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User Manual

RT-1M



Multitone Audio Test System

Version 3.32 E
For Firmware Revision
3.25 and higher

V 3.32 / Feb. 99
\\NTI_SVR1\Instdata\RAPID-TEST\RT-1M\U_Manual\text\RT1M332.doc

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INTERNATIONAL WARRANTY

Limited Warranty

NEUTRIK guarantees the RT-1M system and its components against defects in material or workmanship for a period of one year from the date of original purchase for use and agrees to repair or replace any defective unit at no cost for either 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 any but the specified receptacles. This warranty is void unless service or repairs are performed by an authorized service center.
No responsibility is taken for any special, incidental, or consequential damages. In case of damage please take or ship prepaid your RT-1M System to your nearest authorized service center. Be sure to include your sales invoice as proof of purchase date. All transit damages that may eventually occur are not covered by this warranty.

Note

No other warranty, written or oral, is authorized by NEUTRIK. Except as otherwise stated in this warranty NEUTRIK 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 *2 INSTALLATION* carefully before operating the instrument. Important information about mains voltage selection and fuse rating are given there.**
Do never open, modify or try to repair this instrument unless properly instructed by an authorized service technician or NEUTRIK.

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CE DECLARATION OF CONFORMITY

We, the manufacturer

NEUTRIK CORTEX Instruments AG
Im Alten Riet 34
FL-9494 Schaan

hereby declare that the product

Product Name	Rapid-Test
Model Number	RT-1M
Serial No.	
Year of Construction	1996

conforms to the following standards or other normative documents

EC-Rules	89/392, 91/368, 93/44, 93/68, 73/23, 89/336, 92/31
Harmonized Standards	IEC 65, IEC 68-2-31, IEC 348 EN50081-1, EN50082-1, EN50140, EN 61010-1

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

Date	Schaan, 12. August 1996
Signature	
Position of Signatory	Product Manager Test Instruments

CE

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

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1 OVERVIEW

The trend in modern audio testing is to reduce more and more the time required for a complete performance test of the device being tested. This tendency results partly from the demand of broadcasters being forced to provide 24hour programming, leaving little time for testing. In a modern studio with dozens of input channels, several routing paths and more than 24 recording channels, a complete test including all parts of the studio becomes very time-consuming and boring since the tests are highly repetitive.
Industrial applications also require reduced test time, especially at production lines where any time wasting process becomes a bottleneck. Reducing test time by a factor of 20 to 50 ensures for years that testing will not be the limiting factor and increases production density.

RT-1M is a modern and advanced audio test system with the capability to evaluate the important performance Parameter of a device within a fraction of a second. RT-1M is a complete, optimized system, containing a remote controllable generator as well as an intelligent analyzer, and can be easily integrated into an automated environment. The system provides the highest performance and specifications to meet also the requirement of professional equipment.

- *Frequency range* 20Hz to 20kHz
- *Output level* -60dBVp to +20dBVp
- *Input range* -60dBVp to +20dBVp
- *Measurements* level, noise, distortion, crosstalk and phase in one step
- *Burst transmission time* typ. 250-960ms
- *Residual distortion* < -86dB

RT-1M is very simple in terms of connecting, handling and use within any automated environment, but highly complex in terms of the implemented structures and algorithms to perform the analysis in a extremely short period of time.

RT-1M is very compact, using the most advanced technology available on the market. Within its case of 19“ width and height of one unit (1.75“) only, it provides two generator channels and two independent analyzer channels. The analyzer and generator can be operated completely independently even though they are located in the same housing.

There is no external synchronization required to perform the analysis. Each transmitted multitone signal contains an information header allowing any listening analyzer to synchronize onto the signal.

Communication

Since RT-1M does not provide any control elements, it must be completely controlled by a host PC. Due to performance reasons, an IEEE-488 parallel interface has been integrated into the instrument. This allows to transmit any command independently of the actual generator and/or analyzer activities. The instruction to transmit a previously defined multitone signal can be issued from the PC at any time.

Consequently, the basic requirements for the host PC is a standard IEEE-488 interface board with installed software drivers. Detailed descriptions of the IEEE-488 connection and all commands are filed in chapters ***Mains Cable*** and ***Programming*** respectively.

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Accessories & Options

Software Tools

Following software packages for RT-1M are available free of charge from your local NEUTRIK representative.

- RT-EVAL Evaluation Software
- LabView® Driver Library
- LabWindows® CVI Driver Library

Please notice, that for either of these tools a GPIB-interface board from National Instruments™ (type GPIB-PCMCIA or GPIB/TNT or GPIB-PCIIA [production year 1992 or later]) must be installed in your host controller.

Application Notes

The appendix of this User Manual comprises the documents

- Introduction to RT-1M
- Get Familiar with Writing Code for RT-1M
- Cellular Phone Testing
- Comparison of Conventional vs. Multitone Testing

Additional application notes on speaker testing, external signal analysis etc. will be released in future. Please contact you local NEUTRIK representative for further information.

DTMF Option

Optional PCB to be installed internally, allowing to monitor 1 channel on incoming DTMF (Double Tone Multiple Frequency) signals in parallel to the normal operation (see p. 34).

Microphones & Phantom Power Supply

NEUTRIK provides two measuring microphones for industrial applications.

- 3382 ¼" measuring microphone
- 3384 ½" measuring microphone

To allow the use of these microphones with RT-1M, an optional Phantom power box is available to provide the necessary supply voltage through XLR connectors. The box is plugged to the input banana connectors and comes along with an AC mains adapter.

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2 INSTALLATION

This chapter is intended as help for proper unpacking and installation of the RT-1M system. Please read it carefully to avoid wrong connections or inconveniences during operation of the instrument.

Unpacking

RT-1M has been carefully packed by NEUTRIK to avoid damages during transportation. Should the box show severe damages, please immediately check the instrument inside on external impacts. In case of any visible damage, please do not send the instrument back but contact your local dealer and / or the carrier to avoid loss of claims for replacement.

Rack Mount

RT-1M is designed to mount in a 19“ Rack and occupies one unit of height or rack space (1.75“) only. Please allow at least 2“ additional depth at the rear side for all necessary connectors. Make sure there is enough air circulation around the unit for cooling purposes and please do not place RT-1M besides high temperature devices such as power amplifiers in order to avoid overheating.
The specified operating temperature ranges between 5° and 45°C (40-110F) while humidity must not exceed 90% R.H. non-condensing.

AC Power Connection

Before connecting the instrument via mains cable to the power source, make sure that the voltage selector label on the connector / fuse holder assembly of the RT-1M system matches the supply voltage of the local area. If the instrument is not compatible with the available power source, follow the next paragraph to change the voltage selector.

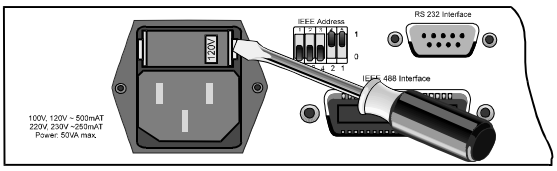


Fig. 1 Voltage Selector

RT-1M can operate from 100VAC, 120VAC and 230VAC sources. To reconfigure the input line voltage, remove the power cable and open the flap of the connector/fuse holder at the rear side of RT-1M. Either 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 matching voltage indication points towards you. At the same time replace the mains fuse with the proper current rating. For voltages of 100V to 120V a slow 2A fuse has to be installed, while for 230V a slow 1A fuse is appropriate.
After selection of the correct mains voltage and fuse, close the flap and insert the power cable.



RT-1M is designed with a protective ground (earth) connection through the ground wire of the power cord. This connection is essential for safe operation. Never operate the instrument if safety ground is unavailable or has been compromised.

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Mains Cable

The enclosed mains power cable has an unconnected end with three colored leads, which correspond to

Brown	=	Live (AC)
Blue	=	Ground
Yellow/Green	=	Earth

Attach a mains plug to the cable that fits the receptacles of your country.

IEEE Connection

The *RT-1M* system provides an IEEE-488 interface (standard design interface for programmable instrumentation) which is connected to the IEEE bus using a standard IEEE-488 interface cable from the rear panel illustrated in ***Fig. 2***.

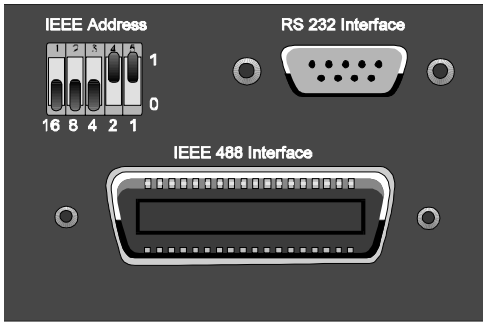


Fig. 2 IEEE Connector

With the IEEE interface bus, up to 31 instruments can be interconnected. The cables have identical piggy-back connectors on each end so that several cables can be connected in virtually any configuration. There must be, of course, a path from the computer to every device operating on the bus.
As a practical matter, avoid stacking of more than three or four cables to a single connector. If the stack gets too long, any force on the stack can damage the connector mounting. Be sure that each connector is firmly screwed in place.

IEEE Address Selection

Each IEEE device has at least one talk and listen address (unless totally transparent or a talk or listen only device). The address of the *RT-1M* can be adjusted with the DIP switch at the rear panel of the instrument (see ***Fig. 2***). Each switch position has a number printed underneath. The resulting IEEE address is the sum of all numbers, where the switch is in position “1“. The above illustrated example has an address selection of 3, since switch 1 and switch 2 are in position "1". The five switches allow the selection of any address in the range from "1" to "31" inclusively.

Audio Connection

RT-1M features balanced and unbalanced BNC and 4mm banana connectors for both inputs and outputs. Balanced connections enhance the noise and hum immunity and are always recommended for measurement purposes. *RT-1M* can also handle unbalanced signals.

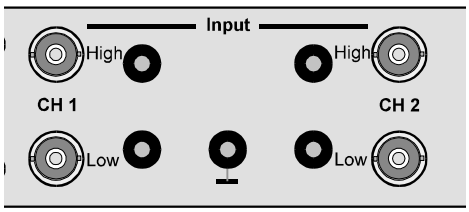


Fig. 3 Front Connectors

Unbalanced signals normally have one hot signal against chassis ground. For this reason unbalanced connections are recommended for short connections only (less than 1m / 3 feet) or in a relatively noise-free environment.
You may use either the set of front connectors with two inputs & outputs or the equivalent set of connectors at the rear panel of the instrument.

Caution:	**Do not connect both front and rear panel connectors at the same time since this may result in signal mismatching.**

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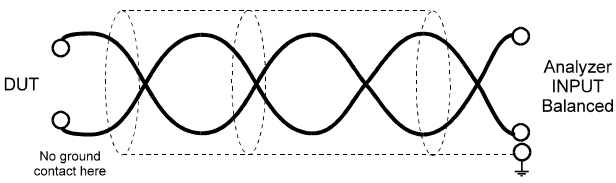


Fig. 4 Shielded Twisted Pair Cable

Connections between an unbalanced DUT and the balanced inputs of RT-1M should preferably be made with shielded twisted pair cables to avoid the introduction of noise and hum. The shield of such a cable shall be grounded only on one side. Grounding the shield on both sides increases the chance to build ground loops.

Balanced Connection

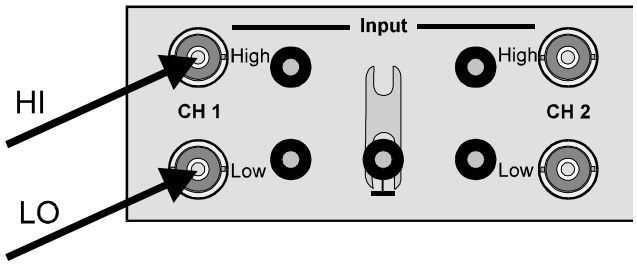


Fig. 5 Balanced BNC / Banana Connection

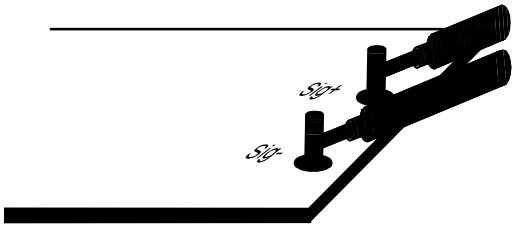


Fig. 6 BNC Cable - Balanced

Balanced connections with two BNC cables can be realized by connecting them to the RT-1M HIGH and LOW inputs. The ground shells of both connectors are wired to ground. Do not connect the shields together on the instrument side of the DUT but leave them open. With balanced connections do not assemble the short circuit bar.
You may also use banana inputs instead of BNC inputs. The respective HIGH and LOW inputs of the BNC and banana connectors are internally wired together.

Caution: For balanced signals make sure that not only the front ground connection is disassembled but also the ground bar at the rear panel!

Unbalanced Connection

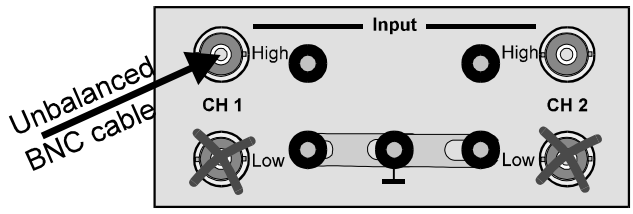


Fig. 7 Unbalanced Connection

If you use the HIGH input only of RT-1M for connecting the hot output of the DUT, use the BNC cable's shield as the return signal (common of the DUT output).
When using the generator in unbalanced mode, the available level will always be 6dB (50%) below the defined level.

Battery Low Indication

RT-1M contains a battery for backup purposes of the internal memories. Life expectancy of the battery is about ten years. Should the battery become low, the 'Error' LED will blink 3 to 4 four times after a start-up and ***Error 220 Battery low (memory backup)*** is generated.

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LED Indicators

During the initialization period of RT-1M system (normally <1s) all LEDs are active. If the unit is switched ON for the very first time or after a firmware change, it has to initialize all its signals and tables. This might take up to a few minutes, depending on the signal resolution. All LEDs are lit during this period.

Power

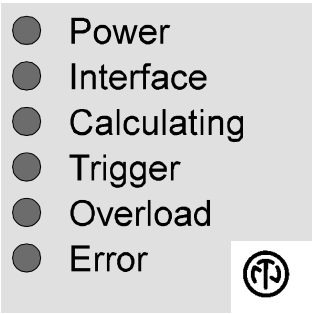


Fig. 8 LED Indicators

This LED indicates that the power of the system is switched on, the internal supply voltages are operating normally and the self-test of the system has been successfully completed.

Should it stay off after switching on the instrument please check whether the power cable is connected to the system, the voltage selector is set for the correct supply voltage and the wall socket is switched on.
Should the power LED still be off, check the power fuse in the connector / fuse holder assembly of RT-1M. Please refer to ***AC Power Connection*** to see how to open it.

WARNING Do not try to do further repairs. Call your local dealer for support.

Interface

This LED indicator lights up if the IEEE interface is busy and receives a command. It remains illuminated until the user has read the answer from the interface. In standby mode with no activity on the IEEE interface the LED is off.

Calculating

Whenever FFT or filtering calculations are performed this LED lights up.

Trigger

This LED indicator goes on as soon as a RT-1M trigger has been successfully detected and remains lit until the user has read the result(s) from the buffer.

Overload

Should the input signal overload one or both channels, the LED indicator goes on. This happens if the maximum input voltage of 20dBu (10V) is exceeded or if a higher voltage than the selected range is applied. In such a case the error LED also lights up. The overload LED resets with the next measurement and the ranges set correctly.

Error

RT-1M handles an error queue internally. Whenever an error is detected – hardware or software – the error LED comes on. It disappears as soon as the error number has been queried through the IEEE interface.

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Test of Function

After connection of the cables and proper setting of the IEEE address it is recommended to run the subsequent short program to confirm the proper function of the system. *RT-1M* can be operated with any operating system providing an IEEE-488 interface.

