Show tone burst peak SPL

If this option is selected, the generator is playing a tone burst and the graph is in spectrum mode the peak SPL in the input data will be shown on the plot. This is similar to the CEA-2010 peak SPL but without 1/3 octave filtering around the fundamental frequency.

Distortion measurements

When the **Distortion Panel** button (keyboard shortcut Alt+D) is selected the analyser calculates and displays harmonic or intermodulation distortion figures for the input, including THD, N+D (A-weighted noise plus distortion), N (noise and non-harmonic distortion), THD+N, HHD (higher harmonic distortion for harmonics from the 10th up to at most the 50th) and the relative levels of the 2nd to 9th harmonics. N and N+D are displayed in the current Y axis units, harmonic distortion can be displayed as percentages or dB relative to the fundamental depending on the Distortion settings.

Harmonic distortion

Harmonic distortion results are only valid when the system being monitored is driven by a tone or tone burst at a single frequency. If the REW signal generator is playing a sine signal or tone burst the generator frequency is used as the fundamental frequency of the input, otherwise the highest peak is used to determine the fundamental. The fundamental and its level are displayed.

When the stimulus is a tone burst the tone burst envelope has a strong spectral spreading effect, which (depending on the envelope shape) means only relatively high levels of distortion can be measured. The distortion calculations use the level from the FFT bin closest to the fundamental and harmonic frequencies. Noise-related results are not calculated as they would not be meaningful.

When calculating the power for the fundamental and harmonics for a continuous tone the energy in the FFT bins within the relevant span of the nominal frequencies appropriate for the RTA window selection is summed and then corrected according to the window's equivalent noise bandwidth. To obtain accurate results the window should have low side lobes. Good choices in order of reducing side lobe level are Dolph-Chebyshev 150 (side lobes 150 dB down), Blackman-Harris 7 (side lobes 180 dB down), Dolph-Chebyshev 200 (side lobes 200 dB down) and Cosine sum 9-235 (side lobes 235 dB down). Hann, Blackman-Harris 4 and Flat-Top are not recommended. If using the REW signal generator the option to lock frequency to the RTA FFT allows a rectangular window to be used.

Dither should be enabled on the generator at the bit width the system is using, check the bottom left corner of the REW main window for the bit width in use. On Windows using Java drivers only 16 bit is supported, for 24-bit use ASIO drivers. On macOS 24-bit is supported, make sure the devices are configured to operate at 24-bit in Audio Midi setup.

The THD figure is based on harmonics up to at most the 50th or the number of harmonics whose levels are displayed and is calculated from the sum of those harmonic powers relative to the power of the fundamental. A separate HHD (higher harmonic distortion) figure is calculated from the sum of harmonic powers for the 10th up to at most the 50th harmonic. The THD figure includes the HHD contribution. Individual harmonic figures are also calculated from their power relative to the power of the fundamental.

The THD+N figure is calculated from the ratio of the input power minus the fundamental power to the total input power (note that it is possible for THD+N to be lower than THD using these definitions). Note that the reciprocal of THD+N is SINAD. The N figure is calculated from THD+N minus THD, either as a ratio to the total input power if the Y axis units are dBc or as an absolute figure for other Y axis settings.

The upper limit for data used in distortion calculations is 95% of the Nyquist frequency (i.e. 95% of half the sample rate) or the Distortion Low Pass, if enabled. The lower limit is the first FFT bin (DC is excluded) or the distortion High Pass, if enabled.

The example below shows data for a 1 kHz sine input. The positions of the harmonics are shown on the spectrum or RTA plot. The Distortion High Pass and Distortion Low Pass have been set to 20 Hz and 20 kHz respectively, hence results are based on data from the span 20 Hz to 20 kHz.

999.9 Hz, -0.9 dBFS	
Span: 20 .. 20,000 Hz	
N+D: -81.9 dBFS A	THD: 0.0069 %
N: 0.0050 %	THD+N: 0.0085 %
HH 10 .. 20	HHD: 0.00013 %
2nd: 0.0060 %	3rd: 0.0033 %
4th: 0.00027 %	5th: 0.00050 %
6th: 0.000015 %	7th: 0.00046 %
8th: 0.000041 %	9th: 0.000020 %

An A-weighted noise plus distortion (**N+D**) figure is also shown alongside the THD data, in the current Y axis units. Using this figure together with the maximum input level (at distortion of better than -40 dB) allows a dynamic range figure to be generated. For a meaningful N+D result per AES17-2015 the system should be driven with a 997 Hz sine wave at 60 dB below the maximum input level.

