e. whether no level can be detected at these two frequencies. If this is the case, the analyzer recognizes the incoming signal as a *RT-2M* multitone burst and triggers to it.

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Fig 65 visualizes the characteristic of a *RT-2M* trigger signal. The bottom bars (**T**) at the frequencies 1, 3 and 5 represent the set signal bins and their amplitudes, defined against the ground level of the generator, whereby signal bin 1 and 5 have identical amplitudes. The frequencies 2 & 4 represent the empty bins.
Obviously, the levels of the five signal bins, together with their frequencies, make the uniqueness of the *RT-2M* trigger signal.

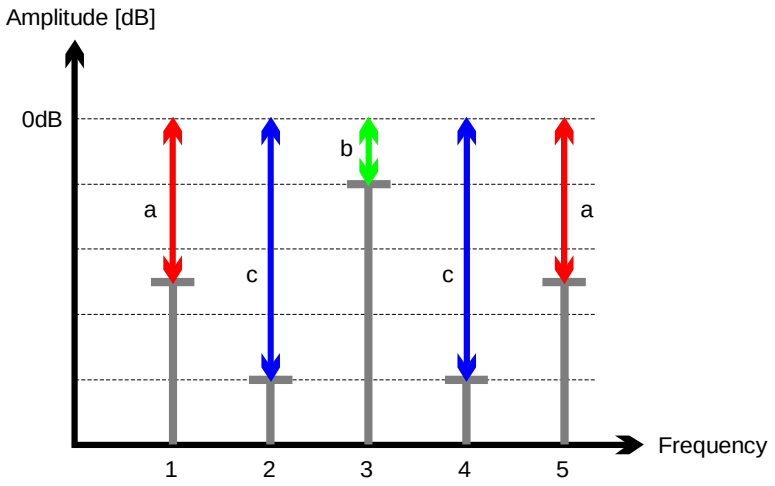


Fig 65 Trigger Definition

The application of the User trigger allows individually defining the 'headroom' between the 0dB line and the bottom bars (**T**). This is a very delicate operation and therefore not recommended for new users of *RT-2M*. In case that this feature truly has to be used, please refer to the explanations of ***INPut:TRIGger:CONFiguration ...*** and ***INPut:TRIGger:USRConfiguration ...*** as well as to the helpfile of the RT-EVAL software package.

The reference level of the analyzer especially for long-distance transmission lines cannot be of the same reference voltage potential as the generator. It is therefore configured by setting the current input range of the analyzing *RT-2M* unit as the reference level. This level equals the maximum detectable amplitude of all incoming signals (all higher levels would be clipped), and is represented by the 0 dB line on top of ***Fig 65***.
Consequently, all received signals will be analyzed against 0 dB. On applying the trigger detection criteria, this would mean that the level pattern of an incoming multitone trigger must be within a certain range, defined by the trigger configuration of the analyzer.

Application Hints

Executing transmission line measurements with *RT-2M* is very demanding, especially if the generator & analyzer (i.e. the sending & receiving unit) are located remotely. Nevertheless, by considering the instructions listed above and the following hints, it should not become a major problem to establish a properly working set-up.

- The most effective approach to successfully execute a first test run is to place the sender & receiver not too far apart (e.g. in the same room), with both units already being controlled by individual PCs. Such a setup will probably not include a long transmission line, but is ideally suited to adjust the required settings of the majority of the involved systems to allow a proper measurement.
- For the first signal measurements, reduce the number of stages involved to a minimum to simplify the search for possible errors. As soon as the first successful tests are completed, the number of systems in the signal path can be increased stepwise, and the respective settings can be optimized to the actual demands.
- A very helpful tool to find out possible problems is to use a monitor speaker to make the transmitted multitone burst audible at the different stages of the line. Consequently, by listening to the sound of the burst, the operator can simply localize critical components and optimize their transmission behavior.

The most frequent obstacle of transmission line test setups is the 'refusal' of the analyzer to trigger to the incoming multitone burst. This effect is usually caused by improper adjustments of

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the involved *RT-2M* generator / analyzer, or by sound enhancing instruments (e.g. equalizer, compressor, limiter, compander etc.) on the transmission line, which modify the trigger signal in a way that cannot be recognized anymore.

Consequently, the efforts to overcome non-successful triggering have to focus on the proper adjustment of the sending and the receiving *RT-2M*, as well as on the mutual optimization between the trigger signal and the sound enhancing systems.

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Units

dBm

This is basically a *RMS level* unit. It refers to the level of a 1 mW signal that is dissipated across 600 Ω. In practice, the reference impedance does not need to be 600 Ω. However, the I/O impedance of the test instrument & the DUT have to match, i.e. must be identical.