HT-BASIC Program Example

```
  10                                        !     RT-1M Demo Program
  20
  30   Adr=11                               !     enter IEEE address here
  40
  50   Adr=Adr+700                          !     evaluate output/enter address J
  51   GOSUB 900                            !     read device informations
  60   OUTPUT Adr;"Output:Mtone:Active 1" END
  65   OUTPUT Adr;"Output:MTone:Start" END  !     measurement loop
  70   OUTPUT Adr;"Measurement1:Level?" END !     terminate output with END
  80   GOSUB 1000                           !     read the measurements
  90   PRINT
 100   GOTO 65
 110   STOP
 900                                        !     read system information
 905   DIM Inf$[100]
 910   OUTPUT Adr;"System:Information?" END
 920   ENTER Adr;Inf$
 930   PRINT Inf$
 940   RETURN
1000                                        !     interpret incoming data stream
1010   DIM Rcv$[1000]
1020   DIM X$[10]
1030   DIM Y$[20]
1040
1050   ENTER Adr;Rcv$                       !     read data A
1060   Xpos=POS(Rcv$,"/")                   !     find X/Y separator
1070   Ypos=POS(Rcv$,",")                   !     find Y/X separator
1080
1090   WHILE (Xpos>0) AND (Ypos>0)          !     as long as there are separators do:
1100          X$=Rcv$[1,Xpos-1]             !     isolate X value
1110          X=VAL(X$)                     !     convert X string to value A
1120          Ypos=POS(Rcv$,",")            !     find Y/X separator
1130          IF Ypos>0 THEN                !     is there another value? >
1140                 Y$=Rcv$[Xpos+1,Ypos-1] !     isolate Y value
1150          ELSE
1160                 Y$=Rcv$[Xpos+1,LEN(Rcv$)] !  isolate Y value
1170          END IF
1180          Y=VAL(Y$)                     !     convert Y string to value
1190          Rcv$=Rcv$[Ypos+1,LEN(Rcv$)]   !     delete the read XY pair from string
1200          Xpos=POS(Rcv$,"/")            !     find next X/Y separator
1210          PRINT "Bin# ",X,"Meas: ",Y
1220   END WHILE
1230   RETURN
1240   END
```


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3 SYSTEM DESCRIPTION

Multitone Signals

Traditionally, audio testing stimulates the device under test (DUT) with a sinusoidal signal. This type of signal is relatively easy to handle and distortion measurements may be performed by simply notching out the single frequency.

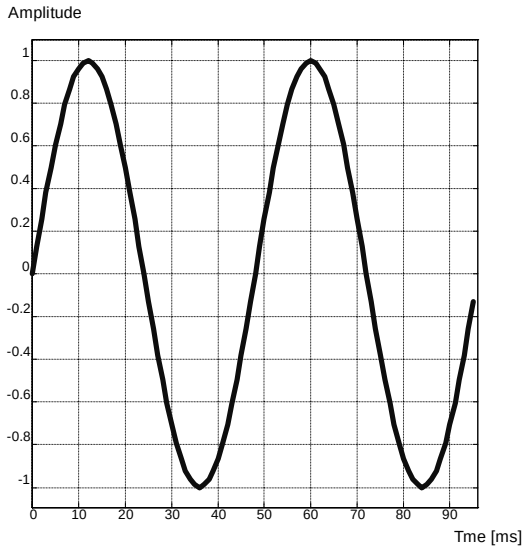


Fig. 9 Time Plot of Sinusoidal Signal

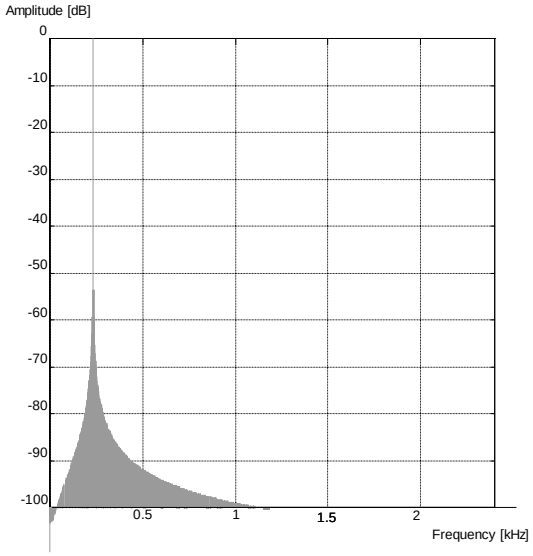


Fig. 10 Spectrum of Sinusoidal Signal

More advanced tests like intermodulation distortion measurements stimulate the device with a pair of sinusoidal signals to come closer to the real situation of audio signal transmission. In the presence of nonlinear transfer characteristics, the DUT generates new harmonic and intermodulation frequencies.

However, in practice the device is normally stimulated by music or speech which is a far more complex signal than any single or twin tone test. Many frequencies with non-correlated phase relations exist in such a real-world signal.

Therefore, multitone testing is a much more realistic approach for audio testing, emulating the complex structure of natural sound. A multitone signal typically contains 2 to ~31 signal frequencies, each with a certain phase relation, distributed over the frequency band of interest. Obviously, sophisticated test instruments are necessary to analyze all these signals with their interactions on each other.

Fig. 9 and ***Fig. 10*** show a typical multitone signal in the time- and frequency domain. It is important to know that the waveform of the time plot strongly correlates with the phase relations between its single frequencies. Since the max. amplitude of the time signal directly determines the dynamic range of both the DUT and the analyzer, a low peak value is both important and desirable.

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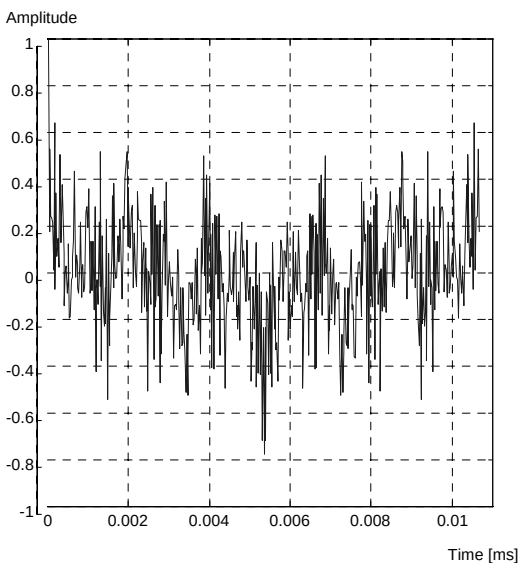


Fig. 11 Time Plot of a Multitone Signal

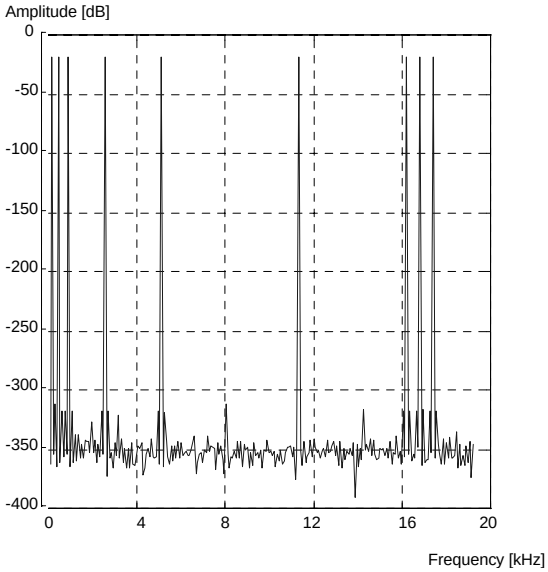


Fig. 12 Spectrum of a Multitone Signal

Obviously, it is necessary to characterize the time signal by an appropriate value in order to allow the optimization of its phase relations. The most suitable value for this purpose is the *Crest factor*, which is defined as

$$Crest\ \ factor = \frac{Peak_Value}{RMS_Value}$$

Equation 1 Crest Factor

For any (multitone) signal with given RMS value, the Crest factor will change with the peak value, which in turn depends on the phases of the signal components. An optimal distribution of the phases results in a low peak value of the resulting time signal and therefore a low Crest factor (refer also to chapter ***Phase / Crest Factor Optimization***).
NEUTRIK provides in its RT-EVAL software package a sophisticated algorithm to optimize the phases of a multitone signal. Please contact your local representative to get a free copy of this software.

Multitone Parameter

RT-1M is a digital processing system that analyzes the transmitted signal by using Fast Fourier Transformation (FFT) and calculates with its DSP all desired results out of the digitized samples.
For proper use and programming of RT-1M it is vital to understand the core parameter of this analysis as well as their relationships. Consequently, the most important definitions and formulas are explained below.

Sampling Rate

Every digitization process, i.e. conversion of an analog signal into a digital bit stream and vice versa, has to be accomplished at a certain *sampling rate* (number of samples per second). The sampling rate determines the analog bandwidth of the converter.

In RT-1M, the sampling rate is 48kHz, thus providing an analog bandwidth of up to 20kHz.

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Blocklength

The number of samples, that are actually used for one FFT, is called *blocklength*. This value determines both the duration & the frequency resolution of a multitone signal. In RT-1M, the blocklength may be selected by the user in five steps from 512 to 8192.

$$MT\ Block\ Duration = \frac{Blocklength}{Sampling_Frequency}\ [s]$$

Equation 2 Duration of One Multitone Signal Block

Note **A RT-1M multitone burst always comprises several multitone signal blocks, thus resulting in a far longer duration than the *'MT Block Duration'*.**

The blocklength also defines the lowest detectable frequency of the incoming spectrum. For example, with a blocklength of 512 @ 48kHz sampling rate, a multitone block duration of 10.7ms results, corresponding to a min. frequency of Δf = 93.75Hz (see ***Equation 3***).

Furthermore, it is important to know that only signals with an integral number of periods (reciprocal value of the signal frequency) fitting into one blocklength may be properly analyzed by the FFT.

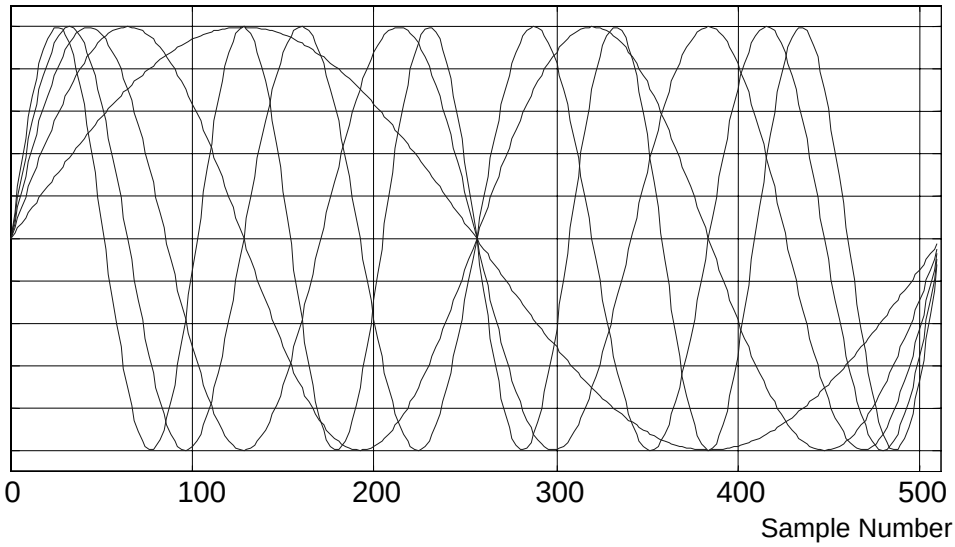


Fig. 13 The 5 Lowest Possible Time Periods @ Blocklength 512

In other words, only frequencies with an integral multiple of the lowest detectable frequency - called frequency spacing Δf - may be transmitted.

Frequency Spacing

The frequency spacing Δf corresponds to the lowest frequency that can be generated & analyzed. It defines the spectral resolution of the FFT and is calculated by following formula.

$$\Delta f = \frac{Sampling_frequency}{Blocklength} = \frac{48'000Hz}{Blocklength}$$

Equation 3 Frequency Spacing

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Only frequencies with an integral multiple of Δf may be defined as *signal bins* (see below) of a multitone burst.

Example
Blocklength = 512 @ 48kHz sampling rate
⇒ Δf = 93.75Hz
⇒ available frequencies = *n* * 93.75Hz (*n* = integral number)

Bins

The frequencies, that may be transmitted in a multitone burst, are called *bins*. For a better understanding, three types of bins have been introduced.

- *Signal bins* are those bins (frequencies) that actually build the multitone signal.
- *Even bins* are all the bins (frequencies) that emerge from ***Equation 3***, i.e. the frequencies that may be used as signal bins in a multitone signal.
- *Odd bins* are an effect the internal FFT computation of RT-1M. They represent all bins halfway between the even bins, i.e. as if the frequency spacing would equal Δf/2.

The subsequent relations indicate the min. and max. available frequencies (*bins*) in a multitone signal at 8kHz / 48kHz sampling rate (f_s).

$$f_{\min} = \Delta f \quad \{\geq 20Hz \text{ may be generated only}\}$$

Equation 4 Minimum Signal Bin Frequency

$$f_{\max} = \Delta f * \left| \frac{20kHz}{\Delta f} \right| \quad \{\leq 20kHz \text{ may be displayed}\}$$

Equation 5 Maximum Signal Bin Frequency

Besides the above equations there are no other constraints for the definition of a multitone signal. This means you can use any bin representing a frequency below or equal to 20kHz as a signal bin. It is up to the operator what the intention of the signal bins is. Please refer also to chapter ***Signal Table***.

Phase / Crest Factor Optimization

In order to achieve a low Crest factor, RT-EVAL – an evaluation PC-program provided free of charge by NEUTRIK - offers a special feature that allows to optimize the phases of any multitone signal. The results can be loaded directly from or back into the RT-1M Generator.

Low Crest factors are important for two reasons. First, the peak level of the multitone signal raises the necessary input range for the analysis and thereby reduces sensitivity for the low-level signal components. Second, the low energy content of a multitone signal with high Crest factor may barely stimulate the DUT.

A non-optimized multitone signal may show Crest factors of up to 10 (20dB), while with a proper minimization algorithm, Crest factors as low as ~2 (6dB) can be found. This difference of 14dB can directly enhance or decrease the dynamic range of the analyzing system.

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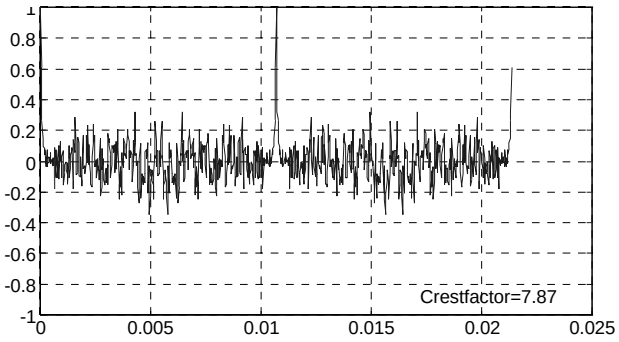


Fig. 14 Non-Optimized Multitone Signal

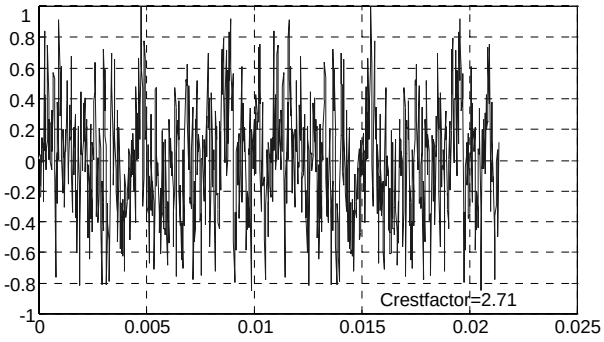


Fig. 15 Optimized Multitone Signal

Comparability of Multitone Measurements

One has to be aware that the results of multitone testing cannot be compared directly with conventionally acquired results. For instance, distortion products may appear over the entire band due to the fact that each signal bin produces harmonics and intermodulates with other signal bins. The strict separation between harmonic distortion and intermodulation cannot be guaranteed, since at certain signal bins some intermodulation products and harmonic frequencies may fall together, thus influencing the Distortion as well as the SINAD results..

However, a multitone signal comes much closer to a "real-world“ signal than any single tone test signal. The results are in qualitative terms comparable with conventional measurement results as long as the specific theory behind multitone testing is considered. With a single tone stimulus, the achieved results are directly comparable to conventional analyzers.

Please refer to the corresponding application note, filed in the appendix of this manual.

Signal Table

RT-1M supports five different blocklengths. According to ***Equation 3*** to ***Equation 5***, each blocklength results in the parameter of ***Table 1***. Please observe that the minimum signal bin frequency is ≥20Hz and that the overall duration of a burst always is longer than of a block.