Intermodulation distortion

Intermodulation distortion results are only valid when the system being monitored is driven using REW's Dual Tone test signal. The signal can be generated live from the generator, or saved to a file and played back on the system being measured. If playing from file the generator must still be showing with the same signal selected so that REW knows what it should calculate.

The generator provides preset signals for SMPTE, DIN, CCIF and AES17-2015 intermodulation measurement signals and a 'Custom' option allowing a user-selected pair of frequencies at a 1:1 or 4:1 amplitude ratio. Signals at 1:1 ratio will begin to clip at -3.0 dBFS (with the View option **Full scale sine rms is 0 dBFS** selected, 3 dB lower otherwise). Signals at 4:1 ratio will clip at -1.8 dBFS.

Dither should be enabled on the generator at the bit width the system is using, check the bottom left corner of the REW main window for the bit width in use. On Windows using Java drivers only 16 bit is supported, for 24-bit use ASIO drivers. On macOS 24-bit is supported, make sure the devices are configured to operate at 24-bit in Audio Midi setup.

To obtain accurate results the RTA window should have very low side lobes. Good choices in order of reducing side lobe level are Dolph-Chebyshev 150 (side lobes 150 dB down), Blackman-Harris 7 (side lobes 180 dB down), Dolph-Chebyshev 200 (side lobes 200 dB down) and Cosine sum 9-235 (side lobes 235 dB down). Do not use the Hann, Blackman-Harris 4 or Flat-Top windows.

IMD_{AES}: 0.0099%	TD+N: 0.010%
ref: f1	ref: f1+f2
f1: 18,000Hz	f2: 20,000Hz
DFD2: 0.0034%	DFD3: 0.0051%
d2L: 0.0034%	d2H:
d3L: 0.0026%	d3H: 0.0026%
d4L: 0.00030%	d4H:
d5L: 0.00012%	d5H:

The CCIF figure is calculated from the level at f2 - f1 (also called the 2nd order Difference Frequency Distortion or DFD2). The 3rd order DFD3 figure based on the levels at 2*f1 - f2 (18 kHz) and 2*f2 - f1 (21 kHz) is also shown. The reference level for the DFD figures is the sum of the level at f1 and the level at f2. An IMD_{pwr} figure is also shown, which is the ratio of the rms sums of the IMD components to the rms sum of f1, f2 and the IMD components.

The TDFD IMD_{TDFD} is calculated from the rms sum of 2nd order and 3rd order components, the reference level for the percentage figure is the sum of the levels at f1 and f2. For TDFD Phono and TDFD akl d2L (f2 - f1) and d3L (2*f1 - f2) are used, for TDFD Bass d2H (f2 + f1) and d3H (2*f2 - f1) are used.

The AES17 DFD IMD_{AES} figure is based on the levels at f2 - f1 (2 kHz), 2*f1 - f2 (16 kHz) and 2*f2 - f1 (22 kHz), the reference level for the IMD_{AES} percentage figure is the level at f1 (18 kHz). In all cases levels are measured across a 500 Hz bandwidth centred on the component being measured, per the AES17-2015 specification. DFD2 and DFD3 are also shown.

The AES17 MD IMD_{AES} is calculated from the rms sum of the 2nd order (d2) components, the reference level for the percentage figure is the level at f2. REW displays the overall IMD figure and the combined 2nd order (MD2 = d2L + d2H) and 3rd order (MD3 = d3L + d3H) figures.

For signals other than AES17 MD with an f2/f1 ratio > 7 (including SMPTE and DIN) the IMD_{DIN} figure is calculated from the rms sum of the 2nd order (d2) and 3rd order (d3) components, the reference level for the percentage figure is the level at f2. REW displays the overall IMD figure and the combined 2nd order (MD2 = d2L + d2H) and 3rd order (MD3 = d3L + d3H) figures.