The definition for true dBm is

$$U[dBm] = 20 * \log_{10}\left(\frac{U_{Z1020}[V_{RMS}]}{\sqrt{0.001[W] * |Z1020|}}\right)$$

Equation 25 dBm Definition

whereby U_{Z1020} [V] is the voltage across $|Z1020|$ [Ω], i.e. the absolute value of the load impedance at 1020 Hz.

NOTE **Some test instruments do not refer their dBm measurements to the actual load impedance, but to an assumed value of 600 Ω. In practice, this corresponds to the *dBu* unit, which refers to a reference level of 0.7746 V. Nevertheless, RT-2M always measures dBm according to *Equation 25*.**

Make sure that RT-2M generates or measures a dBm level correctly by activating the corresponding output- & input-impedance as described in chapter ***Impedance of Analog Output & Input*** (p. ***123***). Keep in mind that the dBm level depends on the actual impedance.

- If the RT-2M output level is expressed in dBm (***OUTPut[1¦2]:LEVel <Level> DBM***), the actual output *Voltage* (expressed in *V*, *dBV*, *Vp* or *dBVp*) depends on the output impedance (commands ***OUTPut[1¦2]:IMPedance …***, ***OUTPut[1¦2]:STATus?***).
- If the measurement results Level, Distortion, RSS or Noise are expressed in dBm, the returned values depend on the actual input impedance (refer to the commands ***INPut[1¦2]:IMPedance …***, ***INPut[1¦2]:STATus?***).

NOTE **Tor generate or measure a dBm level correctly, the selected I/O impedance of RT-2M must match to the corresponding impedance of the DUT.**

NOTE **A generated dBm level or measurement result changes if the I/O impedance is changed. Therefore, always select the RT-2M I/O impedance before the multitone burst is transmitted.**

On the other hand, keep in mind that the output level, expressed in a RMS or peak unit, will not change its value if the output impedance is changed.

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Overview

Unit	*Explanation*	*Conversion Formula*
V, V_{RMS}	Volt RMS	
V_{Peak}	Volt Peak	
dB	Decibel: relative voltage level (U_1 measured against a reference voltage U_2)	$dB = 20 * \log_{10}\left(\frac{U_1\,[V]}{U_2\,[V]}\right)$
dBPA	dB Pascal: air pressure in logarithmic scale	$dBPA = 20 * \log_{10}\left(\frac{U\,[V]}{MicSensitivity\,[V/Pa]}\right)$
dBV	dB Volt: RMS voltage referred to 1 V_{RMS}	$dBV = 20 * \log_{10}\left(\frac{U\,[V]}{1\,[V]}\right)$
dBVp	dB Volt Peak: peak voltage referred to 1 V_{Peak}	$dBVp = 20 * \log_{10}\left(\frac{U\,[V_{Peak}]}{1\,[V_{Peak}]}\right)$
dBm	Power relative to 1 mW. Please note that every dBm result refers to the actual input impedance Z, as e.g. Z = 600 Ω.	$dBm = 20 * \log_{10}\left(\frac{U\,[V]}{\sqrt{0.001\,[W] * Z\,[Ohm]}}\right) = 10 * \log_{10}\left(\frac{P\,[W]}{P_0\,[W]}\right)$

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Voltage Divider

RT-2M supports measurements of voltages higher than the specified max. input range, supposed that a voltage divider is inserted between the DUT and the *RT-2M* input connectors. For instance, testing a 100 V PA-system would exceed the maximum allowed *RT-2M* input voltage, but becomes possible with the setup shown below.