Blocklength	*Min. Burst Duration (without Header)*	*Typical Burst Duration*	*Generator Resolution*	*Analyzer Resolution*
512	154 ms	260 ms	93.8 Hz	46.9 Hz
1024	284 ms	390 ms	46.9 Hz	23.4 Hz
2048	344 ms	450 ms	23.4 Hz	11.7 Hz
4096	684 ms	790 ms	11.7 Hz	5.9 Hz
8192	854 ms	960 ms	5.9 Hz	2.9 Hz

Table 1 Available Blocklengths

Blocklength 512

Frequency spacing Δf	93.75 Hz	
Analyzer resolution	46.875 Hz	
Bin_Min (f_{min})	1	(93.8 Hz)
Bin_Max (f_{max})	213	(19.969 kHz)

Table 2 Signal Parameter with Blocklength 512 @ f_s=48kHz

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Blocklength 1024

Frequency spacing Δf	46.875 Hz	
Analyzer resolution	23.4375 Hz	
Bin_Min (f_{min})	1	(46.9 Hz)
Bin_Max (f_{max})	426	(19.969 kHz)

Table 3 Signal Parameter with Blocklength 1024 @ f_s=48kHz

Blocklength 2048

Frequency spacing Δf	23.4375 Hz	
Analyzer resolution	11.71875 Hz	
Bin_Min (f_{min})	1	(23.4 Hz)
Bin_Max (f_{max})	853	(19.992 kHz)

Table 4 Signal Parameter with Blocklength 2048 @ f_s=48kHz

Blocklength 4096

Frequency spacing Δf	11.71875 Hz	
Analyzer resolution	5.859375 Hz	
Bin_Min (f_{min})	2	(23.4 Hz)
Bin_Max (f_{max})	1706	(19.992 kHz)

Table 5 Signal Parameter with Blocklength 4096 @ f_s=48kHz

Blocklength 8192

Frequency spacing Δf	5.859375 Hz	
Analyzer resolution	2.9296875 Hz	
Bin_Min (f_{min})	4	(23.4 Hz)
Bin_Max (f_{max})	3413	(19.998 kHz)

Table 6 Signal Parameter with Blocklength 8192 @ f_s=48kHz

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Generator

RT-1M comprises a completely independent two-channel 16bit 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

Block Diagram

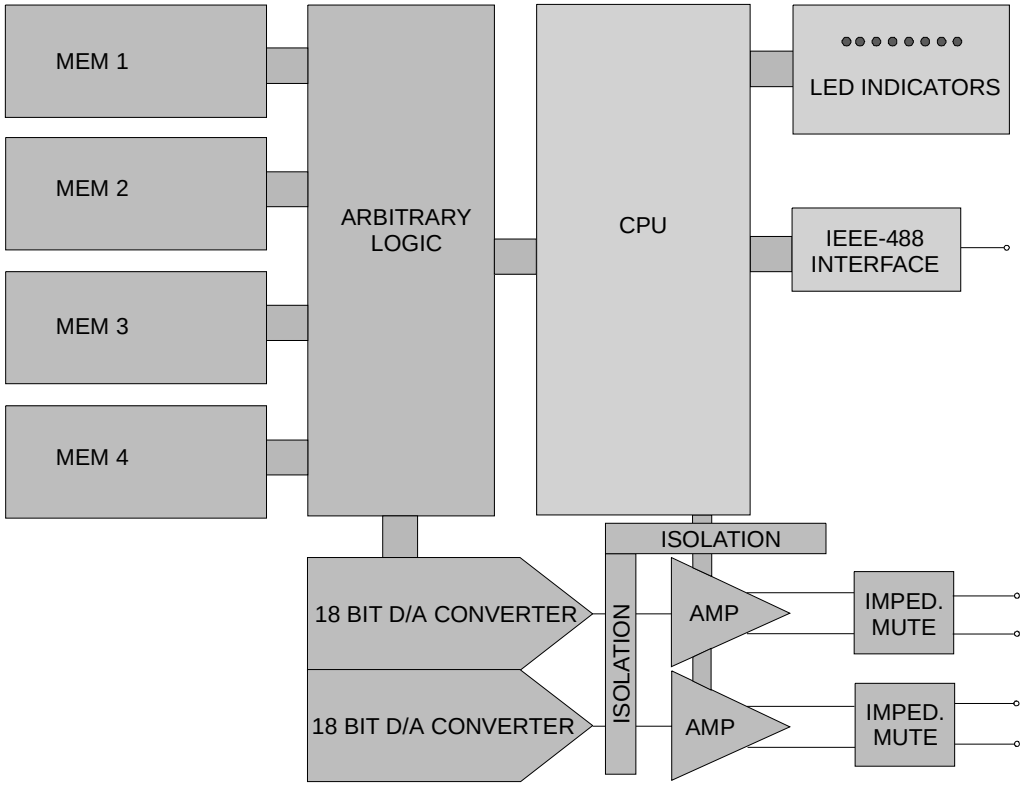


Fig. 16 Block Diagram Generator

Digital Section

The CPU reads the samples out of a non-volatile memory. The memory block provides capacity for four independent test signals, each with 16 bit resolution and any length defined in *Table 1*. 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 behind the D/A converters is fed into a reconstruction filter, cutting off all frequencies above 20kHz. 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 150Ω output impedance (unbalanced 75Ω) at any level in steps of 0.1dB between -60dBVp to +20dBVp.

Analyzer

The RT-1M analyzer consists of a two channel analog input stage, preparing the input signals for the conversion into digital format. With the converted signals an FFT analysis with the

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same blocklength as of the generated signal is performed. Further analysis of the acquired result may be done through individual programming.
Additionally, the analyzer also provides facilities to weight an input result with different weighting curves.

Block Diagram

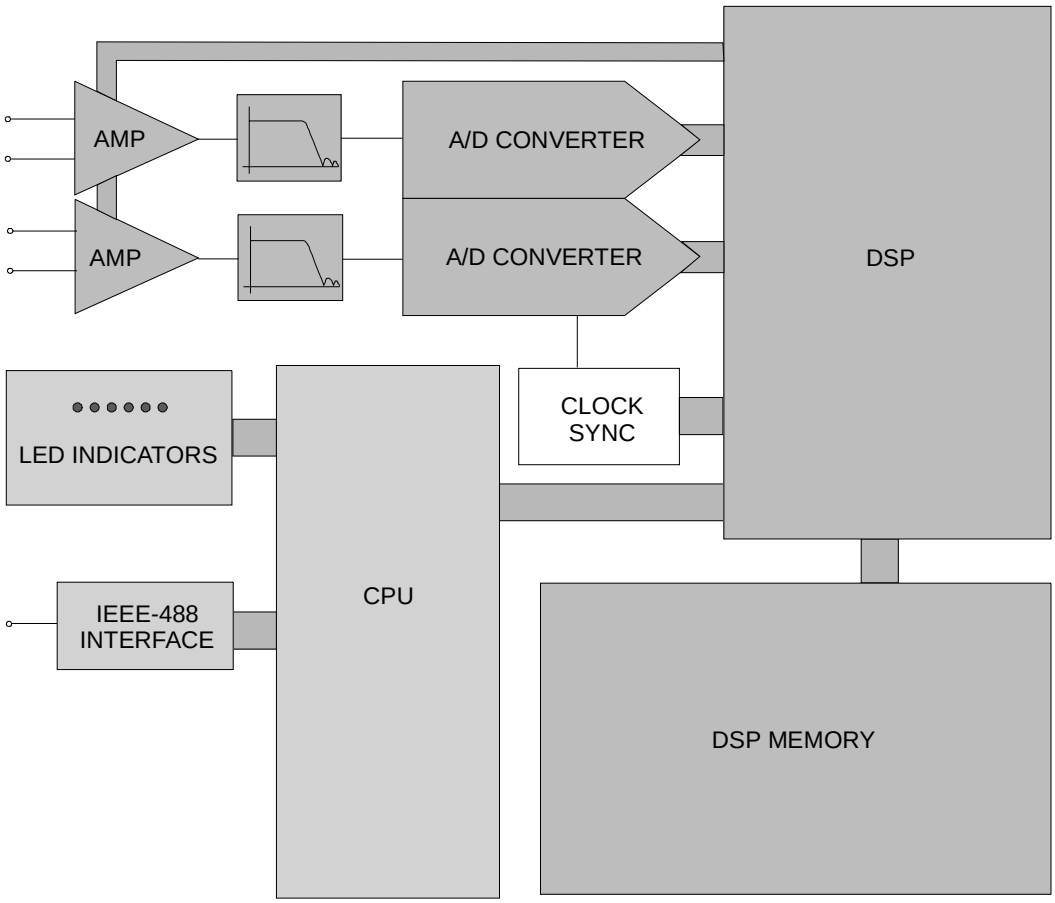


Fig. 17 Block Diagram Analyzer

Analog Section

RT-1M features two independent analog input stages with completely independent ranging facilities. The inputs are balanced with BNC and 4mm banana connectors at the front and rear panel. Input impedance is 100kΩ at all inputs. Levels can be handled from 60dBVp to +20dBVp with full dynamic range.

Filtering

RT-1M provides a set of software weighting and Emphasis filters. The filters have a gain of 1 and can be disabled or enabled. Only one weighting filter and the Emphasis filter may be engaged at a time. The current filters implemented are listed on the next page.

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Filter type	Software
C-Message	☑
CCITT	☑
750µs Emphasis	☑

The commands ***INPut[1-2]:RANGe*** <***Range***> <***Unit***> and ***INPut:DEEMphasis*** allow to select them.

Digital Section

The digital section consists mainly of the DSP and a logic circuitry programmed into a FPGA. 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.

Definition of Multitone Signals

RT-1M may store up to four independent two-channel multitone signals with up to 31 frequencies in a non-volatile memory. This ensures that no programming or parameter loading is required before the generator can be operated. New signals can easily be loaded into one of the memory blocks using an IEEE output command. For the correct syntax please refer to ***OUTPut:MTONe:PARameter?***.

New signals must contain following information

- RT-1M memory-location to store the signal
- Name of the signal
- Blocklength (number of samples)
- Number of signal bins for channel 1
- Number of signal bins for channel 2
- Signal bin numbers of channel 1
- Signal bin numbers of channel 2
- Phases of the signal bins for channel 1
- Phases of the signal bins for channel 2

The *memory location* may be defined by a number from 1 to 4. *Name* is a user defined ASCII string with up to 8 characters. The *blocklength* has to be set to one of the values defined in ***Table 1***. The *number of signal bins* defines how many frequencies shall appear in the multitone signal for CH1 and CH2; the minimum is 1 (sinusoidal) signal, the maximum is 31 bins. The *signal bin numbers* have to be calculated according to ***Equation 7***. Two blocks of *phase* values for CH 1 and CH 2 terminate the definition of a multitone signal.

All signal bins have identical amplitudes. The user has the choice either to set the *overall output level* of the multitone signal or, alternatively, the *signal bin level*. Regardless of this choice, these values may be expressed as peak or RMS levels in linear or logarithmic units (Vp, V, dBVp, dBV).

The overall output level of a multitone signal may be queried at any time. The same goes for the actual Crest factor, that may be queried with the command ***OUTPut[1-2]:MTONe:CRESt?***

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or calculated by using ***Equation 1***. With these two values, the signal bin level may be calculated according to

$$U_{bin_{RMSF}} = \frac{U_{out_{RMS}}}{\sqrt{n}} \quad with\ n = \ total\ number\ of\ \ signal\ bins$$

Equation 6 Bin Amplitude

Following example shall illustrate the signal definition procedure. The multitone signal shall have three signal bins at 300Hz, 1kHz and 3kHz. Both channels are identical. The name of the signal is "Telefon". Since the three frequencies are fairly wide apart, we may use a blocklength of 512, resulting in a frequency spacing of 93.75Hz. To calculate the signal bin numbers, refer to ***Equation 7***

$$Bin_n = Round(\frac{f_n}{f_{\min}}) = \frac{300\,Hz}{93.75\,Hz} = 3$$

Equation 7 Bin Number

Consequently, the bins equaling 300Hz, 1KHz and 3KHz have the numbers 3, 11 and 32. The definition of the phases can be done manually or by using the Crest factor optimizer of RT-EVAL. Finally, the table may look as follows.

```
1,"Telefon",512,3,3,3,11,32,3,11,32,-3.141,1.234,0.707,0,0.810,0.111
```

The duration of this multitone signal (not considering the header explained below) is the reciprocal value of 93.75Hz which is 10.67ms.

ATTENTION **Do never define *exclusively* the three signal bins @ 562.5Hz, 1406.25Hz and 3.0kHz as multitone signal since these three frequencies form the trigger of a multitone burst header.**

Header

Each multitone burst is preceded by a header comprising trigger and clock synchronization.

The standard *trigger* signal has a duration of 42ms and consists of 5 fixed frequencies in the voice band with different levels. By receiving this frequency / level pattern a listening analyzer recognizes a RT-1M multitone signal and wakes up. The pattern has been selected in a way that the false-triggering rate due to voice, music or other synthesized signals, interpreted as multitone signal, is < 10^{-6}.

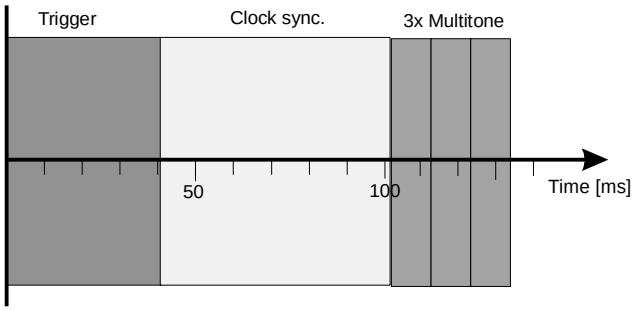


Fig. 18 Multitone Signal with 5 Bursts as Example

Additionally, a *pretrigger* signal may be added in order to allow the DUT to stabilize before transmission of the rest of the multitone signal. See also command ***OUTPut[1-2]:LEVel <Level> <Unit>***.

During the *Clock Sync* period (SYNC block) with a fixed length of 64ms, the analyzer may adjust its sampling frequency to the transmitted clock frequency (3kHz). This ensures that

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frequency shifts, generated by the DUT (modulators / demodulators or tape machines with speed differences) or slightly different clock frequencies of a separated generator / analyzer pair are eliminated automatically.

Multitone Signal

Right after the header information follows the *multitone signal* itself, i.e. transmission of the signal bins. The duration of the multitone signal depends on the block length as defined in ***Table 1***. The multitone signal is transmitted at least 3 times and may be repeated by applying the command ***OUTPut:MTONe:MTONelength***. For instance, several multitone blocks may be transmitted before the analysis starts, in order to stabilize the DUT and to let transients disappear. The analysis itself requires a minimum of two blocks.

Data Acquisition

Wake-up Sequence

The RT-1M analyzer continuously executes a FFT of the input signal. As long as there is no signal or any non-correlated audio information, no action is started. But as soon as the analyzer detects a header, i.e. the RT-1M-specific frequency / level pattern in the input signal, it wakes up and records the incoming multitone signal.

Please notice that the trigger signal can be detected up to -20dB below the set range. That means for example with an input range set to -6dBu the trigger can be detected from levels as low as -26dBu.

Synchronization Mode

Normally, the analyzer of RT-1M uses the internal sample frequency clock of the generator. This mode should be used for all applications where no frequency shifts occur on the signal transmission path.
However, in cases where the device under test (DUT) changes the frequency of the transmitted signal, the analyzer has to synchronize itself onto the incoming signal itself. For this purpose, each header of a multitone burst contains a SYNC block, providing a fixed frequency, onto which the analyzing DSP may synchronize its sampling clock. This feature and the choice, whether a header shall be transmitted at all, may be activated with command ***INPut:SYNC [INTernal¦INTNoheader¦EXTernal¦EXTNoheader]***, offering the four following modes.

INTernal

The analyzer is linked to the generator clock of the same unit and the multitone signal is preceded by a header (trigger & SYNC block). This mode may be chosen if the multitone burst is generated in the same unit where it is analyzed and if no major frequency shifts occur in the DUT. The burst is initiated with command ***OUTPut:MTONe:STARt*** and transmission must not show a delay of more than 1s.

INTNoheader

Again, the analyzer is linked to the generator clock of the same unit, but no header is transmitted. The benefit of this mode appear in noisy environments, where the trigger cannot be detected, and for analysis of signals being generated by the DUT itself. However, the max. allowable transmission duration is 50ms, i.e. the multitone burst must 'arrive' at the analyzer at latest after this time from the moment of its initiation.

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EXTernal

In case of expected clock frequency differences between the generator and analyzer the user has to activate the EXT mode. Frequency shifts appear e.g. in combination with analog tape recorders, where the recording and the playback speed are not identical, or due to local separation of generator and analyzer. Up to 1s transmission time is allowed.

EXTNoheader

This mode may be used after transmission of several multitone burst transmissions in mode EXT only. The analyzer synchronizes itself onto the SYNC blocks of these preceding multitone bursts, before it eventually gathers the burst in mode EXTnoheader.

Gathering Data

After triggering and synchronization, the analyzer waits one period of the multitone burst to let the transients of the DUT disappear before it starts with a two-block FFT. This calculation takes - depending on the block length - between 48ms and 190ms. The analysis includes

- Decoding of the bit stream to get two stereo signals
- Windowing with Hanning window (where necessary)
- Organization of bits (bit reverse organization of results)
- Calculation of level and phase from the complex spectrum

The calculated vector is placed in the result area of the memory and the DSP is ready for the next acquisition.
If the user queries for measurement results, the CPU reads these stored data from the internal memory and computes the required results out of them. This process requires considerable computations since all the bins have to be read, squared and summed up for the results calculation. As soon as this process is finished, the results are transmitted and thus available for further processing.

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Signal Analysis & Result Queries

Level

One core requirement of audio testing is the analysis of the *frequency response* of the DUT. With the multitone approach, this goal is achieved in one step by measuring the returned signal bin levels instead of sweeping a single sine signal through the frequency band of interest.

In practice, the frequency response can be obtained from a transmitted multitone signal by plotting the received signal bin level values. Please notice that this analysis considers the energies of the signal bins only, but not the distortion + noise energy in the bands between the signal bins.

