Damping – REW Guide

(iPhone/iPad/Android App Documentation)

Version 1.002

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Change History

Date	Version	Change
7.3.2025	1.002	Modified text structure

Date	Version	Change
6.3.2025	1.001	Added interpretations for waterfall chart, Noise Floor, Overlays, and Stepped sine

Date	Version	Change
28.2.2025	1.0	First release

Table of Contents

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1 Introduction

Which REW window is used for spectrum analysis and how?

REW (Room EQ Wizard) offers various windows and tools that can be used for spectrum analysis. Typically, the Real-Time Analyzer (RTA) window is used for spectrum analysis, but you can also use Frequency Response by pressing the Measure icon, and then perform Harmonic Distortion analyses in the Distortion tab. Below is a detailed guide:

2 Explanation of terms

With REW, you can measure Signal-to-Noise Ratio (SNR), Signal-to-Distortion Ratio (SDR), Total Harmonic Distortion (THD), and THD+N. Below is an explanation of these terms and their relationships.

Note: SNR and SDR are only visible in Measurement info (Tools->info) if a sweep measurement has been performed. THD and THD+N are only visible once a stepped sine measurement has been done.

2.1 SNR (Signal-to-Noise Ratio)

- Definition: SNR indicates the level of the signal relative to the noise present in the measurement. It is usually expressed in decibels (dB).
- Measuring in REW:
  - REW can calculate SNR based on the spectrum or impulse response of the measurement file.
  - SNR = 20log10 ratio of the RMS level of noise to the RMS level of the signal.

2.2 SDR (Signal-to-Distortion Ratio)

- Definition: SDR is the ratio between the signal and distortions (harmonic and other nonlinearities). It indicates how much distortion is present in the signal compared to the main signal.
- Measuring in REW:
  - SDR can be calculated by analyzing the measurement data and isolating the harmonic components from the signal.
  - SDR = 20log10 ratio of the RMS level of distortions to the RMS level of the signal.

2.3 THD (Total Harmonic Distortion)

- Definition: THD measures how many harmonic components there are in the signal compared to the fundamental frequency. It is often expressed as a percentage.
- Calculation: THD (%) $= 100 * V1\sqrt{V2^2 + V3^2 + ... + Vn^2}$, where V1 is the amplitude of the fundamental, and V2, V3, ..., Vn are the amplitudes of the harmonics.
- REW provides a way to view the spectrum and calculate THD for the harmonic components.

2.4 THD+N (Total Harmonic Distortion plus Noise)

- Definition: THD+N is the total harmonic distortion plus the effect of noise. It measures the overall effect of all distortions (harmonic and non-harmonic) and noise relative to the signal.
- Calculation: THD+N (%)=100* ratio of the signal's RMS to the sum of the squares of distortions + noise.

Relationships: SNR, SDR, THD, and THD+N

1. SNR and THD+N:
    - SNR considers only noise compared to the signal.
    - THD+N includes both harmonic distortions and noise.
2. SDR and THD:
    - SDR measures the ratio of distortions (including harmonic and other distortions) to the signal.
    - THD measures only the effect of harmonic distortions.
3. THD vs THD+N:
    - THD measures only harmonic distortions.
    - THD+N adds in the effect of noise.

Practical use of REW in measurements

- THD and THD+N are often measured using a frequency sweep or a fixed test frequency.
- SNR and SDR can be evaluated through REW's spectrum analysis.
- REW also allows you to visualize these values across the frequency range.

3 What is spectrum analysis used for?

1. Room acoustics analysis:
   - Identify room resonances, standing waves, and attenuated frequencies.
2. Speaker and device evaluation:
   - Measure the frequency response and distortions of speakers.
3. Evaluating the audio source:
   - For example, analyzing noise and distortion levels of amplifiers, microphones, or other devices.
4. Checking signal quality:
   - Identify problems such as nonlinearities or incorrect frequency response, including device noise and distortion levels.

4 Measurement Process

1. Place the microphone at the listening position and make initial measurements without dampers. Save the frequency response, impulse response, SNR, SDR, THD, THD+N, and C80.
2. Install dampers under the speakers and devices.
3. Perform new measurements with the same settings.
4. Compare the **relative** changes (not absolute figures) in the measurement results before and after installing the dampers, paying special attention to low-frequency ranges and clarity metrics.

By analyzing these metrics and comparing the before and after results, you can gain a comprehensive view of the dampers' effect on sound quality. Particularly useful are the SNR and SDR from the Measurement Info window, the THD and THD+N in the RTA window, and the clarity metric C80. Combining these gives a holistic picture of how the dampers affect sound quality.

4.1 Practical instructions for using REW's spectrum analysis

1. Start spectrum analysis:
   - Press the RTA (Real Time Analyzer) icon in REW.
2. Prepare the signal:

    - Use a measurement microphone, sound card, and speaker, or analyze a recorded audio file.

3. Adjust settings:

    - Choose FFT size, averaging, and display settings.

4. Perform analysis:

    - Send the test signal (e.g., “Stepped sine”).

    - Monitor the spectrum in real-time.

5. Interpret the spectrum:

    - Look for harmonic distortions, noise, and anomalies in the frequency response.

4.2 Spectrum analysis in the RTA window

RTA (Real-Time Analyzer) is a tool for viewing the audio frequency distribution in real-time.

How to access the RTA window?

1. Open the REW program.

2. Select the RTA icon or, alternatively, Tools -> RTA from the menu.

Steps for performing spectrum analysis in the RTA window:

1. Prepare the measurement equipment:

    - Use a measurement microphone (e.g., UMIK-1) and its calibration file plus a calibrated sound card.

    - Place the microphone at the desired measurement point, such as the listening position.

2. Start RTA analysis:

    - Click the “Stepped sine” icon.

3. Set the analysis parameters:

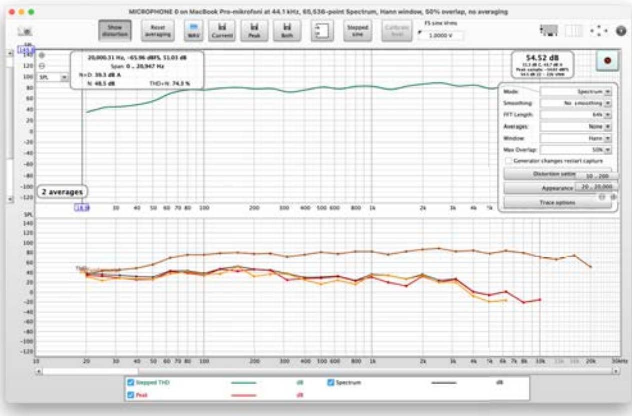
    - Select the FFT size from the “gear” icon (e.g., 32k or 64k for more detailed analysis).

    - Enable averaging from the “gear” icon under “Averages:” to smooth the noise.

4. Monitor the spectrum:

    - The frequency response is displayed in graphical form. You can zoom in and focus on a specific frequency range.

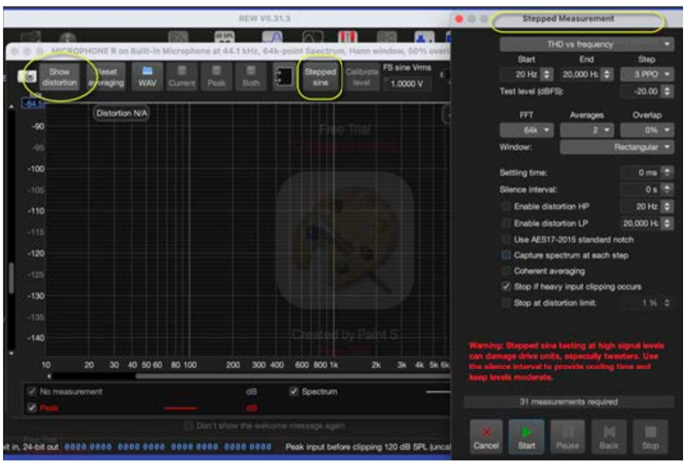
- Check for noise and distortion peaks, as well as possible resonances.



Kuva 1: REW RTA

4.2.1 Stepped sine measurement

Stepped sine measurement can measure lower distortion levels much more accurately than a sweep, especially at higher frequencies and higher harmonics. Stepped sine measurements display distortion components up to the ninth harmonic, THD (total harmonic distortion), and the noise floor in the same way as sweep-based results, but they also include THD+N (total harmonic distortion plus noise and non-harmonic distortion) as well as just N (noise and non-harmonic distortion). Note that the noise floor shows the measured noise spectrum content with no signal playback. “Noise” in N and THD+N indicates the total level of all non-harmonic distortion and noise across the entire frequency range at each test frequency. Therefore, it is considerably higher than the actual noise floor.



Kuva 2: Stepped sine measurement

4.3 Spectrum analysis after measurement

After performing a measurement, you can analyze the frequency response spectrum in more detail:

1. Perform a measurement (e.g., a sweep frequency test) by selecting the Measure icon or Tools -> Measure from the menu.

2. Check the signal level by selecting "Check levels" so that it is around 90 dB. Then press "Start."

3. