Less noise • More sound

Application Note

Audio Amplifier Testing with RT-2M

RT-2M audio analyzer is ideally suited for comprehensive, yet fast verification of amplifiers. Due to the available range of test signals and analysis features, the instrument allows executing virtually all possible measurements within minimum time.

1. Test signals & measurements

RT-2M provides three different test signals, thus allowing to meet virtually all possible requirements of an amplifier test.

1.1 Multitone

A multitone is a synthesized signal that is built by simultaneous generation of an user-defined selection of frequencies. Thus, it is ideally suited for fast, yet accurate production testing, since it requires only the transmission of a single test signal to execute all relevant measurements.

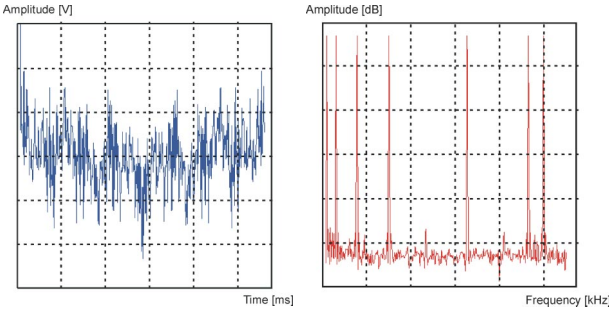

Fig. 1 Multitone burst (time plot and spectrum)

PROs & CONs

+ Minimum test cycle time (e.g. 0.5 sec.), independent of the number of frequencies or measurement functions.
+ High accuracy and noise immunity.
- Maximum 31 frequencies per multitone.

Supported measurement functions

- Level (i.e. frequency response), gain
- Signal-to-noise ratio (must be calculated after signal transmission, based on the acquired level, noise results)
- Distortion, noise
- Interchannel crosstalk and phase

1.2 Stepped sweep

Single sine tone with a frequency that changes stepwise within an user-defined band. Due to high resolution, stepped sweep measurements are typically used for quality assurance testing.

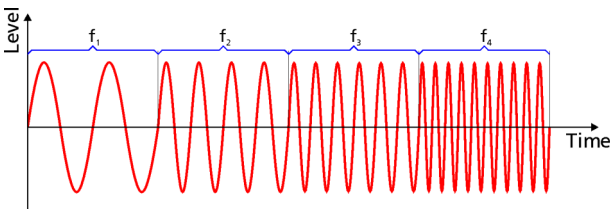

Fig. 2 Stepped sweep

PROs & CONs

+ Very high resolution (up to 500 points)
- Test cycle time linearly rises with growing number of test frequencies.

Supported measurement functions

- Level
- Phase
- THD+N, 2nd & 3rd harmonic distortion

1.3 Gliding sweep (chirp)

PureSound™ transient steepness analysis for reliable detection of audible flaws that are not unveiled by conventional distortion (e.g. THD+N) measurements.

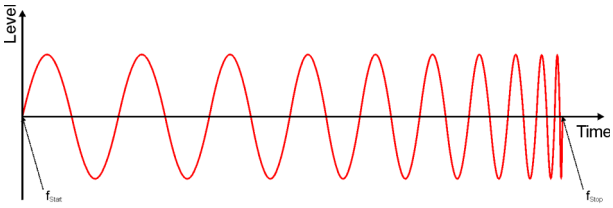

Fig. 3 Gliding sweep

2 Level measurements

2.1 Setup & system preparation

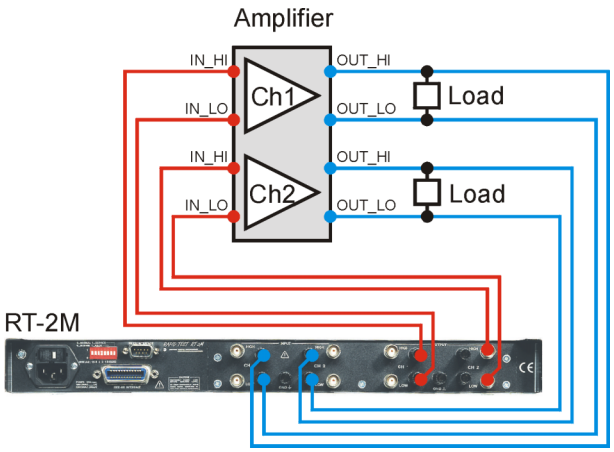

Fig. 4 Typical test setup

Fig. 4 shows a typical amplifier test setup with RT-2M, whereby the resistive load (typically 4 Ω or 8 Ω) could be fitted to the amplifier output. Adjust the RT-2M test parameters as described below.

a) *Test signal*
- Multitone: blocklength, signal bins (i.e. test frequencies) and Crest factor (refer to the *Appendix*).
- Stepped sweep: start & stop frequencies, resolution.

b) *RT-2M generator*
- Output impedance (e.g. 150 Ω).
- Output level: make sure that the RT-2M peak output voltage does not exceed the allowed amplifer input level.

c) *RT-2M analyzer*
- Input impedance (e.g. 100 kΩ).
- Input range: adjust the RT-2M input range (i.e. analyzer sensitivity) so that enough headroom is left to the peak level of an incoming test signal (automatic procedure supported by RT-Eval software).

d) *Test signal transmission*
- RT-Eval: start the burst transmission by pressing the <F5> key or clicking on the "GO" button.
- Command string: alternatively, start the test by sending the following command strings: "`OUTPut:MTONe:STARt`" or "`OUTPut:STEPpedsweep:STARt`".

2.2 Frequency response

- Transmit the test signal (multitone or stepped sweep).

***NOTE** The cycle time of a multitone test is constant, whereas the duration of a sweep analysis linearly rises with the number of steps.*

- Query and decode the level results.

***NOTE** The absolute multitone level results can differ from the stepped sweep results, since the crest factor of a multitone signal is higher than of a swept sine wave.*

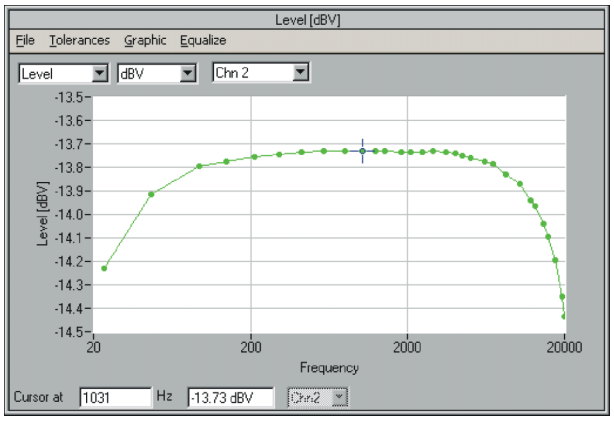

Fig. 5 31-bin multitone level measurement

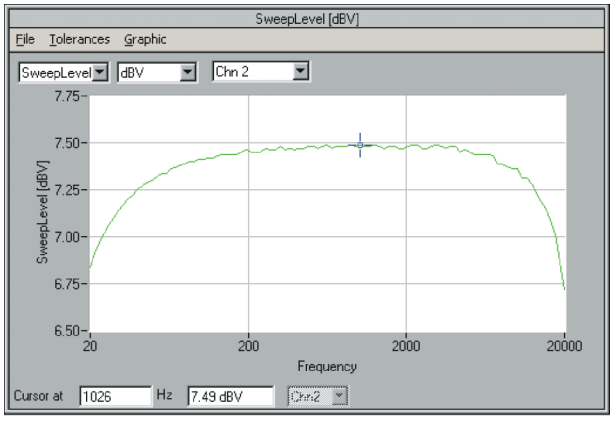

Fig. 6 Sweep level measurement with 100 steps

The frequency response data can be further analyzed to evaluate additional parameters as e.g. flatness, linearity etc.

2.3 Level relative

Based on a frequency response measurement, it is possible to determine the level relative, expressed in dBr.

1. Define the reference voltage (e.g. absolute level @ 1000 Hz).
2. Calculate the level relative results according to following formula:

$$Level_{Relative}\ [dBr] = U\ [dB] - U_{Ref}\ [dB]$$

2.4 Gain

Gain is typically measured with a single-tone test signal at a specific frequency. However, it is also possible to apply a multitone for a more profund amplifier analysis.

- Adjust the 'volume' of the amplifier to a specified value.
- Transmit the test signal.
- Query the gain [dB] results.
- If required, repeat the measurement with different RT-2M ouput levels to calculate the 'gain flatness' (i.e. maximum deviation from the average gain value).

2.4 Signal-to-Noise ratio (S/N)

S/N can be acquired in two ways, either in the absence or presence of an input signal.

a) S/N in the absence of a signal (i.e. with muted RT-2M output):
   - Activate an input filter (e.g. A-weighting, C-message) if required.
   - Transmit the multitone test signal and query the RSS level U_{ON} [dBV].
   - Mute the RT-2M output, transmit the multitone once again and query the RSS level U_{OFF} [dBV].
   - Calculate the signal-to-noise ratio *S/N*:
     $S/N\ [dB] = U_{ON} - U_{OFF}$

b) S/N in the presence of a signal (i.e. parallel measurement of test signal level and noise):
   - Transmit the multitone test signal.
   - Query the RSS level U_{Level} [dBV].
   - Query the total noise U_{Noise} [dBV].
   - Calculate the signal-to-noise ratio *S/N*:
     $S/N\ [dB] = U_{Level} - U_{Noise}$

3 Distortion measurements

The term 'distortion' generally stands for irritating effects that are audible in a sound signal. In practice, RT-2M offers three methods to analyze such distortions.

- TD+N (total distortion + noise), acquired from a multitone transmission.
- Conventional THD+N (total harmonic distortion + noise) or 2nd, 3rd harmonic, measured with stepped sweep analysis.
- NTI's PureSound™ transient steepness analysis.

3.1 Multitone distortion measurements

a) Transmit the multitone.

b) Query the distortion results.
   - TD+N (total distortion + noise): this result sums up all harmonic + intermodulation distortions + noise between neighboured signal bins (refer to the *RT-2M Reference Manual*). The advantage of this analysis is its close correlation to the human perception.
   - MT-SINAD: this measurement returns the inverse of TD+N.

3.2 Stepped sweep distortion analysis

a) Transmit the stepped sweep.

b) Query the distortion results.
   - THD+N: i.e. the total harmonic distortion + noise value at every individual sweep frequency over the full audio frequency band (i.e. 20 Hz - 20 kHz).
   - 2nd, 3rd Harmonic: the level of the second or third harmonic at every individual sweep frequency.

NOTE ***Distortion measurements have a constant test cycle time if executed by multitone analysis. On the other side, stepped sweep measurements result in a much longer test cycle time that depends linearly on the number of sweep frequencies.***

3.2 PureSound™

PureSound™ is a completely new and extremely sensitive analysis principle for the detection of all kinds of audible irritations in a sound signal.

The method is based on measuring the signal's transient steepness in the time domain. Thus, it avoids the drawbacks of conventional distortion measurements, i.e. the averaging effect of spectrum analysis.

- Transmit the test signal (i.e. gliding sweep).
- Query the steepness results (experience tells that peak values above 0.1 V/s are audible).

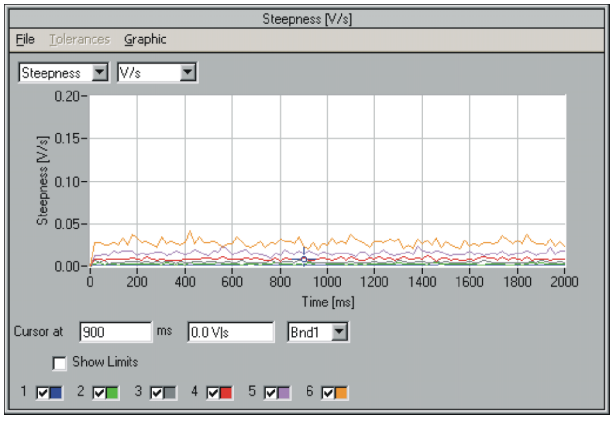

Fig. 7 PureSound™ transient steepness graph

NOTE PureSound™ results can be easily interpreted: the higher the result curve, the more irritating has been the analyzed sound.

4 Interchannel measurements

4.1 Phase

RT-2M measures the phase shift between the two channels of an amplifier.

- Connect the output & input of both RT-2M channels to the DUT.
- Transmit the test signal, i.e. a multitone (whereby at least one signal bin on both channels must be identical), or a stepped sweep.
- Query the phase results.