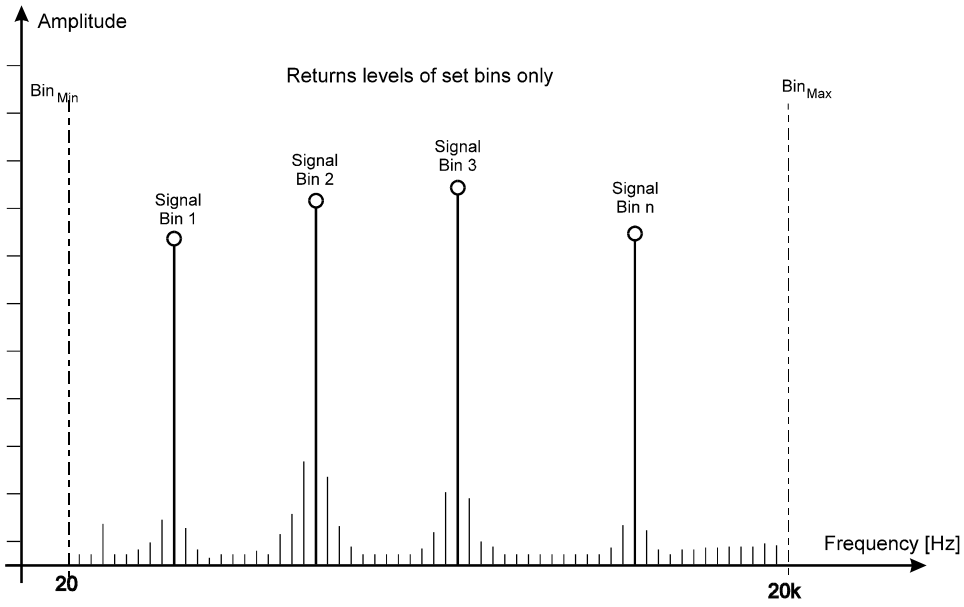


Fig. 19 Level Plot

Keep in mind, 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 reflects its overall attenuation / amplification only, but not the frequency response.

Distortion

Basically, *distortion* is a measure to characterize the nonlinear behavior of a DUT, i.e. the degree of how it generates new signal components at other frequencies than the one(s) of the stimulating signal. Therefore, The RT-1M returns as distortion results the *total distortion + noise energies* (TD+N) for the bands between the signal bins of a multitone signal.

Remains the question, in which way RT-1M actually calculates the TD+N values in the frequency bands of interest. The answer can be given by considering the equations for the RMS and RSS value.

RMS and RSS Value

Purely analog test instruments evaluate the distortion energy as *RMS* voltage (Root Mean Square) by summing up all received signal components V_i according to following equation.

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$$V_{RMS} = \sqrt{\frac{\sum_{i=1..n} (V_i)^2}{n}} \quad with\ n = number\ of\ \ signal\ components$$

Equation 8 RMS Calculation

Unfortunately, when applying this formula on the discrete spectrum of a FFT analysis, the result correlates in inverse proportion to the blocklength / number of bins in the respective band. Therefore, to calculate the TD+N result out of a digitized signal, the *RSS* value (Root Sum Square) has to be used.

$$V_{RSS} = \sqrt{\sum_{i=n..m} (V_i)^2} \quad with\ i = counter\ over\ all\ bins\ (n..m)$$

Equation 9 RSS Calculation

The accuracy of this approach can be proved with any spectral analyzer. The better the resolution (i.e. the higher the blocklength), the lower is the amplitude of a single bin, since the total energy of the band is constant. Consequently, the summing-up of the bins always result in the same value, regardless of the chosen resolution (blocklength).

Interpretation of TD+N

To interpret the TD+N value correctly, it has to be considered that this result slightly differs from a conventionally measured *THD+N* value. With conventional THD+N analysis, a single tone stimulates the DUT. 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 and *SINAD* result respectively.

On the other hand, the transmission of a multitone stimulus will result in the appearance of many harmonics and intermodulation products. However, it is neither possible to relate any of these signal components to a certain signal bin of the original multitone signal, nor to differentiate the received signal between harmonics and intermodulation products.

Distortion Plot

Fig. 20 shows a typical distortion plot, derived from the returned distortion results of RT-1M.

- The first value in the plot *D1* equals the RSS result (TD+N value) of the band between the first bin ≥20Hz 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 ≤ 20kHz.

Please notice, that both the even & odd bins of the received signal are considered for the TD+N calculation.

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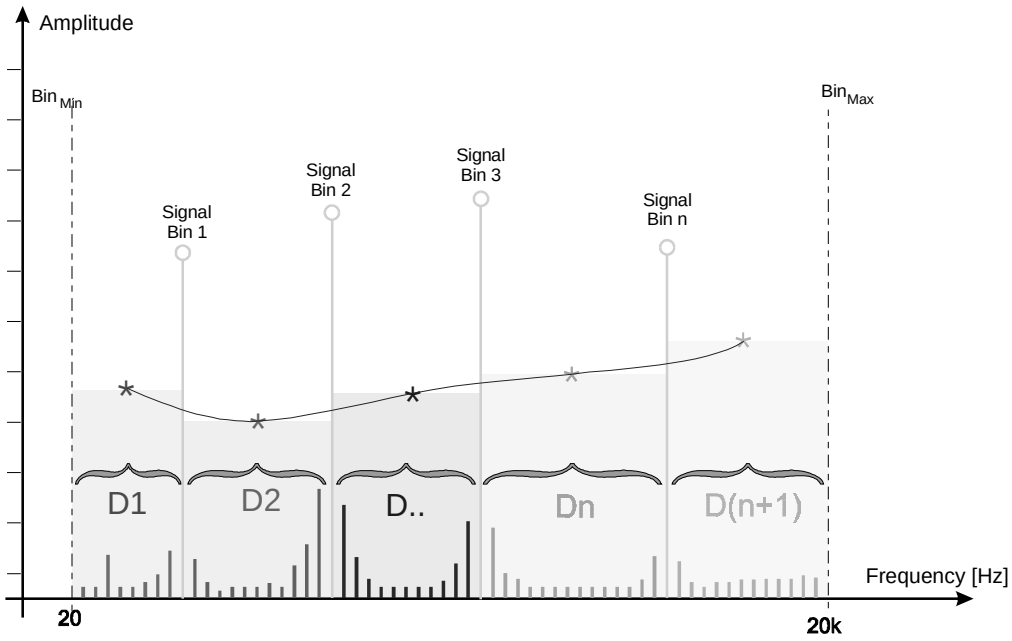


Fig. 20 Distortion Plot

Full Band TD+N Measurement

To evaluate the TD+N value in the full frequency band (20Hz-20kHz), following equation has to be applied.

$$TD+N_{FullBand} = \sqrt{D_1[V]^2 + D_2[V]^2 + ... + D_n[V]^2}$$

Equation 10 Full Band TD+N

wherein D_1-D_n are the returned distortion results, expressed in [V].

THD+N Calculation

To evaluate the THD+N value 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 (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 11 THD+N Calculation

with D_1 = distortion between 20Hz and the signal bin, D_2 = distortion between the signal bin and 20kHz and L_1 = received signal bin level.

MT-SINAD

For some applications, the SINAD result - being the reciprocal of THD+N - is required.

$$SINAD = \frac{Signal + Noise + Distortion}{Noise + Distortion}$$

Equation 12 SINAD Definition

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Obviously, to get a true SINAD result, it is necessary to stimulate the DUT with a single sine tone only. Otherwise, i.e. if a multitone signal is applied, intermodulation products would appear, thus increasing the *Noise+Distortion* value. Nevertheless, it is also possible to calculate the SINAD result out of a transmitted multitone signal. However, in order to avoid misunderstandings, this result is called MT-SINAD herein.
Actually, with RT-1M, just use the query command ***MEASurement[1¦2]:MTSinad?***, to get the calculated value.

In practice, the MT-SINAD result may differ slightly from a conventionally measured SINAD value, due to intermodulation products between the signal bins. However, in qualitative terms, the results are equal as proven in numerous setups.

RSS Selective Measurement

The
MEASurement[1-2]:SELectiverss? <***binstart***> <binstop> command allows to query the TD+N result of a user-defined band anywhere between 20Hz and 20kHz. Both the lower and the upper border of this band may be set freely to any bin number - they don't have to be identical to the signal bins of the transmitted multitone signal.

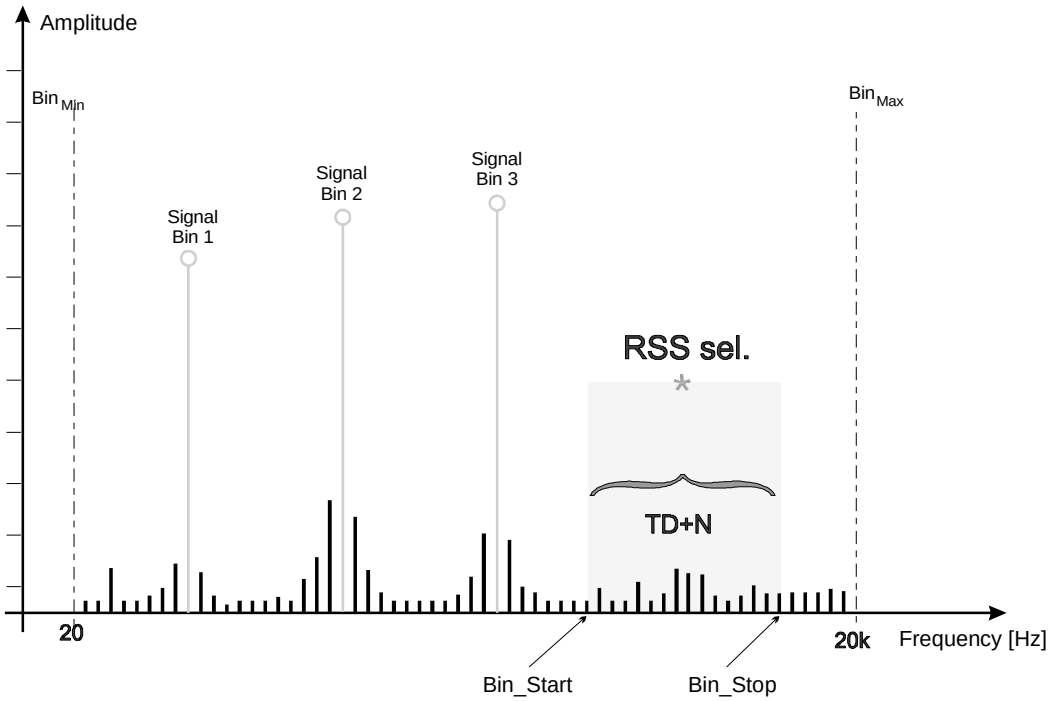


Fig. 21 RSS Selective Plot

NOTE	**Be aware, that if a signal bin is within the band of interest, the RSS selective result will represent the *signal bin level + distortion + noise*.**

The RSS selective feature is especially helpful, if a certain component of a received signal shall be investigated. For instance, after transmission of a single tone signal, it allows to evaluate the individual harmonics of the fundamental frequency.

Noise

As for distortion analysis, the noise measurement divides the frequency band in subbands, split by the signal bins, and calculates the noise values of these subbands.

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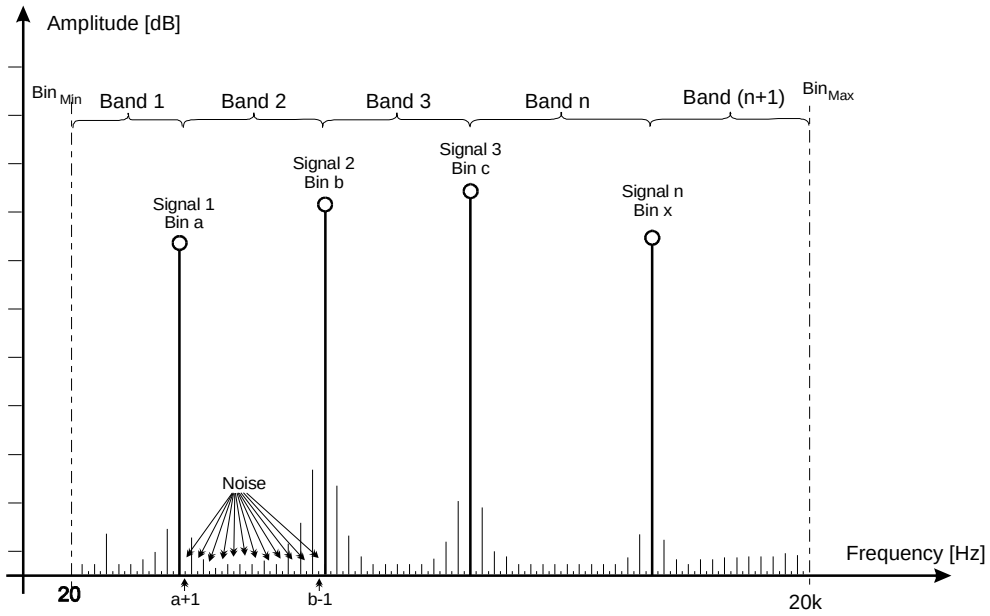


Fig. 22 Noise Plot

Consequently, a multitone measurement with *n* signal bins results in *n+1* noise values, each calculated internally by *RT-1M* according to the following formula.

$$Noise_i = \sqrt{2 * \sum_{i=a+1}^{b-1} \left(U_{2i-1}\right)^2} \quad = RSS\ value\ of\ all\ odd\ bins\ in\ a\ band$$

Equation 13 Noise Calculation

NOTE ***Equation 13*** **describes the internal noise calculation of *RT-1M*, i.e. the actually returned noise results must not be re-calculated in any way.**

Full Band Noise

MeasurementTo evaluate the noise value in the full frequency band (20Hz-20kHz), following equation has to be applied.

$$N_{FullBand} = \sqrt{N_1[V]^2 + N_2[V]^2 + ... + N_n[V]^2}$$

Equation 14 Full Band Noise

wherein N_1-N_n are the returned noise results, expressed in [V], of any multitone measurement.

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Crosstalk

The Crosstalk Plot may be calculated only if a stereo signal is transmitted. This stereo signal must have separate bins set in the 2 channels in a way that the respective bins remain unused in each other channel. In case of bad channel separation of the DUT, the unique frequencies of channel "A" talk into channel "B", i.e. they appear in the received signal of channel "B" and vice versa.
The crosstalk value is the ratio of the unused bin level in channel "B" and the active bin level of channel "A" at the same frequency. It is expressed in % or dB.

$$Crosstalk_i^{LEFT} = \frac{Unused_Bin_ChB_i}{Set_Bin_ChA_i}$$

Equation 15 Calculation of Crosstalk

As an example, we may assume that a signal bin with 10dB @ 1kHz is transmitted via channel "A", while at channel "B" the received bin level @ 1kHz equals -30dB. Consequently, the crosstalk from channel "A" to channel "B" @ 1kHz is 1% or -40dB.

Please note that noise increases the crosstalk value and thereby falsifies the measurement.

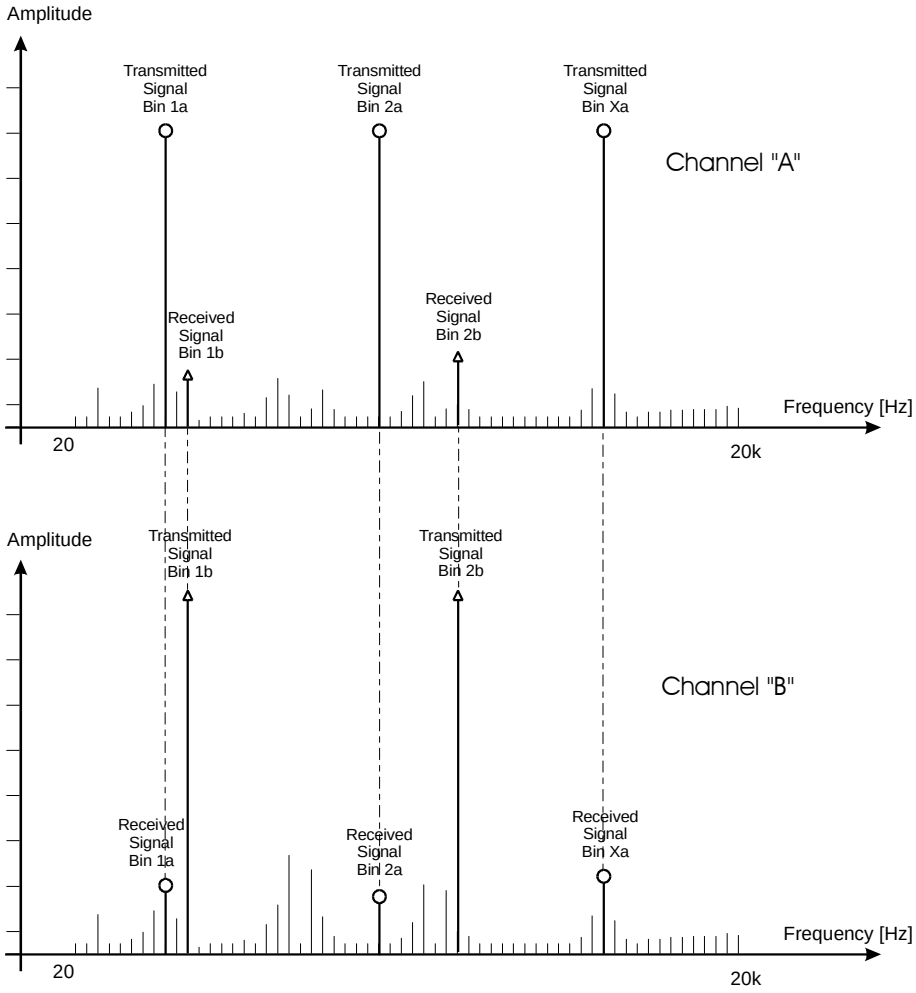


Fig. 23 Crosstalk Plot

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Phase

Since the analyzer knows all information about the transmitted multitone signal from the generator, also the phases of the signal bins are available for further analysis. Therefore, the analyzer may calculate any changes of inter-channel phase relations at each common signal bin of the 2-channel test signal.

$$\varphi_i = \varphi(U_i^{Left}) - \varphi(U_i^{Right})$$

Equation 16 Phase Calculation

However, the exact phase shift between generator output and analyzer input cannot be calculated due to the unknown time delay of the DUT.

DTMF Mode

The DTMF option extends the measuring capabilities of RT-1M in the field of phone testing. It allows to receive & analyze the standardized DTMF (Double Tone Multiple Frequency) tones on channel 1.

Every key of a standard 4x4 phone keypad is represented by a dual tone. These tones comprise the indicated frequencies as shown in ***Table 7***.

	1209Hz	**1336Hz**	**1477Hz**	**1633Hz**
697Hz	1	2	3	*a*
770Hz	4	5	6	*b*
852Hz	7	8	9	*c*
941Hz	*	0	#	*d*

Table 7 DTMF Signal Coding

For instance, the DTMF tone for key #6 is put together of the two frequencies 770Hz & 1477Hz.
The meaning of the four 'empty' keys *a-d* in the last row may be user-defined.

The DTMF mode of RT-1M may be started and reset by using command ***MEASurement1:DTMF:STARt***. From then on, the unit continuously monitors the input channel 1 in parallel to any other operation, and stores all received DTMF tones in an internal buffer.
This 32 keys wide buffer may be queried by command ***MEASurement1:DTMF?***. To clear the contents of the buffer, command ***MEASurement1:DTMF:STARt*** has to be sent to the unit.

The input range of channel 1 must be adjusted to the level of the DTMF tones to be analyzed. Please notice that an overload, caused by an incoming DTMF signal, will not be detected, i.e. the unit will not generate an error message. Furthermore, no DTMF tone analysis will be possible in such a case.

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Broadcast Mode

The broadcast mode allows to let the analyzer of a RT-1M unit wait for an incoming multitone burst that has been generated by another, remote RT-1M unit (generator & analyzer are physically apart). By this, it becomes possible to measure e.g. the characteristics of a transmission line.

Following restrictions have to be considered on behalf of the broadcast mode.

- The measurements under the broadcast mode can be done in one direction only at a time. In order to return a multitone burst in the opposite direction, i.e. from the previously used analyzer to the generator, the operation mode of both units has to be changed.
- The generator & analyzer must be controlled each by a PC through a GPIB interface.
- The transmitted multitone signal must be defined identically on the generator & analyzer.
- In order to avoid false triggering, it is vital to thoroughly understand and apply the trigger configuration as well as the setting of a proper output level and input range in the generator and analyzer.

Mode of Operation

The broadcast mode of RT-1M is based on the command ***INPut:TRIGger:ARMed***. If sent to the unit, this instruction sets the analyzer to a state where it waits until it detects an incoming RT-1M trigger and receives the connected multitone signal.
The trigger must have been generated by another RT-1M instrument and has to match the trigger conditions defined in the analyzing unit.

Setup

The complete procedure to set up a broadcast transmission test with RT-1M may be summarized as follows.

1. Install the generator and analyzer at the intended locations and control each of them with an own PC through GPIB IEEE interfaces.
2. Connect the two units with the ends of the transmission line to be measured.
3. Write an appropriate program to control the units. Optionally, you may also install RT-EVAL V1.60 or higher on both host PCs.
4. Define a multitone signal according to the specific demands of the test (available bandwidth, number of bins, signal duration etc.) identically on both the generator and analyzer. Don't forget to optimize the Crest factor of the signal (e.g. by using the Crest optimizer of RT-EVAL).
5. In the analyzer, set the trigger configuration to TIGHT by using command ***INPut:TRIGger:CONFiguration [LOOSE¦TIGHT¦USER]***.
6. Set the SYNC mode of the generator to INTernal with command ***INPut:SYNC INTernal***.
7. Set the output level of the generator approximately to the level of the broadcast signal. Make sure that no clipping occurs.
8. Set the SYNC mode of the analyzer to EXTernal with command ***INPut:SYNC EXTernal***.
9. Adjust the input range of the analyzer to the incoming signal level. To do this, connect the analyzer to the transmitted broadcast signal and reduce the input range until the Overload LED lights up. Increase the input range by +6dB from this value in order to provide enough headroom.
10. Set the analyzer to the armed mode with command ***INPut:TRIGger:ARMed***.
11. Interrupt the broadcast signal and transmit the multitone burst with command ***OUTPut:MTONe:STARt***.

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12. It is recommended to transmit the burst at a defined time, so that the operator of the analyzer realizes immediately, whether the trigger has been detected or not.

If no successfull line measurements are possible, read the chapter ***Application Hints / Troubleshooting*** (p. *37*) to check possible causes and work out solutions.

Trigger Configuration

The most important topic of broadcast mode measurements with *RT-1M* is the definition and application of an appropriate trigger. For this purpose, three trigger configurations are provided.

- *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. false triggerings have 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* in order to avoid false triggerings. Requires an accurate setting of the generator output level and analyzer input range.
- *USER* - this parameter allows to define the trigger condition according to user-specific demands. However, since this application requires a very thorough and detailed understanding of the whole triggering complex, this approach is for very advanced users only, who have a profound understanding of all possibilities and their consequences.

ATTENTION **Improper configuration of the USER trigger may result in a 'always' or 'never' condition, where the analyzer triggers on almost every incoming signal (music, speech etc.) or never recognizes any trigger, even if it is a correct one.**

The trigger signal of a *RT-1M* multitone burst comprises three signal bins at different frequencies and with individual levels. In order to avoid false triggerings, the receiving *RT-1M* permanently monitors the input signal on strictly 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-1M* multitone burst and triggers to it.

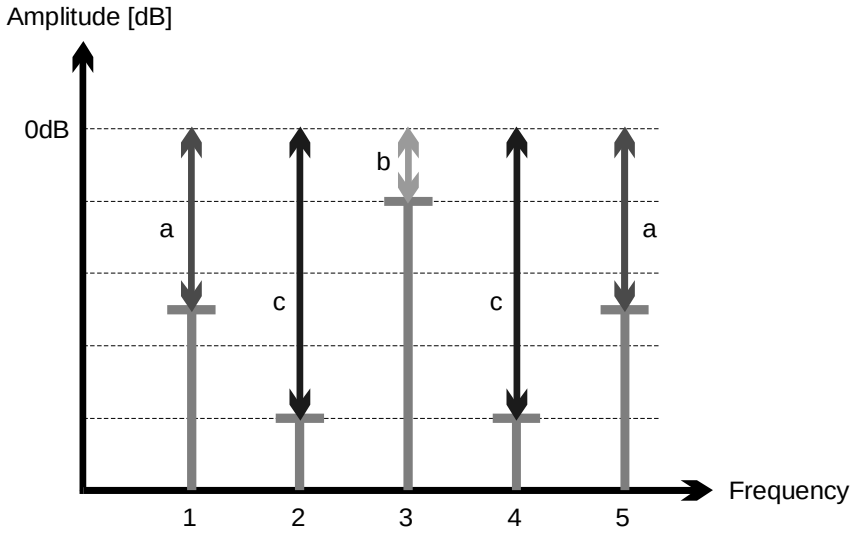


Fig. 24 Trigger Definition

Fig. 24 visualizes the characteristic of a *RT-1M* triggersignal. 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.

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Obviously, the levels of the five signal bins, together with their frequencies, make the uniqueness of the RT-1M trigger signal.

The application of the User trigger allows to individually define the 'headroom' between the 0dB line and the bottom bars (**T**). However, this is a very delicate operation, and therefore not recommended for new users of RT-1M. Anyway, in case that this feature truly has to be used, please refer to the explanations of the commands ***INPut:TRIGger:CONFiguration ...*** and ***INPut:TRIGger:USRConfiguration ...*** as well as to the helpfile of the RT-EVAL software package.

Remains the question about the reference level of the analyzer, since especially for long-distance transmission lines, this instrument cannot use the same reference voltage potential as the generator.
The solution is to assume the currently set input range of the analyzing RT-1M unit as reference level. This level equals the max. detectable amplitude of all incoming signals (all higher levels would be clipped), and is represented by the 0dB line on top of ***Fig. 24***.
Consequently, all received signals will be analyzed against 0dB. Applied on the trigger detection criteria, this means 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 / Troubleshooting

To execute measurements in the broadcast mode is probably one of the more demanding procedures when working with RT-1M, mainly because of the remote location between the generator and analyzer, i.e. the sender and receiver of the multitone burst.

Nevertheless, by considering both the instructions listed in chapter ***Setup*** (p. ***35***) and following hints, it shouldn't 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), however, with both units already being controlled by individual PCs. Such a setup may 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 transmissions / measurements, reduce the number of involved stages 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 may be increased stepwise, and the respective settings may 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 may simply localize critical components and optimize their transmission behaviour.

The most frequent obstacle in the broadcast mode is the 'refusal' of the analyzer to trigger to the incoming multitone burst. This effect is usually caused by improper adjustments of the involved RT-1M 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 it can't be recognized anymore.

Consequently, the efforts to overcome missing triggerings have to focus on the proper adjustment of the sending and the receiving RT-1M, as well as on the mutual optimization between the trigger signal and the sound enhancing systems.

Possible Cause	*Effect*	*Suggested Solution*

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Generator output level too low *and/or* Analyzer input range too high	The incoming trigger signal level doesn't match vs. the analyzer sensitivity, so that the trigger can't be recognized	Increase the generator output level or decrease the analyzer input range stepwise
Generator output level too high	The trigger signal is modified by sound enhancing units in a way, that it can't be recognized any more by the analyzer	Reduce or attenuate generator output level
Analyzer input range too low	The input stage of the analyzer is too sensitive, i.e. overloaded, and therefore can't recognize the incoming trigger	Increase input range of analyzer stepwise
Very strong sound enhancing effects or a low quality of the transmission line	Distortions, noise or sound enhancing effects modify the trigger signal in a way, that it can't be recognized any more by the analyzer	Switch Off all sound enhancing systems during the transmission of the multitone burst
Multitone signal not identical on generator & analyzer	Analyzer triggers correctly, but can't acquire a reasonable result	Set the identical signal bins in the active multitone signal of the generator & analyzer

Table 8 Broadcast Mode Troubleshooting

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4 PROGRAMMING

Communication via the IEEE-488 interface allows complete remote control for all functions of RT-1M.

Command Structure

IEEE-488.1 Compatibility

The IEEE interface function set implemented in RT-1M. The compatibility level is given in *Table 9*.

Function	*Implemented*	*Notes*
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 9 IEEE 488.1 Compatibility

IEEE-488.2 Commands

RT-1M currently does not support all IEEE-488.2 commands. These might be implemented at a later state.

Command Summary

Following commands are currently available to control RT-1M system. The commands are divided into four subsystems.

Subsystem	*Function in RT-1M*
SYSTEM	Control of RT-1M
INPUT	Control of analyzer input section
OUTPUT	Control of generator output section
MEASUREMENT	Query for measurement results
*	Device Status

Table 10 Subsystem Definition

Most of the Parameter have to be completed with channel or signal information.

SYSTem: RESet | *MEASurement: LEVel: UNIT*

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SYSTem:	ERRors?	
SYSTem:	INFormation?	
INPut:	FRONt	
INPut:	LINK	
INPut:	RANGe	
INPut:	SYNC	
INPut:	SWFilter	
INPut:	DEEMphasis	
INPut:	TRIGger:	ARMed
INPut:	TRIGger:	ARMed?
INPut:	TRIGger:	BREak
INPut:	TRIGger:	CONFiguration
INPut:	TRIGger:	USRConfiguration
INPut:	TRIGger:	USRConfiguration?
INPut:	STATus?	
OUTPut:	MTONe:	PARameter
OUTPut:	MTONe:	ACTive
OUTPut:	LEVel	
OUTPut:	BINlevel	
OUTPut:	MTONe:	PRETriggerlength
OUTPut:	MTONe:	MTONelength
OUTPut:	FLOAT	
OUTPut:	MUTe	
OUTPut:	MTONe:	STARt
OUTPut:	MTONe:	CONTinuous
OUTPut:	MTONe:	PARameter?
OUTPut:	MTONe:	NAME?
OUTPut:	MTONe:	BLOCklength?
OUTPut:	MTONe:	CRESt?
OUTPut:	STATus?	

MEASurement:	LEVel?	
MEASurement:	DISTortion:	UNIT
MEASurement:	DISTortion?	
MEASurement:	MTSinad?	
MEASurement:	SELectiverss:	UNIT
MEASurement:	SELectiverss?	
MEASurement:	NOISe:	UNIT
MEASurement:	NOISe?	
MEASurement:	PHASe:	UNIT
MEASurement:	PHASe:	SCALe
MEASurement:	PHASe?	
MEASurement:	CROSstalk:	UNIT
MEASurement:	CROSstalk?	
MEASurement:	DTMF:	STARt
MEASurement:	DTMF?	
*STB?		
*OPC		
*OPC?		
*CLS		
*ESE		
*ESE?		
*SRE		
*SRE?		
*ESR?		
*PSC		
*PSC?		
*IDN?		
*RST		
*TST?		
*WAI		

Descriptive Symbols

Following terms are used in the command description.

Symbol	Description
[ ]	Used to enclose one or more optional Parameter to control RT-1M. Omitting the default Parameter causes the system to use the default action.
{ }	Used to enclose one or more Parameter that may be included several times.
?	Indicates a query by appending the question mark to the last keyword in a command. Not all commands have a query; some are only query commands.
¦	Read this signal as an “OR“. It is used to separate alternative Parameter.
< >	Used to enclose an SCPI defined parameter
:	Used to separate elements of a RT-1M command
;	Used to separate commands in a command list
,	Used to separate arguments in an arguments list
( )	Used to indicate a range of suffixes available
💻 →	String is sent from the controller to RT-1M
→ 💻	Returned string from RT-1M to the controller

Table 11 Symbol Description

RT-1M accepts only the short or the exact and full form of the statements. Sending a command that is neither will generate an error. In following command list, the CAPITAL

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letters indicate the short form to help reduce the required typing. However, the RT-1M parser accepts both lowercase and UPPERCASE commands, i.e. it is not case sensitive.

Command Notation

In the listing of RT-1M commands, descriptive headings are used to divide the information into easily readable parts. The used headings and the contents are shown below. If a heading does not apply on a command, it is not listed.

Use	What the command does and additional information is given in the heading.
Answer	Lists the possible answers on a query and their types (*integer*, *float*, *boolean*, *string*).
Parameter	Description of the Parameter to be set and their types (*integer*, *float*, *boolean*, *string*).
Range	List of the available Parameter and their types (*integer*, *float*, *boolean*, *string*).
Default	Description of the default parameter. After a RESET, all Parameter in an instrument are set to their default values.
Unit	Specification of the available parameter units.
Resolution	Definition the step size of a <Numeric_Value>
Query	Indicates the query command, corresponding to the described command.
Example	Command examples are provided here. The short form and lowercase characters are used as a reminder that both forms are allowed.
Explanation	Additional explanations and hints.

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Command Set

SYSTem Subsystem

SYSTem:RESet

Use Initiates a software RESET. All set Parameter in the instrument are re-set to their default values. Error queue is cleared.

Example 💻 → `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 which are entered shortly after the RESET, may be deleted by the RESET command and are therefore not executed.

SYSTem:ERRors?

Use Queries the number and types of errors since the last Query ¦ Startup ¦ System:Reset command.