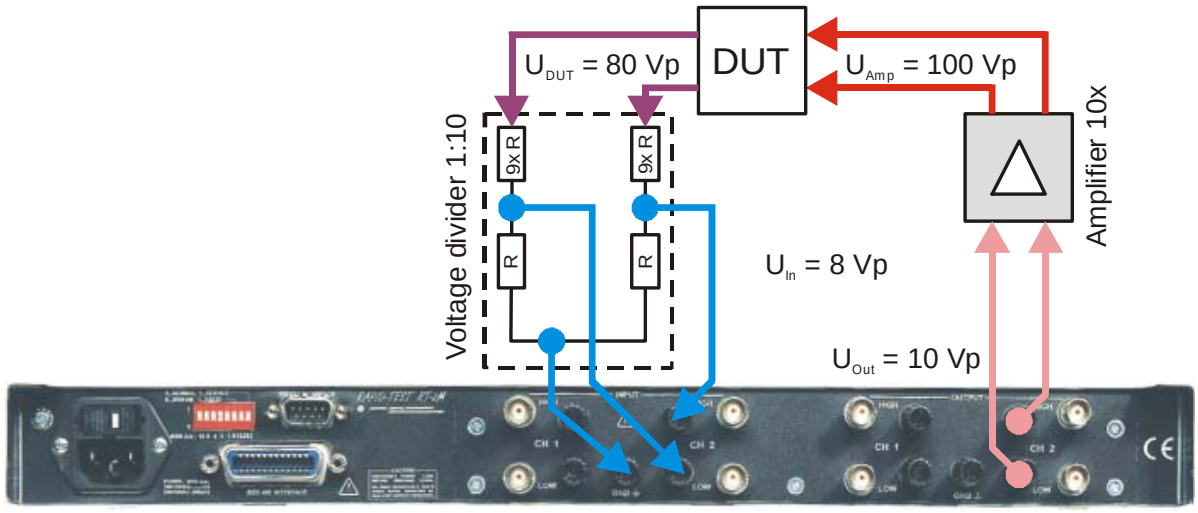


Fig 66 High-Voltage Measurement with Voltage Divider

To get correct measurement results, enter the ratio of the connected voltage divider (in the given example: <Ratio> = 10) with command ***INPut[1¦2]:VOLTagedividerratio*** <***Ratio***>.

NOTE	***RT-2M* automatically adjusts the input range according to the entered ratio. In other words, adjust the input range by entering the voltage U_{DUT}.**

NOTE	**Make sure that the voltage divider is dimensioned properly according to the transmitted signal power.**

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Wiring of Analog Circuits

Analog DUTs can be connected directly to the 4 mm 'banana' or the BNC connectors on the rear panel of *RT-2M*.
These connectors can be used for balanced or unbalanced setups (see below), whereby *balanced* connections between the *RT-2M* inputs & outputs and the DUT are preferred in practice.

Use shielded cables for the wiring between the DUT and *RT-2M* to minimize noise and hum. Connect the shield of the cables to ground only on one side to avoid ground loops.

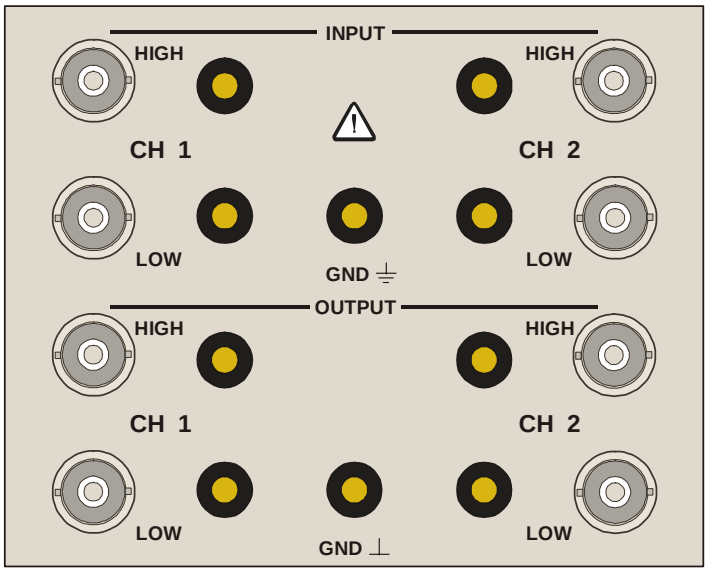


Fig 67 Analog Output & Input Connectors

Analog Input Connections

DUT Output ↔ Balanced RT-2M Input

Apply the *balanced* input connection to get a high noise and hum immunity. This applies for almost all measurements.