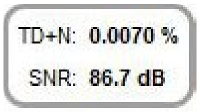
In all cases REW also shows a total distortion + noise percentage, TD+N. This figure is the square root of the ratio of the noise and distortion powers to the power of the tones.

DFD Components		**MD Components**	
Component	Freq	Component	Freq
d2L	f2 - f1	d2L	f2 - f1
d2H	f2 + f1	d2H	f2 + f1
d3L	2*f1 - f2	d3L	f2 - 2*f1
d3H	2*f2 - f1	d3H	f2 + 2*f1
d4L	3*f1 - 2*f2	d4L	f2 - 3*f1
d4H	3*f2 - 2*f1	d4H	f2 + 3*f1
d5L	4*f1 - 3*f2	d5L	f2 - 4*f1
d5H	4*f2 - 3*f1	d5H	f2 + 4*f1

Multitone Total Distortion

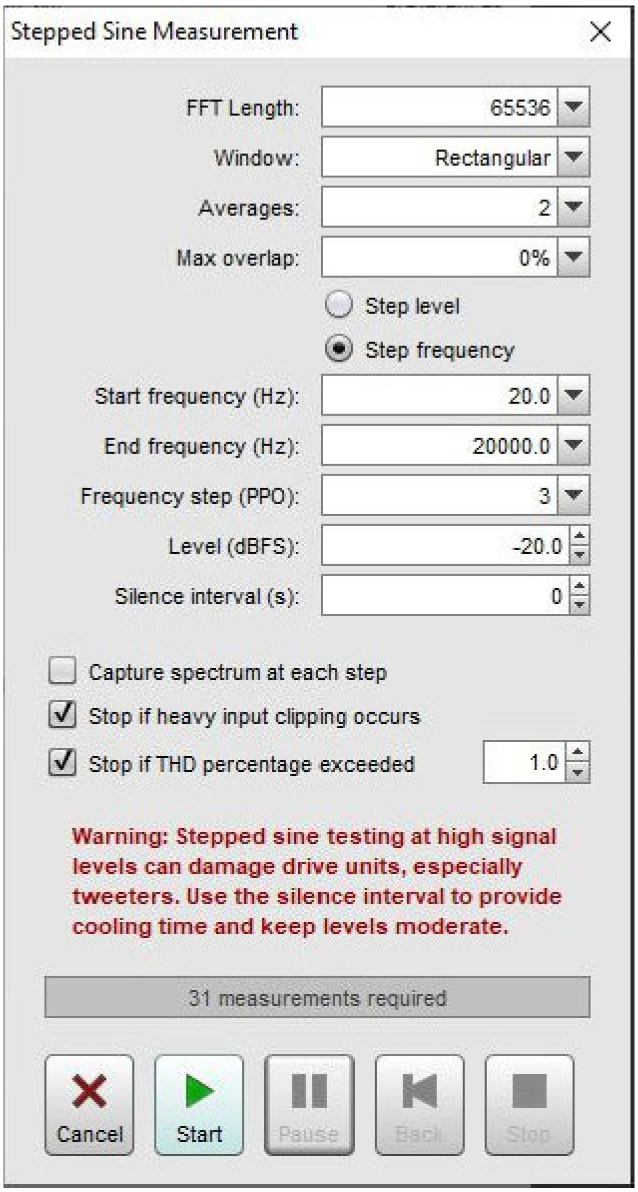
When the system being monitored is driven using REW's Multitone test signal the RTA shows a figure for total distortion + noise, TD+N. This figure is the square root of the ratio of the power of the noise and distortion components to the power of the tones. The signal generator and signal capture must be operating at the same sample rate for correct results, through the same device or devices with synchronised sample clocks. The RTA window type must be set to Rectangular for this calculation, REW will select that if it is not already selected.

A signal-to-noise ratio figure is also displayed if the FFT is two or more times the signal length, in which case the tones will only occupy even bins and anything in odd bins will be noise. The noise figure is obtained by rms summing the odd FFT bins and multiplying by sqrt(2), SNR is the ratio of the total rms level to that unweighted noise level.



Stepped sine distortion

When the **Stepped Sine Measurement** button is pressed a dialog appears to configure and run a stepped sine distortion measurement, stepping in either level or frequency.