Answer <Error_No> *integer*

Range

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)
140 No MEASurement command found (e.g. LEVEL)
141 No MEASurement[1-2] command found (e.g. TDN)
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
155 String parameter expected (e.g. "ON")
156 "ON" or "OFF" string expected
157 Filter parameter expected (e.g. "CCITT")
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 to bin number out of range
163 Phase value out of range
164 Wrong number of MT Parameter
165 IEEE bus error
166 Output buffer overflow
167 Bins must be in increasing order
168 Too many parameter

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169 Integer parameter must be in increasing order
170 Illegal unit
180 Option not installed (e.g. FLOAT)
182 Command not executable during input trigger armed mode
190 Not available in this hardware version
191 Not available with this firmware version
199 Unexpected error occurred – please report to NEUTRIK
200 No parameter in list for start multitone signal in generator
201 No parameter in list referring to received data in analyzer
202 Output 1&2 muted while multitone is started
203 No trigger detected
204 No stereo trigger detected (e.g. for phase measurement)
205 Measurement function needs ≥1 identical bins on both channels
206 Measurement function needs ≥1 different bins on both channels
210 Analyzer overload
220 Battery low (memory backup)
230 Hardware and software revisions do not match
240 Minimum one external measurement required beforehand
246 Measurement not possible – Signal bins defined too close to each other
(chose higher block length or change signal bins)
250 DTMF receive buffer overflow
255 RS232/GPIB Interface Output Buffer overflow
256 RS232/GPIB Interface Input Buffer overflow
600-716 Please report to NEUTRIK

Example

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

💻 → `SYST:ERR?`
→ 💻 `0`

Explanation If no errors occurred, a "0" is returned. In any other case the list of error numbers in the queue is returned. All errors are cleared in the instrument after the query.

SYSTem:INFormation?

Use Query for serial number, hardware revision and firmware version of RT-1M system. Compatible with SCPI <*IDN?> command.

Answer

<Manufacturer>	*string*
<Instrument_type>	*string*
<Serial_number>	*string* (4 digits)
<Firmware_Revision>	*float*

Example

💻 → `System:Information?`
→ 💻 `NEUTRIK,RT1M,0456,3.20`

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INPut Subsystem

INPut:FRONt [ON¦OFF]

Use Activates either front or rear panel input connectors (output connectors are always active at front & rear panel).

Range OFF ¦ ON *boolean*

Default ON (front input connectors are active)

Query Use command ***INPut[1-2]:STATus?***

Example 💻 → `Inp:Fron OFF`

INPut[1-2]:LINK [OFF¦ON]

Use Links internally the generator output of RT-1M to the analyzer input. The input connectors of the selected channel are physically disconnected at front and rear.

Range OFF ¦ ON *boolean*

Default OFF

Query Use command ***INPut[1-2]:STATus?***

Example 💻 → `Input2:Link ON`

💻 → `INP1:LINK OFF`

Explanation This command allows e.g. to check the proper operation of RT-1M.

INPut[1-2]:RANGe <Range> <Unit>

Use Defines the input range & unit for an input channel.

Parameter <Range> *float*
<Unit> *string*

Unit [dBVp ¦ Vp]

Range -60 to +20 dBVp (rounded to nearest 0.1dBV)
0.001 to 10 Vp

Default 0 dBVp

Query Use command ***INPut[1-2]:STATus?***

Example 💻 → `INPUT1:Range 0 dBVp`

💻 → `Inp2:Rang 0.5 Vp`

Explanation Insert a white space between the value and the unit. The allowed units are peak level units only, since the Crest factor of the input signal is unknown.

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

Use Defines the synchronization mode of the instrument.

Range INT ¦ INTN ¦ EXT ¦ EXTN *boolean*

INT Analyzer sampling clock is derived from the generator crystal. No frequency shift correction is performed. Use this mode if analyzer and generator are located together and no frequency shifts are expected. Max. allowable time delay is 1s.

INTN Analyzer sampling clock is derived from the generator crystal. No frequency shift during transmission must occur. The multitone signal is sent out without any header. The analyzer expects the multitone signal without trigger and SYNC block. Use this mode if analyzer and generator are located together but no header information can be transmitted (e.g. muted measurements) or for analysis of externally generated signals. Max. allowable time delay is 50ms.

EXT The analyzer clock is synchronized to the frequency of the SYNC block in the header of the received multitone burst. Frequency shifts are compensated. This mode is recommended if notable frequency shifts are expected. Max. allowable time delay is 1s.

EXTN No synchronization is transmitted or performed at all. Analyzer clock runs at the frequency synchronized to the last transmitted multitone burst in Sync Mode EXT. No further tuning will be performed. Analyzer expects the signal with no trigger information and generator is set to transmit the multitone signal only. No major time delay must occur in that mode. This mode requires at least one measurement in EXT mode before to ensure that the analyzer crystal is tuned.

Default INT

Query Use command ***INPut[1-2]:STATus?***

Example 💻 → `Inp:Sync Internal`

💻 → `INPUT:SYNC INTN`

Explanation Any multitone burst transmission & sampling must be initiated by ***OUTPut:MTONe:STARt***.

INPut:SWFilter [OFF¦CWE¦CCITT]

Use Activates one of the implemented software weighting filters. Filters are selected for both channels simultaneously. The filters may be engaged also after the measurements has been performed. This allows to get first unweighted and afterwards weighted results.

Range OFF ¦ CWE ¦ CCITT *boolean*

Default OFF

Query Use command ***INPut[1-2]:STATus?***

Example 💻 → `INPUT:SWFILTER OFF`

💻 → `Inp:SWF CWE`

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INPut:DEEMphasis [OFF¦ON]

Use Activates the 750µs deemphasis, which applies on both channels, regardless of other filters.

Range OFF ¦ ON *boolean*

Default OFF

Query Use command ***INPut[1-2]:STATus?***

Example 💻 → `INP:DEEM ON`

💻 → `Input:Deemphasis OFF`

INPut:TRIGger:ARMed

Use Puts RT-1M into the armed mode, where the analyzer waits for an externally generated incoming multitone burst with trigger.

Query Use commands ***INPut:TRIGger:ARMed?*** and ***INPut[1-2]:STATus?***

Example 💻 → `Inp:Trigger:Armed`

Explanation This command allows the analyzer to receive multitone bursts that have been generated by a remote RT-1M unit, i.e. to run the analyzer in the so-called ***Broadcast Mode***.
In the armed status, the Trigger LED will be flashing until a trigger is detected (LED is lit).

Keep in mind that for broadcast applications it is necessary to set the synchronization mode of the generator / analyzer to INTernal / EXTernal, while the trigger configuration for both units must be TIGHT (see p. ***3-36***).

INPut:TRIGger:ARMed?

Use Queries whether RT-1M is in the armed mode.

Answer <Trigger_Status>

Range ARMED ¦ STOPPED *string*

ARMED — As long as RT-1M is in this mode, it will wait until an incoming multitone burst is detected or until the unit is re-set into the normal operation.

STOPPED — This status indicates that RT-1M is not armed (i.e. waiting for a trigger), but in the normal mode. In this status, the Trigger LED will be dark.

Example 💻 → `Inp:Trigger:Armed?`
→ 💻 `ARMED`

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INPut:TRIGger:BREak

Use Disables the armed mode of RT-1M, i.e. re-sets the unit into the normal mode.

Query Use commands ***INPut:TRIGger:ARMed?*** and ***INPut[1-2]:STATus?***

Example 💻 → `Inp:Trigger:Break`

Explanation This command returns RT-1M into the normal operation, after it has been in the armed mode.
In the normal mode, the Trigger LED will be dark.

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

Use Sets the trigger configuration.

Range LOOSE ¦ TIGHT ¦ USER *string*

LOOSE	Applies the normal trigger condition on 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	Applies the tight trigger condition on 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 the user to define the trigger condition individually. However, since this requires a highly sophisticated fine-tuning, it is strongly recommended to be used by very advanced users only.

Default LOOSE

Query Use command ***INPut[1-2]:STATus?***

Example 💻 → `Inp:Trigger:Configuration Tight`

Explanation It is recommended to change the trigger configuration for broadcast operation only, and to select the TIGHT condition in such cases. As soon as RT-1M is used again for industrial applications, the trigger configuration should be re-set to LOOSE.

INPut:TRIGger:USRConfiguration <setbin1(dB)>,<setbin2(dB)>,<emptybin(dB)>

Use Allows to custom-design the trigger configuration by defining the trigger bins.

Parameter

<setbin(1)>	*integer*
<setbin(2)>	*integer*
<emptybin>	*integer*

Range

<setbin(1)>	-10 to -50 dB
<setbin(2)>	-10 to -50 dB
<emptybin>	0 to -80 dB

Query Use command ***INPut:TRIGger:USRConfiguration?***

Example 💻 → `Inp:Trigger:Usrconfiguration -20,-40,-80`

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Explanation

This command requires highly sophisticated handling for proper operation!
It shall not be applied as by very advanced users only!

INPut:TRIGger:USRConfiguration?

Use

Queries the defined trigger configuration.

Answer

<setbin1>	*integer*
<setbin2>	*integer*
<emptybin>	*integer*

Range

<setbin1>	-10 to -50 dB
<setbin2>	-10 to -50 dB
<emptybin>	0 to -80 dB

Example

```
💻 →    Inp:Trigger:Usrconfiguration?
→ 💻    -20,-40,-80
```

Explanation

See chapter ***Broadcast Mode***.

INPut[1-2]:STATus?

Use

Queries the complete input channel status.

Answer

<Range_Unit>	*float* & *string*	RANGE [-60 to +20 dBVp ¦ 0.001 to 10 Vp]
<SW_Filter>	*boolean*	SWFILTER [OFF ¦ CWEighting ¦ CCIT]
<Front_Conn>	*boolean*	FRONT [OFF ¦ ON]
<Link>	*boolean*	LINK [OFF ¦ ON]
<SYNC_Mode>	*boolean*	SYNC [INT ¦ INTN ¦ EXT ¦ EXTN]
<Deemphasis>	*boolean*	DEEMPHASIS [OFF ¦ ON]
<Trig_Config>	*string*	TRIGGER [LOOSE ¦ TIGHT ¦ USER]

Example

```
💻 →    Inp2:Status?
→ 💻    RANGE -3.5000E0 dBVp,SWFILTER CCITT,FRONT OFF,
        LINK ON,SYNC INTERNAL,DEEMPHASIS ON,TRIGGER:
        CONFIGURATION LOOSE

💻 →    INPUT1:STAT?
→ 💻    RANGE 1.0000E1 Vp,SWFILTER OFF,FRONT ON,LINK
        OFF,SYNC EXTERNAL,DEEMPHASIS ON,TRIGGER:
        CONFIGURATION TIGHT
```


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OUTPut Subsystem

OUTPut:MTONe:PARameter <Parameter>

Use Defines a multitone signal.

Parameter

<Sig_Number>	*integer*	target memory of RT-1M
<Sig_Name>	*string*	user-defined signal name
<No_Of_Samples>	*integer*	blocklength
<No_Of_Bins_CH1>	*integer*	total number of bins set in channel 1
<No_Of_Bins_CH2>	*integer*	total number of bins set in channel 2
{<Bin_X_CH1>}	*integer*	bin numbers set in Chn1
{<Bin_X_CH2>}	*integer*	bin numbers set in Chn2
{<Phase_X_CH1>}	*float*	phases of bins set in Chn 1
{<Phase_X_CH2>}	*float*	phases of bins set in Chn 2

Range

<Sig_Number>	1 ¦ 2 ¦ 3 ¦ 4
<Sig_Number>	(up to 8 ASCII characters, no spaces allowed)
<No_Of_Samples>	512 ¦ 1024 ¦ 2048 ¦ 4096 ¦ 8192
<No_Of_Bins_CH1>	1 to 31
<No_Of_Bins_CH2>	1 to 31
<Bin_No_X_CH1>	Bin_Min[1] to Bin_Max[2]
<Bin_No_X_CH2>	Bin_Min[1] to Bin_Max[2]
<Phase_X_CH1>	-π to +π
<Phase_X_CH2>	-π to +π

$$^{1)}\ Bin_Min = \left| \frac{\text{NoOfSamples}}{48'000\,Hz} * 20\,Hz \right| \qquad ^{2)}\ Bin_Max = \left| \frac{\text{NoOfSamples}}{48'000\,Hz} * 20\,kHz \right|$$

Query Use command ***OUTPut:MTONe:PARameter?***

Example 💻 →
```
Output:Mtone:Par
1,'Telefon',2048,3,3,25,85,256,25,85,256,0,1.5707
,3.14,0,1.5707,3.1415
```

Explanation This command defines all compulsory parameter of a new multitone signal.
<No_Of_Bins_CH*X*> equals the total number of signal bins for channel 1 / 2.
<Bin_No_X_CH*Y*> indicate the bin numbers as calculated with *Equation 7* (p. 25).
<Phase_X_CH*Y*> indicate the phases of the signal bins.

OUTPut[1-2]:LEVel <Level> <Unit>

Use Set the total output level of the multitone signal.

Parameter

<Level>	*float*
<Unit>	*string*

Unit dBVp ¦ Vp ¦ dBV ¦ V

V	Peak value in logarithmic scale (RMS value is lower by crest factor)
dBV	Peak value in linear scale (RMS value is lower by crest factor)
Vp	RMS output level in logarithmic scale (peak level is higher by crest factor)
dBVp	RMS output level in linear scale (peak level is higher by crest factor)

Range

-60 to +20	dBVp	(rounded to nearest 0.1dBVp)
+0.001 to +10	Vp	

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Default 0 dBVp

Query Use command ***OUTPut[1-2]:STATus?***

Example
💻 → `Outp1:Level -6.2 dBVp`

💻 → `OUTPUT2:LEVEL 3.5 V`

Explanation This command allows to set the output level in either RMS or peak units. The maximum output level of 10Vp cannot be exceeded..

OUTPut:MTONe:PRETriggerlength <Length>

Use Definition of the pretrigger duration for the active multitone signal in milliseconds.

Parameter <Length> *float*

Range 0 to 30'000

Unit ms (milliseconds)

Default 0

Query Not possible.

Example
💻 → `Output:Mtone:Pret 0`

💻 → `Outp:Mtone:Pretriggerlength 50.5`

Explanation The duration value is rounded to the next possible value. The duration of the pretrigger excludes the duration of the trigger, which always occupies some 42ms. The value 0 defines the shortest possible pretrigger length of 0ms.
The command mainly allows the DUT to stabilize before the multitone signal is transmitted.

OUTPut:MTONe:MTONelength <Length>

Use Definition of the multitone signal duration for the active multitone signal in milliseconds.

Parameter <Length> *float*

Range 0 to 30'000

Unit ms (milliseconds)

Default 0

Query Not possible

Example
💻 → `Output:Mtone:Mton 500`

Explanation The duration value is rounded to the next possible integer multiple of the duration of one multitone block. The value 0 results in transmission of the min. number of multitone blocks.
The command mainly allows the DUT to stabilize onto the multitone signal before analysis is started.

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OUTPut[1-2]:BINlevel <Level> <Unit>

Use Set the bin level of the multitone signal (all bins have equal level).

Parameter
<Level> *float*
<Unit> *string*

Unit dBV ¦BV ¦ dBVp ¦ Vp

dBV	RMS binlevel in linear scale
V	RMS binlevel in logarithmic scale
dBVp	Peak value in linear scale
Vp	Peak value in logarithmic scale

Range -60 to xx dBVp (max. binlevel has to be calculated acc. ***Equation 1*** & ***Equation 6***)
+0.001 to +yy Vp

Query Use command ***OUTPut[1-2]:STATus?***

Example 💻 → `Outp1:Binlevel -6.2 dBVp`

Explanation

> **Be aware that when bin level is set, the total output level is higher as per *Equation 6*. The maximum output level of 10Vp cannot be exceeded.**

OUTPut[1-2]:MUTe [OFF¦ON]

Use Mute or unmute a channel output.

Range OFF ¦ ON *boolean*

Default OFF

Query Use command ***OUTPut[1-2]:STATus?***

Example 💻 → `Output1:Mute ON`

💻 → `OUTP1:MUT OFF`

OUTPut:FLOAT [OFF¦ON]

Use Sets both output channels to either float or ground mode. In float mode the center tap of the generator can float to any level. Ground mode is necessary for unbalanced output signals.

Range OFF ¦ ON *boolean*

Default OFF

Query Use command ***OUTPut[1-2]:STATus?***

Example 💻 → `Output:Float ON`

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OUTPut:MTONe:ACTive [1¦2¦3¦4]

Use Defines the current multitone signal as the active signal used for transmission. All commands with no signal number refer to the active signal.

Range 1 ¦ 2 ¦ 3 ¦ 4 *integer*

Default 1

Query Use command ***OUTPut[1-2]:STATus?***

Example
💻 → `OUTP:MTON:ACT 2`

💻 → `Output:Mtone:Active 1`

OUTPut:MTONe:STARt

Use Start transmission (i.e. generation & analysis) of the active multitone burst.

Example 💻 → OUTP:MTONE:START

Explanation This command has to be sent either if a multitone burst shall be
- generated and analyzed *or*
- generated only *or*
- sampled & analyzed only.

OUTPut:MTONe:CONtinuous

Use Starts the generator to endlessly send out the active multitone signal.

Example 💻 → `OUTP:MTONE:CON`

Explanation The signal is sent out in an endless loop. Only the multitone signal is transmitted, i.e. without header. **No measurement may be performed on this signal**. This is a generation mode only. The signal can be stopped by any IEEE command being sent to RT-1M.

OUTPut[1-2]:STATus?

Use Queries the generator status for channel 1 or channel 2.