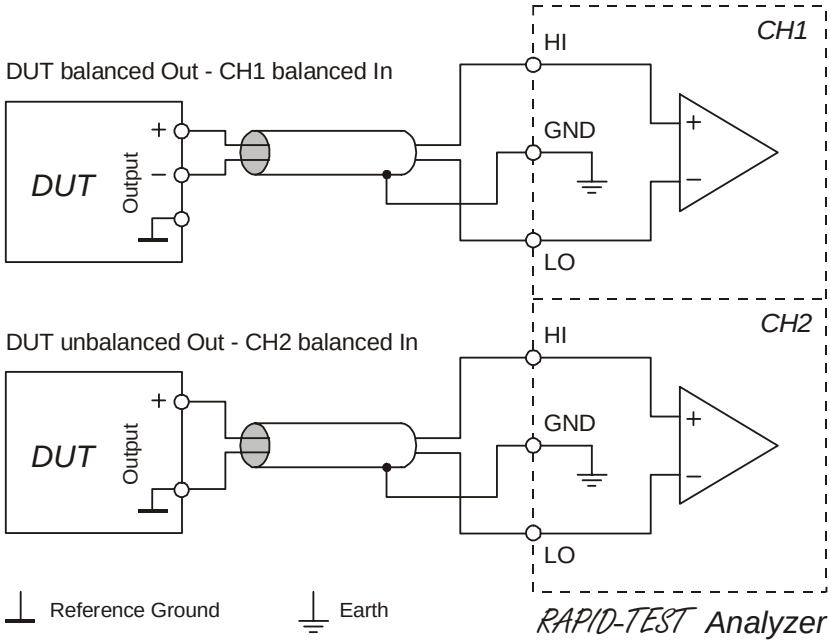


Fig 68 Balanced Input Connection through Banana Cables

Fig 68 shows the possible wiring between a DUT and the balanced input section of *RT-2M* by using shielded cables with *banana* connectors. In both cases, the 'hot' signal ("+") is connected to the HI input, whereby the shield of the cable is tied to earth on the side of *RT-2M*.

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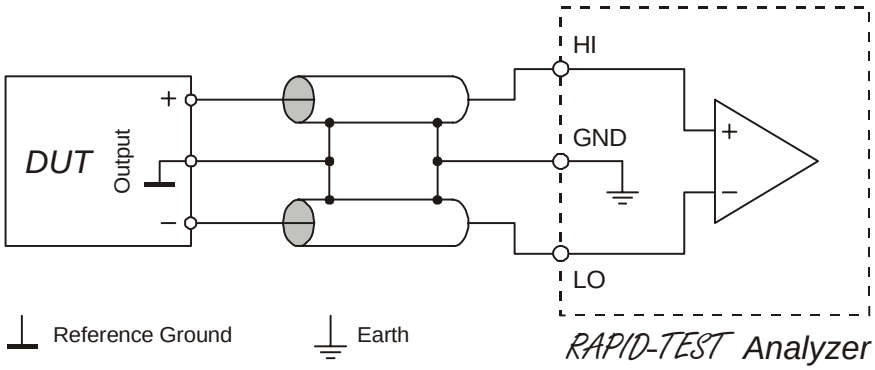


Fig 69 Balanced Input Connection through BNC Cables

Fig 69 shows the only possible wiring between a DUT and the balanced input section of ***RT-2M*** by using shielded cables with *BNC* connectors. Please note that ground loops could occur if the 'Reference Ground' is connected to earth within the DUT.

DUT ↔ Unbalanced RT-2M Input

The ***RT-2M*** input section can handle *unbalanced* signals as well. Unbalanced connections have one hot signal against chassis ground and are only recommended for short lines (below 3 ft / 1 m) and in noise-free environments.

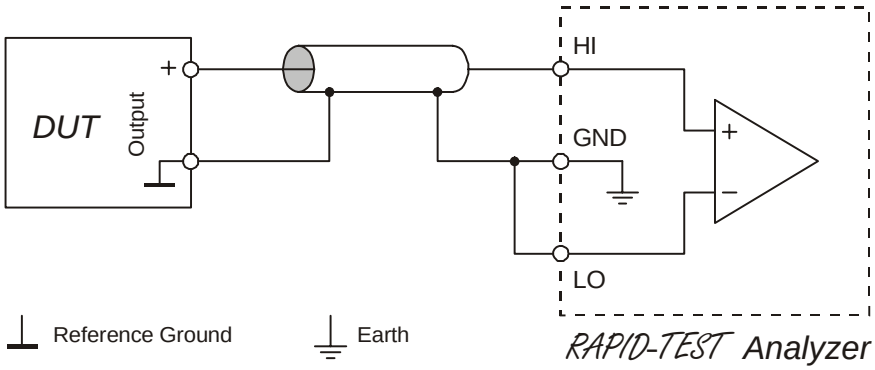


Fig 70 Unbalanced Input Connection

Fig 70 shows an example of how to connect an unbalanced DUT to the ***RT-2M*** input section. This wiring can be established either through banana or BNC connectors.

In this setup, the 'hot' output signal from the DUT is connected to the HIGH input of ***RT-2M***, whereby the cable's shield is used as the return signal, i.e. as common ground. Please note that the LO input of ***RT-2M*** must be connected to the cable shield / GND.

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Analog Output Connections

Balanced RT-2M Output ↔ DUT

NTI recommends connecting the *RT-2M* output section with the DUT through a *balanced* wiring. For most applications this setup is preferable to an unbalanced wiring.

Fig 71 and ***Fig 72*** show such a wiring between the *RT-2M* generator and the balanced inputs of a DUT, established through banana and BNC cables. In both cases, the output Voltage U_{Out} = 1 Vp is achieved by superposing the two voltages of the HIGH and the LO output, U_{Out_HI} and U_{Out_LO}.

