

Multitone Testing

Most audio / voice frequency (VF) test instruments stimulate the device under test (DUT) with a single sinusoidal wave. By analyzing its output signal, one test result per frequency - e.g. Level, Distortion / SINAD or Noise - may be acquired.

Another, more powerful approach is the use of a multitone signal as stimulus. This principle allows to acquire the result of several measurement functions at different frequencies in a single step only.

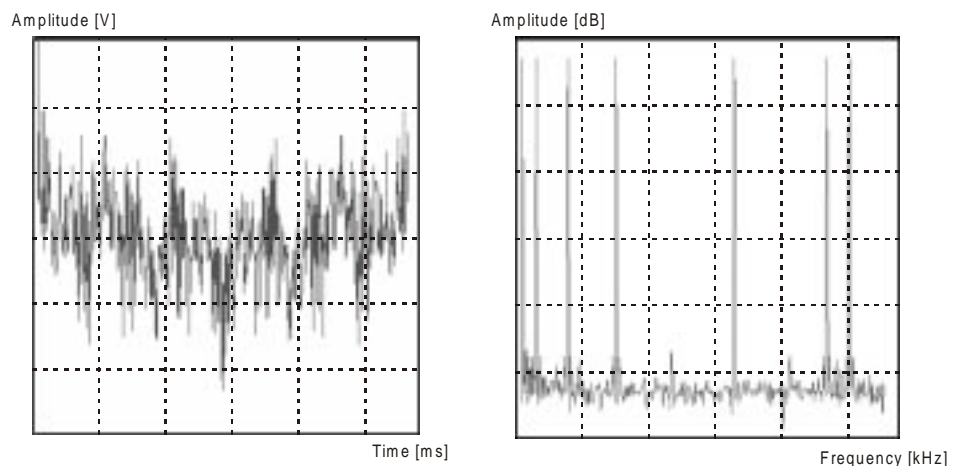
The most striking advantage of single-tone measurements is simplicity. Especially from the operator's point of view, this approach requires a minimum of understanding or specialized knowledge.

On the other hand, single-tone measurements also suffer from a serious disadvantage which frequently arises in industrial quality-control (QC) applications. The demand for a more profound examination of the DUT has made it a requirement for each parameter to be measured at different frequencies. Consequently, every single-tone test has to be repeated for all the frequencies of interest, thus increasing the overall cycle-time proportionally.

The Multitone Approach

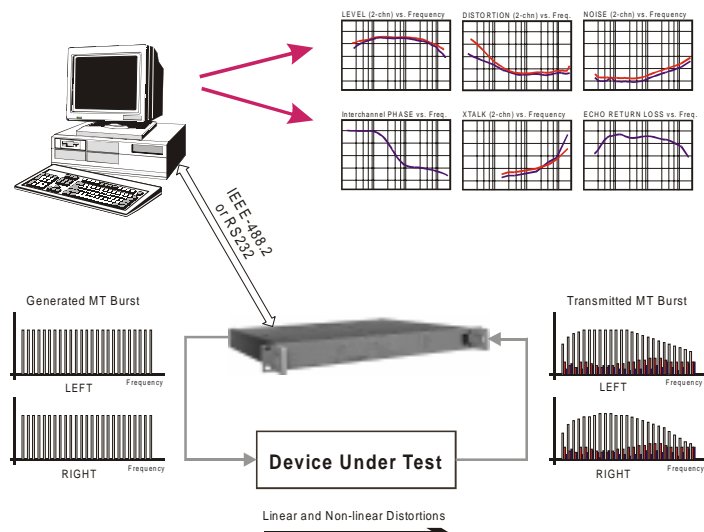
Multitone testing represents a more powerful approach to overcome the time bottleneck. It bases on the principle of simultaneously transmitting all the sinusoidal tones (frequencies) of interest in a single burst. This stimulus is called 'multitone signal'.

The two pictures show a multitone signal with 7 frequencies, displayed on an oscilloscope (in the time domain) and on a spectrum analyzer (in the frequency domain) respectively.



In a typical multitone measurement, the generator sends the user-defined burst through the DUT to the analyzer. The latter samples the transmitted signal and calculates the required results. Finally, these data are uploaded to the controlling PC, where they may be post-processed individually.

The typical test cycle duration of the whole procedure ranges from 500 ms to about 1.5 sec, depending on the required frequency resolution.



RAPID-TEST

RAPID-TEST is a sophisticated 2-channel multitone test instrument with each an independent generator and analyzer in each unit. Due to its flexibility and additional features, it supports a wide range of typical industrial, audio / VF and telecom applications.

In addition to the typical multitone measurements - based on the transmission of bursts - it may also stimulate a DUT with an arbitrary signal only, or analyze an externally generated signal.