Answer

<Active>	*string*	ACTIVE [1 ¦ 2 ¦ 3 ¦ 4]
<Out_Level>	*string*	LEVEL [-60 to +20 dBVp ¦ 0.001 to 10 Vp]
<BinLevel>	*string*	BINLEVEL [-60 to xx dBVp ¦ 0.001 to yy Vp]
<Mute_State>	*boolean*	MUTE [ON ¦ OFF]
<Float_State>	*boolean*	FLOAT [ON ¦ OFF]

Resolution <Out_Level> 0.1dBV

Example
💻 → `OUTPUT1:STATUS?`

→ 💻 `ACTIVE 1,LEVEL -3.5000E0 dBV,BINLEVEL 0.1 V, MUTE OFF,FLOAT ON`

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OUTPut:MTONe:NAME?

Use Queries the name of the active multitone signal.

Answer <Name> *string*

Default (the active signal name)

Example
```
💻 →   Output:mtone:Name?
→ 💻   Telephon
```

OUTPut:MTONe:BLOCklength?

Use Queries the number of samples (i.e. blocklength) of the active multitone signal.

Answer <Blocklength> *integer*

Range 512 ¦ 1024 ¦ 2048 ¦ 4096 ¦ 8192

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

OUTPut:MTONe:PARameter?

Use Queries the parameter of the active multitone signal. Format is compatible with the command ***OUTPut:MTONe:PARameter***.

Answer

<Sig_Number>	*integer*	1 ¦ 2 ¦ 3 ¦ 4
<Sig_Name>	*string*	up to 8 ASCII characters
<No_Samples>	*integer*	512 ¦ 1024 ¦ 2048 ¦ 4096 ¦ 8192
<No_Of_Bins_CH1>	*integer*	1 to 31
<No_Of_Bins_CH2>	*integer*	1 to 31
{<Bin_X_CH1>}	*integer*	Bin_Min to Bin_Max
{<Bin_X_CH2>}	*integer*	Bin_Min to Bin_Max
{<Phase_X_CH1>}	*float*	-π to +π
{<Phase_X_CH2>}	*float*	-π to +π

Example
```
💻 →   Output:Mtone:Par?
→ 💻   1,Telefon,2048,3,2,25,85,256,11,102,0.000E+00,1.5
       707E+00,3.14150E+00,1.234E+00,0.14170E+00
```


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OUTPut[1-2]:MTONe:CRESt?

Use Queries the Crest factor of the active multitone signal.

Answer <Crestfac> *float*

Range (any positive number ≥√2)

Example
💻 → `OUTP1:MTONe:CREST?`
→ 💻 `2.33433E0`

Explanation Refer to chapter ***Phase / Crest Factor Optimization*** for further explanations.

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MEASurement Subsystem

MEASurement[1-2]:LEVel:UNIT [dBVp¦Vp¦dBV¦V]

Use Defines the unit in which the level results shall be expressed.

Range dBVp ¦ Vp ¦ dBV ¦ V *string*

Default dBVp

Example 💻 → `MEAS1:LEV:UNIT VP`

MEASurement[1-2]:LEVel?

Use Returns the measured signal bin levels of the last received multitone signal for one channel.

Answer

{Set_bin_n}	*integer*	
{Amplitude_n}	*float* & *string*	(level value & unit)

Range

Set_Bin_n	Bin_Min to Bin_Max (see ***Equation 4*** and ***Equation 5***)
Amplitude_n	*float* ¦ NaN & *string*

Unit Defined by ***MEASurement[1-2]:LEVel:UNIT [dBVp¦Vp¦dBV¦V]***.

Default NaN (not a number)

Example

💻 → `MEAS1:LEV?`
→ 💻 `3/1.240E0 dBV,23/9.727E-1 dBV,84/8.254E-1 dBV`

Explanation The returned level vector is grouped in result pairs, starting with the first signal bin number, a "/", the corresponding level value, 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.

MEASurement[1-2]:DISTortion:UNIT [dBV¦V]

Use Defines the unit in which the distortion result shall be expressed.

Range dBV ¦ V *string*

Default dBV

Example 💻 → `MEAS1:DIST:UNIT V`

MEASurement[1-2]:DISTortion?

Use Returns the distortion values of all the bands between Bin_Min → Bin_1, Bin_1 → Bin_2, etc., Bin_n → Bin_Max (see also ***Distortion***).

Answer

Bin_Min	*integer*
Dist_1	*float* + *string*
{Set_bin_n}	*integer*
{Dist_n}	*float* + *string*

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Range	Bin_Min	Bin_Min
	{Set_Bin_n}	Bin_Min to Bin_Max (see ***Equation 4*** and ***Equation 5***)
	Dist_1,{Dist_n}	*float* ¦ NaN + *string*

Unit Defined in ***MEASurement[1-2]:DISTortion:UNIT***

Example
```
💻 →   Measurement1:Dist?
→ 💻   3/2.23E-2 V,11/8.23E-3 V,27/1.35E-2 V
```

Explanation The returned distortion vector starts with the number of the first bin ≥20Hz / the distortion up to the first signal bin. Second pair is the number of the first signal bin / the distortion result between this first signal bin and the second signal bin, etc. The last pair is the last signal bin / the distortion result between this last signal bin and Bin_Max (last bin ≤20kHz; see ***Fig. 20***). If a band between two signal bins is too narrow to measure a distortion, 'NaN' is returned.

MEASurement[1¦2]:MTSinad?

Use Returns the SINAD value using the selected Multitone signal in the full bandwidth between Bin_Min (>20Hz) and Bin_Max (<20kHz). The single value calculation considers: Signal plus Distortion plus Noise to Distortion plus Noise for any defined multitone signal. (see also chapter ***MT-SINAD***, ***p. 30***).

Answer	Bin_Max/	*integer*	(see ***Equation 5***, ***p. 19***)
	MT_Sinad	*float* ¦ NaN & *string*	(measured MT-SINAD result & unit)

Default NaN (not a number)

Unit dB

Example
```
💻 →   Measurement1:MTSinad?
→ 💻   214/5.2235E+01 dB
```

Explanation The returned MT-SINAD value considers all signal components, starting with the lowest possible frequency in the signal at the first bin ≥20Hz up to the highest frequency bin below 20kHz. It calculates from the distortions and the signal components the single SINAD value. If a band between two signal bins is too narrow to measure a distortion, the error 246 is returned.

MEASurement[1-2]:SELectiverss:UNIT [dBV¦V]

Use Defines the unit in which the RSS (root sum square) selective result shall be expressed.

Range	dBV ¦ V	*string*

Default dBV

Example
```
💻 →   Meas1:Sel:Unit dBV
```

MEASurement[1-2]:SELectiverss? <binstart> <binstop>

Use Returns the RSS value for the band from <binstart> to <binstop> (including both levels).

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Parameter <binstart>, <binstop> *integer*

Range Bin_Min to Bin_Max

Units Defined by

MEASurement[1-2]:SELectiverss:UNIT [dBV¦V].

Default NaN (not a number)

Example
💻 → `MEAS2:SEL? 11 32` (RSS value from Bin #11 to Bin #32,
→ 💻 `32/-1.01352169+02 dBV` including levels of Bin #11 + #32)

Explanation The RSS selective measurement (see p. ***3-30***) allows to measure the total distortion + noise in any frequency band between 20Hz - 20kHz. <binstart> defines the lower border of this band, while <binstop> defines the upper border of the band.
Please notice, that if the selected band comprises a signal bin, the RSS selective result will include this signal bin level in addition to the distortion + noise value of the band.

MEASurement[1-2]:NOISe:UNIT [dBV¦V]

Use Defines the unit in which the noise measurement results shall be expressed.

Range dBV ¦ V *string*

Default DBV

Example 💻 → `MEAS1:NOISE:UNIT V`

MEASurement[1-2]:NOISe?

Use Returns the noise values of all the bands between 20Hz → Bin_Min, Bin_Min → SigBin_1, etc., SigBin_n → Bin_Max, Bin_Max → 20kHz (see also chapter ***Noise***).

Answer

Bin_Min	*Integer*
Noise_1	*float + string*
{SigBin_n}	*integer*
{Noise_n}	*float + string*

Range

Bin_Min	Bin_Min
{Set_Bin_n}	Bin_Min to Bin_Max (see ***Equation 4*** and ***Equation 5***)
Noise_1,{Noise_n}	*float* ¦ NaN + *string*

Unit As defined by command ***MEASurement[1-2]:NOISe:UNIT [dBV¦V]***

Default NaN (not a number)

Example
💻 → `Measurement1:Noise?`
→ 💻 `3/6.56E-3 V,11/7.32E-3 V,27/6.55E-3 V,`
`87/5.87E-3 V,2048/4.27E-3 V`

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Explanation The returned noise vector starts with Bin_Min (i.e. the first possible bin ≥20 Hz), followed by the noise result between this bin and the first signal bin. Second pair is the bin number of the first signal bin and the noise value between this first signal bin and the second signal bin, etc. Last pair is the last signal bin with the noise result between the last signal bin and Bin_Max (i.e. the last possible bin ≤20kHz). See also ***Fig. 22***.
If a band between two signal bins is too narrow to measure noise value, 'NaN' is returned.

MEASurement[1-2]:CROSstalk:UNIT [dB¦%]

Use Defines the unit in which the crosstalk measurement shall be expressed.

Range dB ¦ % *string*

Default %

Example 💻 → `MEAS1:CROS:UNIT dB`

MEASurement[1-2]:CROSstalk?

Use Returns the measured crosstalk of the last received multitone signal for one channel. The crosstalk result can be evaluated only if at least one signal bin of each channel is set at an exclusive frequency.

Default NaN (not a number)

Example 💻 → `MEAS1:CROS?`
→ 💻 `3/-87 dB,11/-67 dB`

Explanation The returned result pairs indicate the signal bin number, followed by a "/", the corresponding crosstalk value, a white space, the unit, in which the result is expressed, and a ",".
If the crosstalk value is too small to be measured, 'NaN' (not a number) will be returned.

MEASurement:PHASe:UNIT [rad¦deg]

Use Defines the unit in which the phase measurement result shall be expressed.

Range rad ¦ deg *string*

Default rad

Example 💻 → `MEAS:PHASE:UNIT DEG`

MEASurement:PHASe:SCALe <Scale>

Use Defines the lower border of the phase-plot scale, in which the result shall be expressed. The scale always comprises a full circle, i.e. 2π (rad) or 360° (deg) respectively.

Parameter <Scale> *float*

Range [-2π to 0 ¦ –360 to 0]

Default 0

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Example 💻 → `MEAS:PHASE:SCALE -180` (-180 to +180 deg.)

💻 → `Meas:Phas:Scal 0` (0 to +2π rad.)

MEASurement[1-2]:PHASe?

Use Returns the measured phase-difference between the 2 channels of the last received multitone signal. The phase value can be calculated only if both channels have recognized a trigger and if at least one signal bin is identical, i.e. set on both channels.
ATTENTION: In order to get accurate phase values, it is important to set the input ranges of both channels to the same level.

Answer

{SigBin_1}	*integer*
{Phase_1}	*float* + *string*
{SigBin_n}	*integer*
{Phase_n}	*float* + *string*

Range

{SigBin_n}	Bin_Min to Bin_Max (see ***Equation 4*** and ***Equation 5***)
{Phase_n}	*float* ¦ NaN + *string*

Unit (as defined by command ***MEASurement:PHASe:UNIT***)

Example

💻 → `MEAS1:PHASE?`
→ 💻 `3/1.24E0 deg,23/9.27E-1 deg`

Explanation The returned result is composed of pairs, each starting with the signal bin number, followed by a "/", the phase result, a white space the unit, in which the phase was measured, and a ",".

MEASurement1:DTMF:STARt

Usage Resets the DTMF tone receiver buffer (32 keys wide) of channel 1.
NOTE: This command requires installation of the DTMF option for RT-1M.

Examples 💻 → `Meas1:Dtmf:Start`

Explanation After this command, RT-1M continues to store all incoming DTMF tones in its buffer.

MEASurement1:DTMF?

Usage Queries the DTMF tone receiver buffer (32 keys wide) of channel 1.
NOTE: This command requires installation of the DTMF option for RT-1M.

Examples

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

Explanation RT-1M returns pairs of x-/y-coordinates, identifying the DTMF keys in the received order.
The standard 4x4 keypad coding is:
(unused fields may be user-defined)

↓*y-coord.*	*1*	*2*	*3*	*4* → *x-coord.*
1	1	2	3	A
2	4	5	6	B
3	7	8	9	C
4	*	0	#	D

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Device Status

*STB?

Use Fetches the STatus Byte register. See also chapter ***IEEE Standard Status Data Structure***.

Calculation $STB = n_7*128 + n_6*64 + n_5*32 + n_4*16 + n_3*8 + n_2*4 + n_1*2 + n_0$

n_7	Not used
n_6	Master summary status (MSS) The MSS message indicates that RT-1M has at least one reason for requesting service.
n_5	Event status summary bit (ESB), indicating whether any of the enabled events has occurred since the last reading of the standard event status register.
n_4	Message available summary bit (MAV). The MAV message indicates whether or not the output queue is empty. Whenever RT-1M is ready to accept a request by the controller to output data, MAV summary message will be TRUE.
n_3	Not used
n_2	Not used
n_1	Not used
n_0	Not used

Example

```
💻 →  *STB?
→ 💻  32
```

*OPC

Use The OPeration Complete command causes RT-1M to generate the operation complete message in the standard event status register (Bit 0) when all pending selected device operations have been finished. The *OPC command allows synchronization between controller and RT-1M..

Example

```
💻 →  *esr?                          (clears previous events)
      *ese 1;*sre 32                 (enable operation complete event)
      output:mtone:start, *OPC       (RT-1M will request service [serial poll]
                                      as soon as the measurement is finished)
```

*OPC?

Use The OPeration Complete query causes RT-1M to place an '1' into the RT-1M output queue when all pending selected device operations have been finished. The *OPC command allows synchronization between controller and RT-1M using the MAV bit in the status byte register. See also chapter ***IEEE Standard Status Data Structure***.

Parameter <OPCvalue> *boolean*

Range

0	not finished
1	finished

Example

```
💻 →  *OPC?
→ 💻  1
```

Explanation Use *OPC? with serial polling (e.g. MAV).

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*CLS

Use The CLear Status command clears status data structures, i.e. standard event status registers, so that the corresponding summary ESB bit is clear. See also chapter ***IEEE Standard Status Data Structure***.

Example 💻 → `*CLS`

Explanation *CLS has same effect as *ESR? query, except it is a command.

*ESE

Use The standard Event Status Enable command sets the standard event status enable register bits. The standard event status enable register allows one or more events in the standard event status register to be reflected in the ESB summary-message bit. See also chapter ***IEEE Standard Status Data Structure***.

Parameter <Enable_value> Byte

Range 0 to 255

Example 💻 → `*ESE 32` (enables command error event)

*ESE?

Use The standard Event Status Enable query allows the programmer to determine the current contents of the standard event status enable register. See also chapter ***IEEE Standard Status Data Structure***.

Parameter <Enable_value> Byte

Range 0 to 255

Example 💻 → `*ESE?`
→ 💻 `32`

*SRE

Use The Service Request Enable command sets the service request enable register bits. The service request enabling allows a programmer to select which summary messages in the status Byte register may cause service request (SRQ). The programmer can select reasons to issue a service request by altering the contents of the service request enable register. See also chapter ***IEEE Standard Status Data Structure***.

Parameter <Enable_value> Byte

Range 0 to 255

Example 💻 → `*SRE 32` (enables standard event status bit [ESB])

*SRE?

Use The Service Request Enable query allows to determine the current contents of the service

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request enable register. See also chapter ***IEEE Standard Status Data Structure***.

Parameter <Enable_value> Byte

Range 0 to 255

Example 💻 → *SRE?
→ 💻 32

---

*ESR?

Use The standard Event Status Register query allows the programmer to determine the current contents of the standard event status register. *Reading* the standard event status register *clears* it. See also chapter ***IEEE Standard Status Data Structure***.

Calculation ESR = n_7*128 +n_6*64 + n_5*32 + n_4*16 + n_3*8 + n_2*4 + n_1*2 + n_0

n_7	Power-On event flag, indicating that an Off-to-On power transition has occurred
	Not used
n_6	Command error event flag, indicating that either a syntax or a semantic error has
n_5	been detected. The error-number can be read with the <system:errors?> query
	Not used
n_4	Device specific error event flag (e.g. no trigger detected). The occurred error-
n_3	number can be read with the <system:errors?> query.
	Not used
n_2	Not used
n_1	Operation complete event flag. This event bit is generated in response to the *OPC
n_0	command. It indicates that the device has completed all pending operations.

Parameter <Enable_value> Byte

Range 0 to 255

Example 💻 → *ESR?
→ 💻 32 (command error has occurred)

---

*PSC

Use The Power-on Status Clear command controls the automatic power-on clearing of the service request enable register and the standard event status enable register.
<*PSC 0> no power-on clearing of the registers.
<*PSC 1> power-on clearing of the registers and therefore disabling of service request assertion after power-on
See also chapter ***IEEE Standard Status Data Structure***.