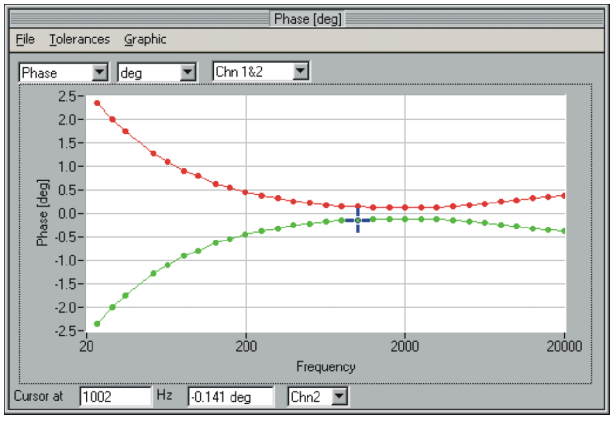

Fig. 8 Multitone phase

4.2 Crosstalk

- Define a multitone test signal, whereby at least one signal bin of channel 1 must have a different frequency than channel 2.
- Transmit the multitone test signal.
- Query the crosstalk results.

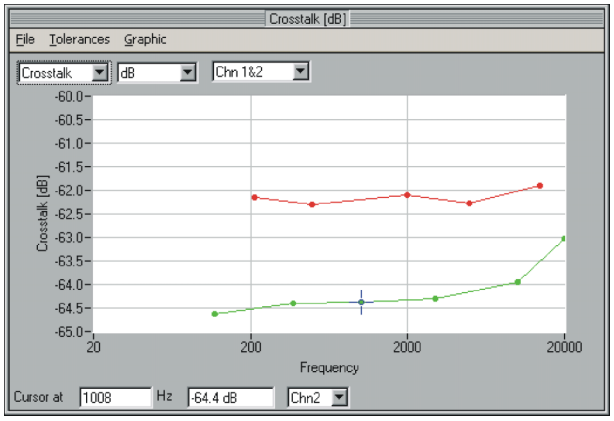

Fig. 9 Multitone crosstalk

Appendix

A1) Multitone test sequence

The command sequence below was created by using the RT-Eval code generator. It executes a multitone test that acquires three measurement results in one cycle:

- Frequency response
- Gain
- Distortion

NOTE ***Replace instruction „`SendToRT`“, „`ReadFromRT`“ with the proper commands of your communication interface (IEEE or RS232). Define the multitone signal as well as the output level and input range according to the requirements of your test.***

```
//  ----------------------- INITIALIZATION PART -----------------------
SendToRT "SYSTEM:RESET"

//  *************** MTONE INITIALIZATION (ACTIVE SIGNAL) ***************
SendToRT "OUTPUT:MTONE:PAR
4,'31TONE',8192,30,30,4,5,6,9,11,14,17,22,27,34,43,54,
68,86,108,136,171,215,271,341,430,541,681,857,1079,1359,1711,2154,2711,3413,4,5,6,
9,11,14,17,22,27,34,43,54,68,86,108,136,171,215,271,341,430,541,681,857,1079,1359,
1711,2154,2711,3413,-1.91611E+00,2.03564E+00,1.80155E+00,-2.16967E+00,
-2.78476E+00,3.26923E-01,-2.04725E+00,-2.57799E+00,1.26421E-01,2.28652E+00,
-2.87497E+00,9.14347E-01,2.82450E+00,-1.85101E+00,1.03174E+00,-3.35515E-01,
-1.27469E+00,2.00116E+00,-2.40465E+00,2.81182E-01,-2.86640E+00,7.73970E-02,
9.81765E-01,-5.05764E-01,-4.45733E-01,-9.55046E-01,-2.51474E+00,-2.83730E+00,
-2.02350E+00,-3.13323E+00,-1.91611E+00,2.03564E+00,1.80155E+00,-2.16967E+00,
-2.78476E+00,3.26923E-01,-2.04725E+00,-2.57799E+00,1.26421E-01,2.28652E+00,
-2.87497E+00,9.14347E-01,2.82450E+00,-1.85101E+00,1.03174E+00,-3.35515E-01,
-1.27469E+00,2.00116E+00,-2.40465E+00,2.81182E-01,-2.86640E+00,7.73970E-02,
9.81765E-01,-5.05764E-01,-4.45733E-01,-9.55046E-01,-2.51474E+00,-2.83730E+00,
-2.02350E+00,-3.13323E+00"

//  *************** MTONE SETTINGS ***************
SendToRT "OUTPUT:MTONE:ACTIVE 4"

//  *************** OUTPUT SETTINGS ***************
SendToRT "OUTPUT:FLOAT OFF"
SendToRT "OUTPUT1:IMPEDANCE 150"
SendToRT "OUTPUT2:IMPEDANCE 150"

//  *************** INPUT SETTINGS ***************
SendToRT "INPUT1:RANGE 6.00 dBVp"
SendToRT "INPUT2:RANGE 6.00 dBVp"
SendToRT "INPUT:SYNC INTNOHEADER"
SendToRT "INPUT:TRIGGER:TIMEOUT  500"
SendToRT "INPUT:SWFILTER OFF"
SendToRT "INPUT1:IMPEDANCE 100k"
SendToRT "INPUT2:IMPEDANCE 100k"

! REM  ********* OUTPUT LEVEL SETTINGS ***********
SendToRT "OUTPUT1:LEVEL 0.00 dBVp"
SendToRT "OUTPUT2:LEVEL 0.00 dBVp"

//  ----------------------- END INITIALIZATION PART ---------------------
```