The following test & measurement functions are supported *.

- RMS & Peak Level / frequency response (band-selective or full-band)
- Distortion / SINAD
- Noise (band-selective, full-band, idle channel)
- Interchannel Phaseshift / Crosstalk
- Frequency measurement (band-selective or full-band)
- Return Loss (RL) / Echo Return Loss (ERL)
- DTMF (Dual-Tone Multi-Frequency) signal generation & analysis
- Arbitrary signal generation

Application Example

The subsequent program example has been created with the aid of RT-EVAL, the free evaluation software for RAPID-TEST. A special feature of this package, the „Code Generator“, allows the user to automatically generate the program code of the actual setup, i.e. to write all the RAPID-TEST command and query strings, that define a test sequence, to a textfile.

*: Please refer to the corresponding NEUTRIK application sheets for further information



The setup procedure starts with the definition & storage of four user-specific multitone signals, that are kept in the internal, non-volatile memory of RAPID-TEST. Keep in mind, that this definition needs to be executed only once (i.e. doesn't need to be repeated for each test).

```

/* ***** MTONE INITIALIZATION (ALL SIGNALS) *****
OUTPUT:MTONE:PAR 1, "SINE", 512, 1, 1, 11, 11, 0.0000, 0.0000
OUTPUT:MTONE:PAR 2, "5_BIN", 1024, 5, 5, 7, 21, 43, 53, 64, 7, 21, 43, 53, 64, -2.2125,
    2.6557, 0.8985, 1.4555, -1.0840, -2.2125, 2.6557, 0.8985, 1.4555, -1.0840
OUTPUT:MTONE:PAR 3, "XTALK", 2048, 4, 3, 21, 64, 107, 149, 43, 85, 128, -1.7387,
    2.2693, -2.0919, -1.3973, -0.5238, -2.2409, 1.9400
OUTPUT:MTONE:PAR 4, "28_BIN", 8192, 28, 28, 4, 7, 9, 11, 14, 18, 23, 29, 37, 47, 59, 76,
    96, 122, 154, 196, 248, 315, 400, 508, 644, 817, 1037, 1316, 1670, 2120, 2690, 3413,
    4, 7, 9, 11, 14, 18, 23, 29, 37, 47, 59, 76, 96, 122, 154, 196, 248, 315, 400, 508, 644,
    817, 1037, 1316, 1670, 2120, 2690, 3413, 1.8712, -2.2825, -2.8964, 1.4767,
    -1.2966, 1.4623, -1.4028, -1.0476, 2.6470, 3.0129, -2.4307, 2.9625, -2.9812,
    0.3894, 0.9749, 2.1062, 1.1204, 2.0935, -2.5161, 3.1253, -0.2581, 1.1443,
    -1.0145, 2.8173, -0.3991, -2.3928, -0.1097, 0.0843, 1.8712, -2.2825, -2.8964,
    1.4767, -1.2966, 1.4623, -1.4028, -1.0476, 2.6470, 3.0129, -2.4307, 2.9625,
    -2.9812, 0.3894, 0.9749, 2.1062, 1.1204, 2.0935, -2.5161, 3.1253, -0.2581,
    1.1443, -1.0145, 2.8173, -0.3991, -2.3928, -0.1097, 0.0843
    
```

The format of the above listed command strings follows a defined structure, that is explained in the corresponding chapters of your RAPID-TEST user manual.

Nevertheless, for a better understanding, the seven first parameter groups of these four signals have been summarized in the table below.

Memory No.	Signal Name	Blocklength	Number of Freq. for Chn 1	Number of Freq. For Chn 1	Frequencies of Chn 1 [Hz]	Frequencies of Chn 2 [Hz]
1	SINE	512	1	1	1031	1031
2	5_BIN	1024	5	5	328, 984, 2016, 2484, 3000	328, 984, 2016, 2484, 3000
3	XTALK	2048	4	3	492, 1500, 2508, 3492	1008, 1992, 3000
4	28_BIN	8192	28	28	23, 41, 53, 64, 82, 105, 135, 170, 217, 275, 345, 445, 562, 715, 902, 1148, 1453, 1846, 2344, 2977, 3773, 4787, 6076, 7711, 9785, 12422, 15762, 19998	23, 41, 53, 64, 82, 105, 135, 170, 217, 275, 345, 445, 562, 715, 902, 1148, 1453, 1846, 2344, 2977, 3773, 4787, 6076, 7711, 9785, 12422, 15762, 19998

Please notice, that the correlation between the 'signal bin numbers' (the 6th and 7th parameter group) and the frequencies listed in the table, is given by the following formula:

$$\text{Freq.} = \text{BinNo} * \frac{48'000}{\text{Blocklength}}$$



Obviously, one of the four stored multitone signals must be activated (i.e. selected).

```
/* Make signal #2 ('5_BIN') the active multitone signal
OUTPUT:MTONE:ACTIVE 1
```

In a next step, the *output level*, the *trigger condition* and the *input range* of RAPID-TEST has to be defined according to the characteristics of the signal path.