Parameter <Enable_value> Byte

Range 0 to 1

Default 0

Example 💻 → *PSC 0

---

*PSC?

Use The Power-on Status Clear query allows the programmer to query RT-1M's power-on status

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clear flag. See also chapter ***IEEE Standard Status Data Structure***
<*PSC 0> no power-on clearing of the registers.
<*PSC 1> power-on clearing of the registers and therefore disabling of service request assertion after power-on

Parameter <Power_on_flag> Byte

Range

0	not cleared
1	cleared

Example

💻 → `*PSC?`
→ 💻 `0`

---

*IDN?

Use The IDentificatioN query gets the unique identification of RT-1M. See also chapter ***IEEE Standard Status Data Structure***.

Parameter

<Manufacturer>	*string*
<Instrument_type>	*string*
<Serial_number>	*string* [4]
<Firmware_revision>	*float*

Example

💻 → `*IDN?`
→ 💻 `NEUTRIK,RT1M,0122,3.01`

---

*RST

Use The ReSeT command performs a device reset. All Parameter are set to default values except the output- and command-queue. See also chapter ***IEEE Standard Status Data Structure***.

Parameter No Parameter

Example 💻 → `*RST`

---

*TST?

Use The self-TeST query causes an internal self-test and places a response into the output queue indicating whether or not RT-1M completed the self-test without errors.

Parameter <Self_test> Byte

Range

0	errors occurred
1	self test OK

Example

💻 → `*TST?`
→ 💻 `1`

---

*WAI

Use The WAIt-to-continue command prevents RT-1M from executing any further commands or queries until the no-operation pending flag is TRUE. However, since RT-1M has implemented only sequential command execution, the no-operation command flag is always TRUE.

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Example 💻 → `*WAI`

Examples

Use of an *OPC command

The *OPC and *WAI commands and the *OPC? query allow the controller to synchronize itself to the end of a calculation performed by *RT-1M*.

```
💻 →  *esr?                                  (clears previous events)
      *sre 32;*ese 1                         (enable operation complete event)

      output:mtone:par
      1,'telephon',8192,3,3,600,1000,3000,
      630,970,3030,0,0,0,0,0,0,*opc

→ 💻                                         (as soon as the calculation is finished,
                                             RT-1M requests service [SRQ] by serially
                                             polling the controller)
```

Use of MAV bit in the status Byte register

```
💻 →  *sre 16                                (enable Output queue Not-empty event)

      output:mtone:start                     (start measurement)

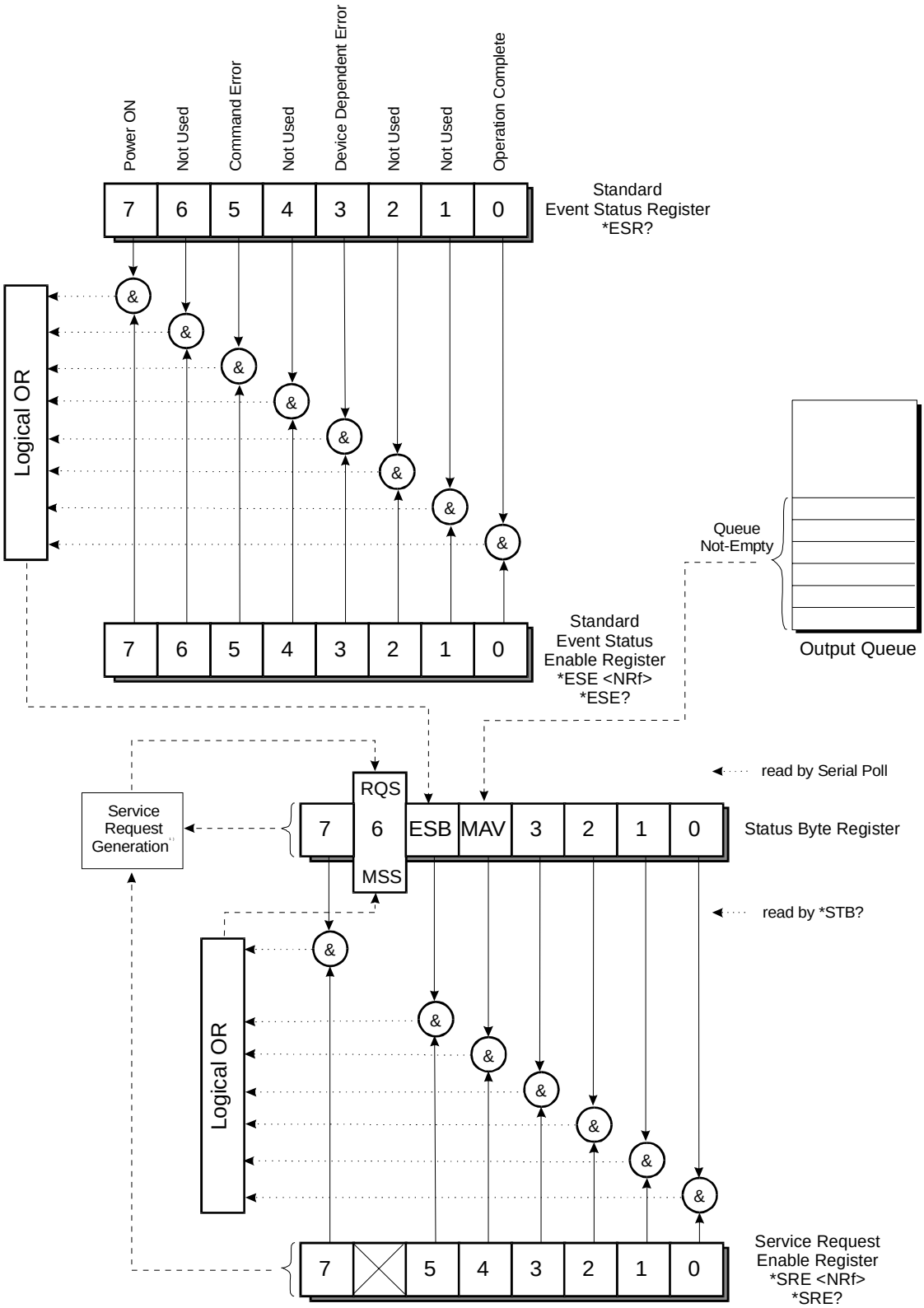
      meas1:dist?                            (get distortion values)

→ 💻                                         (as soon as the output queue has the valid distortion results, RT-
                                             1M requests service [SRQ] via serial poll)
```

As soon as e.g. a *SRE 16 has been sent to the unit, *RT-1M* is set to the service request mode. This means that *RT-1M* will send back a service request to the PC each time that it has a new message (e.g. measurement result) ready.
However, please notice that this message may be transferred to the PC by serial polling only, since *RT-1M* cannot add any further information to the service request.

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IEEE Standard Status Data Structure



For more detailed information refer to IEEE Std 488.2-1992 (IEEE Standard Codes, Formats, Protocols, and Common Commands).

[1] Service Request clears RQS but not MSS!

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5 APPLICATION HINTS

RT-1M is ideally suited to be integrated into industrial environments, having virtually no switches and buttons. All control is established through IEEE commands, allowing to introduce Audio tests as a standard part of the entire QC procedure.

Arbitrary Generator

With its flexibility, ease of operation and its excellent price/performance ratio, RT-1M can be used as a simple arbitrary generator. This way, after few minutes of programming only, RT-1M can serve as a sine wave generator with one fixed, extremely stable frequency or as an IMD, DFD or W&F generator with two frequencies defined. The four dual channel memory locations also allow to have all these configurations permanently stored.

Alignment and Adjustments for Audio Repair Facilities

With the ability to plot two to three frequency responses every second, alignment sequences for tapes, where they have to be done manually, or bias adjustments of amplifiers can be speeded up. Repeated phase measurements simplify the alignment of the azimuth angle of the playback head of a tape recorder - a procedure that normally has to be repetitively performed for low-, mid- and high frequencies.

Cellular Phone Testing

Increasing production volume, based on the fast growth of cellular networks and coupled with the requirement for 100% testing of the units, makes an improvement at production bottleneck - the audio analysis - necessary. RT-1M is ideally suited to serve as a high-speed audio analyzer for production testing. The LF- output signal of the system may be RF-modulated and transmitted through an antenna, to quickly obtain the frequency response and distortion in the voice band of the whole signal path. Frequency shifts as they may appear on AM/FM transmissions are eliminated by the synchronization capabilities of RT-1M.
SINAD measurements with a single bin stimulus are possible down to a value of 1dB. The trigger detection works reliably if the signal is transmitted on the second channel, too.

The dual channel capabilities of RT-1M even makes it possible to perform transmit and receive testing simultaneously. One channel generates the source signal for the transmitter path of the phone (Mic input), while an external test demodulator feeds back the signal to the analyzer of the same channel. The output of the second channel is fed into an external modulator, that supplies the RF signal for the receiver path of the phone. The phone demodulates the signal and the feeds into the second analyzer channel of RT-1M.

Rub & Buzz Speaker Testing

The multitone feature of RT-1M is ideally suited for Rub & Buzz speaker testing in production lines. Most frequently seen defects of speakers are mechanical friction of the moving coil and the magnet, as well as excentrical alignments leading to a staggering movement of the coil. In any of these cases, the speaker either starts to produce nonlinear distortion or adds additional signal energy to frequencies not being part of the original signal. Both of these effects can be measured in a fraction of a second. Harmonics and new frequencies will appear in the distortion-, and in most cases in the noise-plot.
Anyway, the stimulation of a speaker with a multitone signal is more realistic and comes closer to real-world signals. Actually, the mentioned effects may remain unnoticed when stimulating with a single frequency only.

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RT-EVAL Software Package

In order to simplify the operation of RT-1M especially for new users, an easy-to-understand evaluation package has been released. This versatile tool provides not only access to almost all available features of the unit, but also extends this range by some very useful functions like a Crest factor optimizer etc.

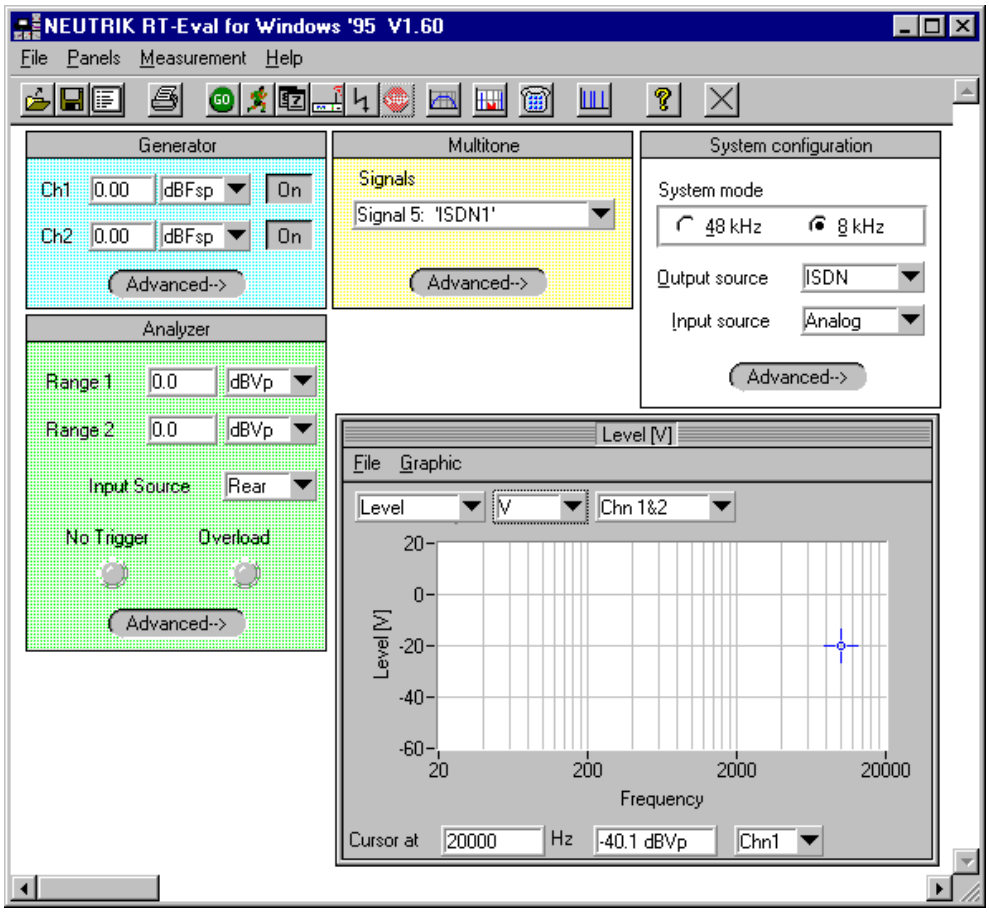


Fig. 25 RT-EVAL Screenshot

Fig. 25 shows a typical screen shot of the RT-EVAL software with generator, analyzer, multitone, system configuration & measurement panel.
Please contact you local representative to get a free copy of this package.

Units & Conversion

Especially in the field of telecommunication, there exists a large number of different units to express a level value, while for practical reasons, RT-1M provides a restricted number of these units only.
The subsequent table lists the most common units and provides the necessary conversion formulas and examples for a better understanding.

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Unit	Explanation	Conversion Formula	Examples
dB	Decibel - unit of measure of relative voltage level	$dB = 20 * \log_{10}(\frac{V_1}{V_2})$	
dBV	RMS Voltage in dB referred to 1[V_{RMS}]	$dBV = 20 * \log_{10}(\frac{V_{RMS}}{1[\mathrm{V_{RMS}}]})$	$0dBV = 20 * \log_{10}(\frac{1[\mathrm{V_{RMS}}]}{1[\mathrm{V_{RMS}}]})$
dBVp	Peak Voltage in dB referred to 1[V_{Peak}]	$dBVp = 20 * \log_{10}(\frac{V_{Peak}}{1[\mathrm{V_{Peak}}]})$	$0dBVp = 20 * \log_{10}(\frac{1[\mathrm{V_{Peak}}]}{1[\mathrm{V_{Peak}}]})$
dBm	Power in relative to 1[mW]. Please notice, that every dBm result refers to the actual input impedance, as e.g. 600Ω.	$dBm = 20 * \log_{10}(\frac{V_{RMS}}{\sqrt{0.001[W] * R_{In}[\Omega]}})$	$2.22dBm = 20 * \log_{10}(\frac{1[\mathrm{V_{RMS}}]}{\sqrt{0.001[\mathrm{W}] * 600[\Omega]}})$
dBm0	dBm referred to or measured at a point of zero transmission level.		
dBrn	dB above reference noise. Weighted circuit noise power in dB referred to 1pW @ 600[Ω]which is defined as 0dBrn (-90dBm). Type of weighting is indicated by next letter (see dBrnc).	$dBrn = 20 * \log_{10}(\frac{V_{RMS}}{\sqrt{1^{-12}[W] * R_{In}[\Omega]}})$	$0dBrn = 20 * \log_{10}(\frac{0.000025[\mathrm{V_{RMS}}]}{\sqrt{1^{-12}[\mathrm{W}] * 600[\Omega]}})$
dBrnc	Weighted circuit noise power in dBrn, measured on a line by measuring set with 'C' message weighting.		
dBrnc0	Noise measured in dBrnc referred to zero transmission level point (0TLP).	$dBrnc0 = dBrnc - 20 * \log_{10}(\frac{R_{Load}}{600[\Omega]})$	

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6 SPECIFICATIONS

Generator

Number of channels	2
Generator type	multitone arbitrary
Resolution	16bit
Sampling rate	48kHz
Frequency resolution	5.86Hz @ blocklength 8192
Number of signal memories	4 (stereo)
Number of test signal frequencies	1 to 31
Signal Frequencies	20Hz to 20kHz
Multitone burst duration	260ms to 960ms depending on frequency resolution max. up to 30sec or continuous (programmable)
Residual distortion	< -86dB or 10µV
Output Level Symmetric	-60 to +20 dBVp in 0.1dB steps (for each channel individually)
Level accuracy	< 0.2dB (@ 1kHz)
Flatness	< 0.2dB (20Hz to 20kHz)

Analyzer

Measurement functions	Level, Total Distortion, Noise, Interchannel Phase, Crosstalk (measured simultaneously)
Number of channels	2
Resolution	18bit
Sampling rate	48kHz
Residual distortion	< -86dB (input signal > -15dBVp)
Frequency resolution	2.95Hz minimum
Input Range (bal.)	-60 to +20 dBVp
Level accuracy	< 0.2dB (@ 1kHz)
Flatness	< 0.2dB (20Hz to 20kHz)
Synchronization	Internal or External
Measurement turn around time	800ms @ blocklength 512 and 3 signal bins

General

Dimensions	483 x 318 x 44 mm (19“ x 12.5“ x 1.75“ - 1 rack unit high)
Weight	7kg
Remote control	IEEE-488
Power requirements	100/120/230V, 50/60Hz, 60VA
Calibration	1 year recommend calibration interval
Operating temperature	5°C to 45°C (40 to 110F) with R.H. < 90% non condensing

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