(continued on next page)

```
//  -------------------- MULTITONE MEASUREMENT PART --------------------

//  Transmit the multitone burst & execute the measurements
SendToRT "OUTPUT:MTONE:START"

//  *************** MEASUREMENT Level [dBVp] ***************
SendToRT "MEAS1:LEVEL:UNIT dBVp"
SendToRT "MEAS2:LEVEL:UNIT dBVp"

// --- Query the channel 1, 2 level results and check for errors.
SendToRT "MEAS1:LEVEL?"
ReadFromRT
// --- Interpret the returned result string ---

SendToRT "MEAS2:LEVEL?"
ReadFromRT
// --- Interpret the returned result string ---

SendToRT "SYSTEM:ERR?"
ReadFromRT
// --- Interpret the returned result string ---

//  *************** MEASUREMENT Gain [dB] ***************
// --- Query the channel 1, 2 gain results and check for errors.
SendToRT "MEAS1:GAIN?"
ReadFromRT
// --- Interpret the returned result string ---

SendToRT "MEAS2:GAIN?"
ReceiveFromRT
// --- Interpret the returned result string ---

SendToRT "SYSTEM:ERR?"
ReadFromRT
// --- Interpret the returned result string ---

//  *************** MEASUREMENT Distortion [dBV] ***************
SendToRT "MEAS1:DIST:UNIT dBV"
SendToRT "MEAS2:DIST:UNIT dBV"

// --- Query the channel 1, 2 distortion results and check for errors.
SendToRT "MEAS1:DIST?"
ReadFromRT
// --- Interpret the returned result string ---

SendToRT "MEAS2:DIST?"
ReadFromRT
// --- Interpret the returned result string ---

SendToRT "SYSTEM:ERR?"
ReadFromRT
// --- Interpret the returned result string ---

//  ------------------- END MULTITONE MEASUREMENT PART -----------------
```

A2) Stepped sweep test sequence

The command sequence below transmits a stepped sweep to acquire three measurement results in one cycle:

- Frequency response [V]
- THD+N [dB]
- Phase shift [deg]

```
// ------------------------ INITIALIZATION PART ------------------------
// *************** OUTPUT SETTINGS ***************
SendToRT "OUTPUT:FLOAT OFF"
SendToRT "OUTPUT1:IMPEDANCE 150"
SendToRT "OUTPUT2:IMPEDANCE 150"

// *************** INPUT SETTINGS ***************
SendToRT "INPUT1:RANGE 6.00 dBVp"
SendToRT "INPUT2:RANGE 6.00 dBVp"
SendToRT "INPUT1:LINK OFF"
SendToRT "INPUT2:LINK OFF"
SendToRT "INPUT:SYNC INTNOHEADER"
SendToRT "INPUT:TRIGGER:TIMEOUT  500"
SendToRT "INPUT:SWFILTER OFF"
SendToRT "INPUT1:IMPEDANCE 100k"
SendToRT "INPUT2:IMPEDANCE 100k"

// *************** STEPPEDSWEEP SETTINGS ***************
SendToRT "OUTPUT:STEPPEDSWEEP:FSTART 20.00"
SendToRT "OUTPUT:STEPPEDSWEEP:FSTOP 20000.00"
SendToRT "OUTPUT:STEPPEDSWEEP:NSTEPS 100"
SendToRT "OUTPUT:STEPPEDSWEEP:AMPLITUDESHAPE  DISABLE"
SendToRT "MEAS:STEPPEDSWEEP:NOISEIMMUNITY OFF"
SendToRT "MEAS:STEPPEDSWEEP:HIPRECISION ON"
SendToRT "MEAS:STEPPEDSWEEP:ACQUISITION  RMSLEVEL"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:MODE NORMAL"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:TYPE RMSLEVEL"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:ACTIVE CHANNEL1"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:TOLERANCE 1.00 %"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:TIMEOUT 600.00"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:DELAY 1.00"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:CYCLES 0.00"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:SAMPLE 3"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:FLOOR -70.000000 dBV"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:ALGORITHM EXPONENTIAL"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:FBEGIN 30.00"
SendToRT "MEAS:STEPPEDSWEEP:SETTLING:FEND 200.00"
SendToRT "MEAS:STEPPEDSWEEP:SMOOTHING:MODE OFF"
SendToRT "MEAS:STEPPEDSWEEP:SMOOTHING:ACTIVE BOTHCHANNELS"
SendToRT "MEAS:STEPPEDSWEEP:SMOOTHING:RESOLUTION 33.000000"

// *************** OUTPUT LEVEL SETTINGS ***************
SendToRT "OUTPUT1:LEVEL 0.00000 dBV"
SendToRT "OUTPUT2:LEVEL 0.00000 dBV"

// -------------------- END INITIALIZATION PART --------------------
```

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```
// ------------------ STEPPEDSWEEP MEASUREMENT PART -----------------

// --- Transmit the stepped sweep & execute the measurment ---
SendToRT "OUTPUT:STEPPEDSWEEP:START"

// *************** MEASUREMENT SweepLevel [V] ***************
SendToRT "MEAS1:STEPPEDSWEEP:RMSLEVEL:UNIT V"
SendToRT "MEAS2:STEPPEDSWEEP:RMSLEVEL:UNIT V"

//--- Query the channel 1, 2 level results and check for errors ---
SendToRT "MEAS1:STEPPEDSWEEP:RMSLEVEL?"
ReadFromRT
//--- Interpret the returned result string ---

SendToRT "MEAS2:STEPPEDSWEEP:RMSLEVEL?"
ReadFromRT
//--- Interpret the returned result string ---

SendToRT "SYSTEM:ERR?"
ReadFromRT
//--- Interpret the returned result string ---

// *************** MEASUREMENT THD+N [dB] ***************
SendToRT "MEAS1:STEPPEDSWEEP:DISTORTION:THDN:UNIT dB"
SendToRT "MEAS2:STEPPEDSWEEP:DISTORTION:THDN:UNIT dB"

//--- Query the channel 1, 2 THD+N results and check for errors ---
SendToRT "MEAS1:STEPPEDSWEEP:DISTORTION:THDN?"
ReadFromRT
//--- Interpret the returned result string ---

SendToRT "MEAS2:STEPPEDSWEEP:DISTORTION:THDN?"
ReadFromRT
//--- Interpret the returned result string ---

SendToRT "SYSTEM:ERR?"
ReadFromRT
//--- Interpret the returned result string ---

// *************** MEASUREMENT SweepPhase [deg] ***************
SendToRT "MEAS:STEPPEDSWEEP:PHASE:UNIT deg"
SendToRT "MEAS:STEPPEDSWEEP:PHASE:UNIT deg"

//--- Query the channel 1, 2 phase results and check for errors ---
SendToRT "MEAS1:STEPPEDSWEEP:PHASE?"
ReadFromRT
//--- Interpret the returned result string ---

//  ---------------- END STEPPEDSWEEP MEASUREMENT PART ---------------
```