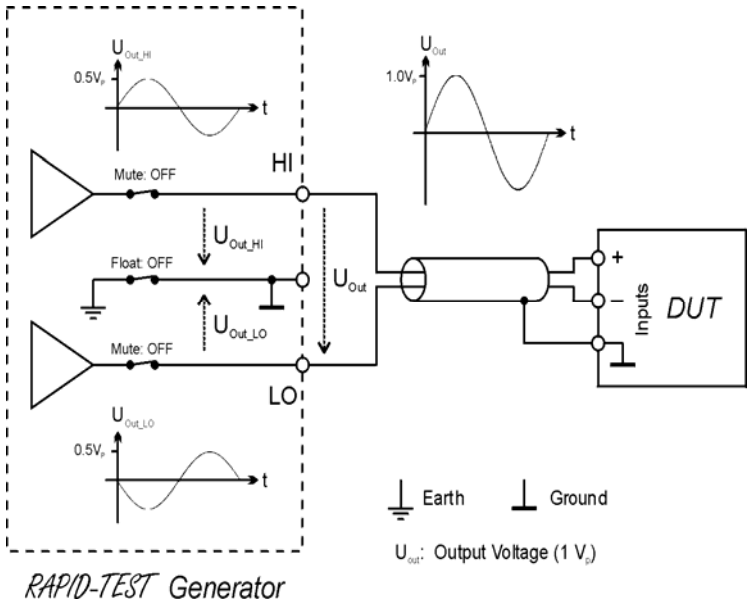


Fig 71 Balanced Output Connection through Banana Cables

In case of a balanced connection through *banana* cables, link the reference ground of the *RT-2M* generator to earth by closing the FLOAT relay with command ***OUTPut:FLOAT OFF***.

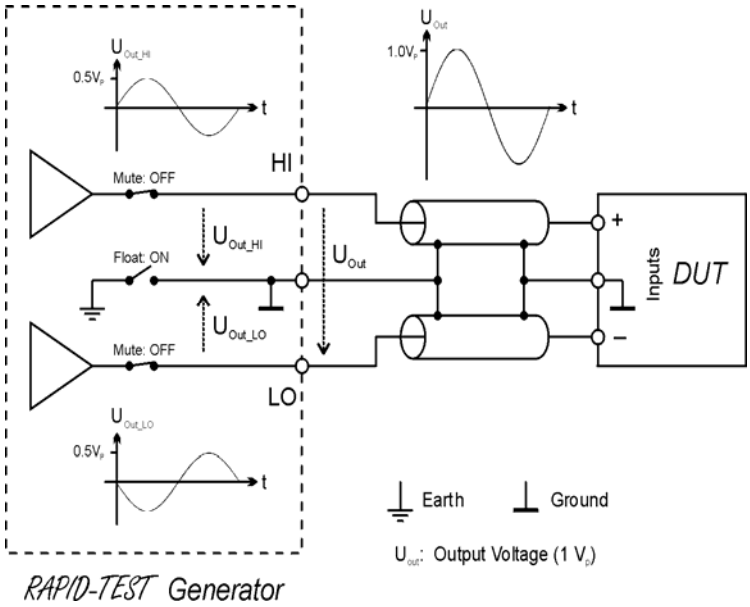


Fig 72 Balanced Output Connection through BNC Cables

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In case of a balanced output connection through *BNC* cables, open the FLOAT relay to avoid a ground loop (unless the DUT has no ground connection). Use the command ***OUTPut:FLOAT ON*** for this setting.

NOTE **NTI strongly recommends to establish balanced connections, where both the *RT-2M* HI and LO output are connected to the DUT.**

If the DUT has only an *unbalanced input*, it is still possible to connect it to the *balanced output* of *RT-2M* by using Banana cables.