- The output level of RAPID-TEST must be adjusted to the dynamic range of the DUT in order to avoid clipping of the signal. For this procedure, it is recommended that the level is expressed as a *peak* value in dBVp or Vp. This provides a direct relation to the maximum allowable input signal amplitude of the DUT.
- The trigger condition - or 'SYNChronization mode' - has to be selected according to the amount of time delays, frequency shifts and noise present in the test circuit. Please refer to the user manual for further details on this topic.
- The input range of RAPID TEST must be selected according to the expected input signal amplitude, thus avoiding the overloading at the analyzer input. In order to simplify this procedure, a *headroom query* command* that aids the user in finding the best input range has been introduced (*MEASurement[1;2]:HEADroom?*).

The subsequent listing provides an example of the required steps for the output level definition, the selection of the SYNC mode and the optimization of the input range. Please note, that a headroom of approx. +6 dB must be kept between the max. input signal amplitude and the input range.

```
/* Output level definition & SYNC mode selection
OUTPUT1:LEVEL -3.00000 dBVp
OUTPUT2:LEVEL -3.00000 dBVp
INPUT:SYNC INTERNAL

/* Set input range to max., transmit MT signal and query headroom
INPUT1:RANGE 40.0 dBVp
INPUT2:RANGE 40.0 dBVp
OUTPUT:MTONE:START
MEAS1:HEADROOM?
MEAS2:HEADROOM?
-> 4.13703E+01 DB
-> 4.13846E+01 DB

/* Adjust input range to +4.62 dBVp = 40.0 dBVp - 41.4 dB + 6.0 dB
INPUT1:RANGE 4.62 dBVp
INPUT2:RANGE 4.62 dBVp
```

In this state, the RAPID-TEST is ready for the test cycle (i.e. the multitone burst transmission).

```
/* Transmit multitone burst
OUTPUT:MTONE:START
```

*: Not available for RT-1M



After the multitone burst transmission, the operator may query all the results of interest. The following commands reflect the procedure for Level, Distortion, MT-SINAD and Noise.

```
/* Set level measurement unit to dBVp and query the results
MEAS1:LEVEL:UNIT dBVp
MEAS2:LEVEL:UNIT dBVp
MEAS1:LEVEL?
-> 7/-2.70166E+01 dBVp,21/-9.13142E+00 dBVp,43/-1.20623E+01 dBVp,
   53/-1.76097E+01 dBVp,64/-2.48798E+01 dBVp
MEAS2:LEVEL?
-> 7/-2.70213E+01 dBVp,21/-9.13599E+00 dBVp,43/-1.20661E+01 dBVp,
   53/-1.65872E+01 dBVp,64/-2.48959E+01 dBVp

/* Set distortion measurement unit to dBV and query the results
MEAS1:DIST:UNIT dBV
MEAS2:DIST:UNIT dBV
MEAS1:DIST?
-> 7/-1.43287E+02 dBV,21/-1.09664E+02 dBV,43/-1.03673E+02 dBV,
   53/-1.56582E+02 dBV,64/-2.01874E+02 dBV,427/-1.14612E+02 dBV
MEAS2:DIST?
-> 7/-1.40594E+02 dBV,21/-1.06763E+02 dBV,43/-1.00733E+02 dBV,
   53/-1.60014E+02 dBV,64/-2.00101E+02 dBV,427/-1.11221E+02 dBV

/* Query the MT-SINAD results (always expressed in dB)
MEAS1:MTSINAD?
-> 427/8.93784E+01 DB
MEAS2:MTSINAD?
-> 427/9.00121E+01 DB

/* Set noise measurement unit to dBm, query the results and check for errors
MEAS1:NOISE:UNIT dBm
MEAS2:NOISE:UNIT dBm
MEAS1:NOISE?
-> 7/-1.63081E+02 dBm,21/-1.34972E+02 dBm,43/-1.28163E+02 dBm,
   53/-1.10478E+02 dBm,64/-1.25478E+02 dBm,427/-1.36824E+02 dBm
MEAS2:NOISE?
-> 7/-1.61495E+02 dBm,22/-1.36752E+02 dBm,64/-1.29092E+02 dBm,
   53/-1.54896E+02 dBm,64/-1.25479E+02 dBm,427/-1.35697E+02 dBm
SYSTEM:ERR?
-> 0
```

Further information about the whole range RAPID-TEST measurement functions, their applications and additional information are filed in the corresponding Applications Sheets and the User Manual.