REW's signal generator is used to produce the measurement frequency. **Note** that the currently applied signal generator settings are used, so dither will only be applied if selected (it is selected by default and is recommended). The frequency can be stepped in intervals of between 1 and 96 points per octave over the selected span, level can use steps down to 0.1 dBFS. The nominal test frequencies will be the preferred values at the chosen measurement PPO that are within the span. To avoid scalloping loss effects the test frequencies use the closest FFT bin frequency, that ensures the peaks of the fundamental and all harmonics are captured in the plots.

At each step all the distortion data is captured, when all points have been captured a new measurement is generated. The levels of the fundamental (brown), 2nd harmonic (red), 3rd harmonic (orange) and THD are shown on the RTA graph while the measurement progresses. If the **Stop** button is pressed a measurement is generated from the data collected up to that point. Stepped sine measurements typically take many minutes. The **Pause** button pauses the measurement, turning off the signal generator. Press it again to resume the measurement. The **Back** button removes the last point measured and re-measures it. **Back** can be used when the measurement is running or paused. **Cancel** discards the measurement.

When stepping in frequency a 96 PPO log spaced copy of the spectrum data at each measurement step will be captured if **Capture spectrum at each step** is selected. That spectrum data can be viewed on the Waterfall or Spectrogram graphs or exported to a text file. Note that exported spectrum data should not be used to try and calculate distortion levels as it does not have sufficient frequency resolution to accurately calculate the energy in each harmonic.

If **Stop measurement if heavy input clipping occurs** is selected the measurement will be stopped if more than 30% of the samples in an input block are clipped. That corresponds to an input level about 2 dB above the clipping threshold.

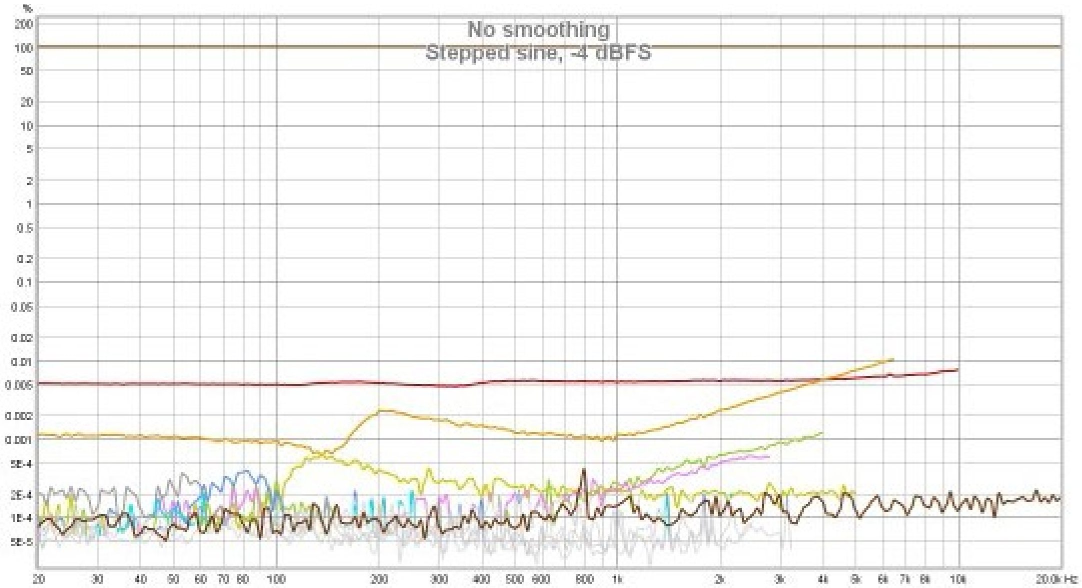
If **Stop if THD percentage exceeded** is selected the measurement will be stopped if the THD goes beyond the limit entered. To arm this THD must first drop below the limit, that allows stepped level measurements to start at low levels, where the THD figure may be high purely due to noise when the signal level is very low.