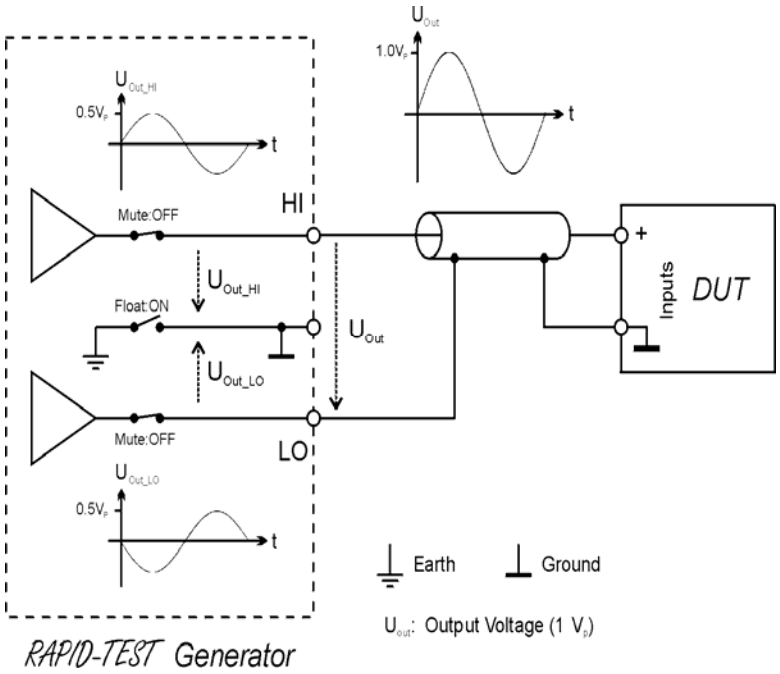


Fig 73 Balanced Output to Unbalanced DUT Connection through Banana Cables

In this case the *RT-2M* output level U_{Out}, defined through the command ***OUTPut[1¦2]:LEVel <Level> [V¦VP¦DBV¦DBVP¦DBM]*** is equal to the DUT's input level.

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Unbalanced RT-2M Output ↔ DUT

Another application is the *unbalanced output* connection of ***RT-2M*** to a DUT. In this case, the actual output level of ***RT-2M*** will always be 50 % (–6 dB) below the value of ***OUTPut[1¦2]:LEVel <Level> [V¦VP¦DBV¦DBVP¦DBM]***. The reason for this effect is explained in the following picture.

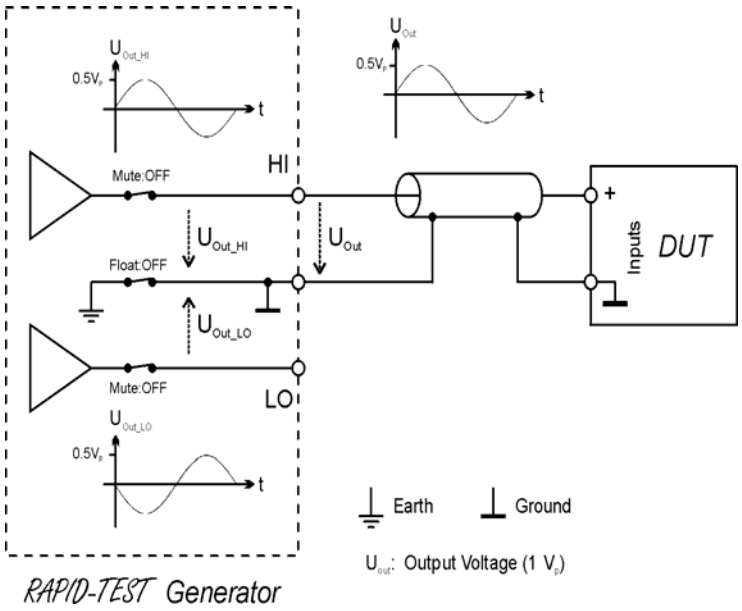


Fig 74 Unbalanced Output Connection through BNC Cables

Obviously, the "LO"-component of the differential output signal is not connected to the DUT, thus resulting in an output voltage $U_{Out} = U_{Out_HI}$, equaling the "HIGH"-signal. In other words, the actual output signal – i.e. the signal that is fed into the DUT – corresponds to *half* the amplitude of the selected output level.

NOTE **In case of an unbalanced output connection, the actual output voltage only equals half the selected output level ($U_{Out} = U_{Selected}$ – 6 dB).**

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APPENDIX

Technical Specifications

Generator & Analyzer

Level flatness of the combined generator & analyzer	
• *100 Hz – 10 kHz*	< ±0.1 dB
• *20 Hz – 20 kHz*	< ±0.2 dB
Temperature coefficient	0.025 dB / 5 °C in the operation range +5 to +45 °C with minimum 12 mm free rack space above and below the RT unit as well as free air circulation