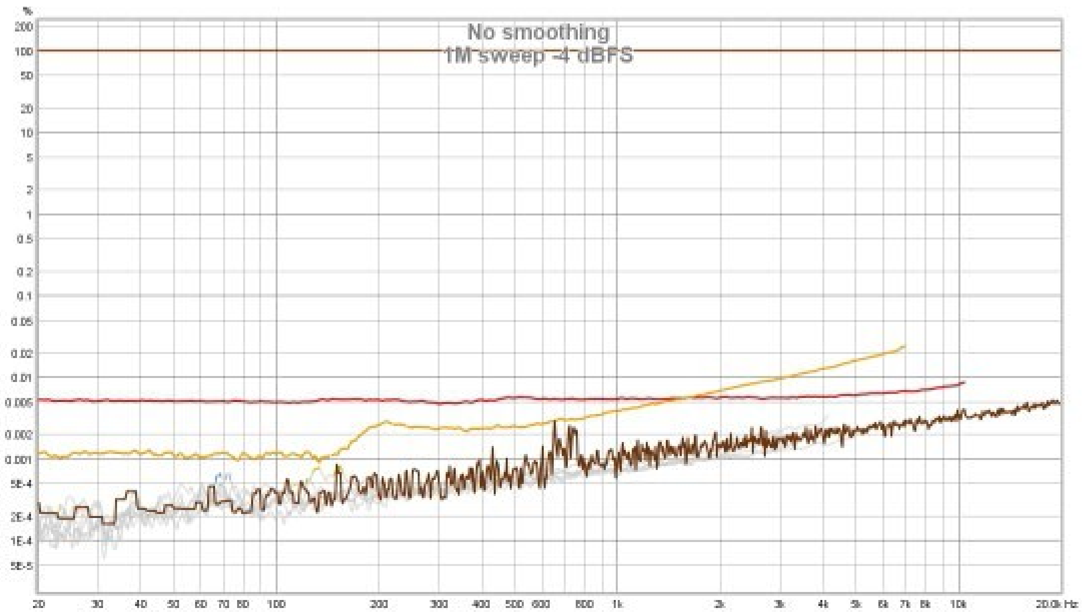
When stepping in frequency the minimum start frequency depends on the FFT length and the sample rate - for example, for an 8192 point FFT and 44.1 kHz sample rate the minimum start frequency is approx 60 Hz, for a 32768-point FFT at 44.1 kHz the minimum start is approx 15 Hz. The spreading effect of the RTA window would obscure the 2nd harmonic level at frequencies lower than the minimum and prevent a valid reading of distortion. The measurement frequencies are chosen so that they correspond to bin frequencies for the selected FFT length, this prevents window scalloping loss from affecting the amplitudes of the fundamental or harmonics.

At the beginning of each measurement the noise floor is captured and used to (optionally) mask distortion results that are below the noise floor (see the distortion graph help).

The progress bar shows the approximate time remaining to complete the measurement. Stepped sine measurements are faster when using ASIO drivers as the input and output buffers are smaller than when using Java drivers, hence less time is required for the buffers to flush through when changing frequency. The distortion results can be viewed on the Distortion graph. If the Analysis Preference Apply cal files to distortion is selected the results will include corrections for the cal file responses (as is the case for the RTA distortion figures). Applying the cal files provides more accurate results in regions where the fundamental or harmonics are affected by interface roll-offs but boosts the noise floor in those regions. This should be borne in mind when viewing the results. If large cal file corrections are required make sure the Analysis Preference Limit cal data boost to 20 dB is not selected.

Although much, much slower than a log sweep the stepped sine measurement captures N (noise and non-harmonic distortion) and THD+N (neither is available with a log sweep) and can measure low distortion levels more accurately than a sweep, particularly at high frequencies and for higher harmonics. This makes it well suited to measuring the distortion of electronic components. The plots below show a soundcard loopback measurement at -12 dBFS measured with stepped sine (64k FFT, 24 ppo) and with 8 repetitions of a 1M log sweep. Note the rise in the levels of harmonics with frequency when measuring with the sweep. This reflects the rise in the noise floor of the device (as can be viewed with the RTA in RTA mode), the sweep cannot separate distortion from noise as well as the stepped sine measurement.


No smoothing
Stepped sine, -4 dBFS


No smoothing
1M sweep -4 dBFS