Multitone Generator

Number of frequencies (signal bins) per multitone signal	1 – 31
Sampling rate (fs)	48 kHz
Frequency range	20 Hz – 20 kHz
Number of channels	2 independent channels with individual levels
Level range (balanced)	–60 to +29 dBVp in 0.1 dB steps (0.1 mVp to 28 Vp) –60.8 to +28.1 dBm @ 600 Ω, sine signal (1–tone)
Level setting resolution	0.1 dB
Maximum load	150 Ω HIGH to LOW (level ≤ 23 dBVp [14.14 Vp]) 2.0 kΩ HIGH to LOW (whole level range)
Variable BinLevel dynamic range	60 dB
Level accuracy @ 1 kHz	< ±0.1 dB
Level flatness	
• *100 Hz – 10 kHz*	< ±0.1 dB
• *20 Hz – 20 kHz*	< ±0.2 dB
Frequency resolution	5.85 – 93.6 Hz (depending on blocklength)
Frequency accuracy	< ±50 ppm
Blocklength	512, 1024, 2048, 4096, 8192
Residual distortion	< –86 dB (16 bit DAC)
Number of stereo multitone signal memories	4 programmable
Selectable output impedance per channel	150 Ω, 600 Ω

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Stepped Sweep Generator

Number of channels	2 channels with individual levels
Sampling rate (fs)	48 kHz
Frequency range	20 Hz – 20 kHz
Level range (balanced)	–60 to +29 dBVp in 0.1 dB steps (0.1 mVp to 28 Vp) –60.8 to +28.1 dBm @ 600 Ω
Level setting resolution	0.1 dB
Maximum load	150 Ω HIGH to LOW (level ≤ 23 dBVp [14.14 Vp]) 2.0 kΩ HIGH to LOW (whole level range)
Amplitude shape dynamic range	60 dB
Level accuracy @ 1 kHz	< ±0.1 dB
Level flatness	
• *100 Hz – 10 kHz*	< ±0.1 dB
• *20 Hz – 20 kHz*	< ±0.2 dB
Frequency resolution	1 – 500 steps
Frequency accuracy	< ±50 ppm
Residual distortion	< –86 dB (16 bit DAC)

Chirp Generator

Number of channels	2 channels with individual levels
Sampling rate (fs)	48 kHz
Frequency range	20 Hz – 6 kHz
Level range (balanced)	–60 to +29 dBVp in 0.1 dB steps (0.1 mVp to 28 Vp) –60.8 to +28.1 dBm @ 600 Ω
Level setting resolution	0.1 dB
Level accuracy @ 1 kHz	< ±0.1 dB
Level flatness	
• *100 Hz – 6 kHz*	< ±0.1 dB
• *20 Hz – 6 kHz*	< ±0.2 dB
Maximum load	150 Ω HIGH to LOW (level ≤ 23 dBVp [14.14 Vp]) 2.0 kΩ HIGH to LOW (whole level range)
Frequency accuracy	< ±50 ppm

External Output Load

Absolute maximum DC load	
• *High/Low to GND*	±10 V_{DC}
• *High to Low*	±20 V_{DC}
Absolute maximum AC load	./. (not permitted)

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Analyzer

Number of channels	2 independent channels with individual input range
Sampling rate (fs)	48 kHz
Bandwidth	20 Hz – 20 kHz
Level range	–60 to +40 dBVp (0.1 mVp to 100 Vp)
Level accuracy @ 1 kHz	< ±0.1 dB
Level flatness	< ±0.1 dB @ 100 Hz – 10 kHz < ±0.2 dB @ 20 Hz – 20 kHz
Level resolution at full scale	20 bit
Residual distortion @ level +25 to –20 dBVp	
▪ *THD+N (1-tone)*	< –86 dB
▪ *Multiton-SINAD (3-tone)*	> 86 dB
Residual noise	< –100 dBV (10 μV)
Residual input idle channel noise @ C-message filter active, inputs shorted, input range @ –60 dBVp	< –18 dBrnc (–108 dBm @ 600 Ω)
Phase accuracy (interchannel)	±1.0 deg @ 20 Hz – 17 kHz ±1.3 deg @ 17 kHz – 20 kHz
Residual interchannel crosstalk @ level +25 to –20 dBVp	< –80dB @ 20 Hz – 10 kHz < –75dB @ 10 kHz – 20 kHz

Internal frequency resolution

Blocklength	*Frequency resolution*
512	46.9 Hz
1024	23.4 Hz
2048	11.7 Hz
4096	5.86 Hz
8192	2.93 Hz

Internal frequency accuracy: ±50 ppm

Frequency measurement range and accuracy of an external signal

Blocklength	*Measurement range*	*Measurement accuracy* [5]
512	187.5 – 19968.8 Hz	± (0.4 Hz + 25 ppm of f_m)
1024	93.8 – 19968.8 Hz	± (0.2 Hz + 25 ppm of f_m)
2048	46.8 – 19992.2 Hz	± (0.1 Hz + 25 ppm of f_m)
4096	23.45 – 19992.2 Hz	± (0.05 Hz + 25 ppm of f_m)
8192	23.43 – 19998.05 Hz	± (0.025 Hz + 25 ppm of f_m)

Selectable input impedance per channel	100 kΩ, 600 Ω
Input impedance accuracy	Return Loss ≥ 46 dB or 1% of resistor value
Input impedance coupling	DC coupled
Phantom power voltage	48 V_{DC} or 15 V_{DC}
Phantom voltage accuracy	±1 V_{DC}
Phantom power inward resistance	
▪ *48 V*	6.8 kΩ
▪ *15 V*	1.0 kΩ

[5] f_m = measured frequency (e.g.: fs = 48 kHz, blocklength = 2048, f_m = 2'100 Hz ⇒ accuracy = ±0.1525 Hz)

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ICP power supply option	
▪ *Open circuit voltage*	25.7 V ±5%
▪ *Current Source*	3.6 mA ±20%
Signal transmission time	260 – 1500 ms (depending on blocklength)
Synchronization & trigger modes	▪ Internal with header (analyzer triggers to proprietary header of the same RT-2M) ▪ Internal without header (analyzer triggers to generator of the same RT-2M; no proprietary header involved) ▪ External with header (analyzer triggers to proprietary header that was generated by an external signal source) ▪ Threshold (analyzer triggers as soon as the input signal exceeds the custom-defined threshold level)
Filters	▪ C-message weighting filter according to north american standard ▪ CCITT psophometric weighting filter according to ITU O.41 ▪ A-weighting filter according to IEC 651 ▪ 750 µs De-emphasis
Standard measurements	Level vs. frequency, Selective Level, Gain vs. frequency, Distortion vs. frequency, Noise vs. frequency, Phase vs. frequency, Crosstalk vs. frequency, MT-SINAD, Frequency (full band or selective)
Optional measurements	Longitudinal Conversion Loss (LCL), Longitudinal Conversion Transfer Loss (LCTL), Return Loss (RL), Echo Return Loss (ERL), Singing Return Loss (SRL high, SRL low) Transient Steepness (Rub & Buzz, sound correlation)
Test cycle time @ blocklength 512, 3 signal bins	500 ms typical

External Input Load

Absolute maximum DC load	
▪ *input impedance = 100 kΩ, HIGH/LOW to GND*	±120 V_{DC}
▪ *input impedance ≠ 100 kΩ, HIGH/LOW to GND*	±30 V_{DC} (overvoltage protection switches to 100 kΩ if U_{In} > ±30 V_{DC})
Absolute maximum AC load	
▪ *input impedance = 100 kΩ, HIGH/LOW to GND*	±120 V_{AC} (sine signal)
▪ *input impedance ≠ 100 kΩ, HIGH/LOW to GND or HIGH to LOW*	±30 Vp_{AC} [6] (overvoltage protection switches to 100 kΩ if U_{In} > ±30 V_{DC})

[6] Example: 30 Vp_{AC} ≅ 28.8 dBm @ 600 Ω, sine signal

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DTMF Generator

DTMF availability	Analog and digital mode
DTMF tones (4 x 4 keys)	1 – 9, *, 0, #, A – D
Frequency deviation	±5 % selectable in 0.01% steps
Frequency accuracy	±25 ppm
Amplitude ratio	0.1 – 10 selectable
DTMF tone length	1 – 5000 ms selectable

DTMF Analyzer

DTMF key recognition	Analog
Valid input signal levels	maximum –20 dB below input range
Freq. deviation acceptance	±1.5 %
Tone duration acceptance	minimum 50 ms
Interdigit pause acceptance	minimum 50 ms

Options & Accessories

PureSound™ license	Key code to enable the transient steepness analysis functions. Required for Rub & Buzz and sound correlation measurements. Also includes RT-Speaker software for production applications.
XLR adapter	Hook-up box for ***RT-2M*** input connectors. Provides 2 pcs. XLR inputs, e.g. for the operation of the 3382 and 3384 measuring microphones.
M2010 *measuring microphone*	Balanced ½" omni-directional microphone, 20 Hz – 20 kHz, flatness ±0.5 dB (class 1), 48 V Phantom power required.

General

Dimensions	483 x 318 x 44 mm (19" x 12.5" x 1.75", i.e. 1 rack unit high)
Weight	7 kg (15 lbs.)
Remote control interfaces	GPIB (IEEE-488.2)
	RS232 (38400 bps, 8 databits, 1 stopbit, no parity; protocol RTS/CTS; requires NTI RS232 cable)
Standard software	RT-EVAL evaluation software package
	National Instruments LabView and LabWindows CVI drivers
Mains power requirements	100, 120, 230 V_{AC} / 50, 60 Hz / 60 VA
Calibration	1 year recommend calibration interval
Operating temperature	+5 to +45 °C (+40 to +110 F), R.H. < 90 % non condensing

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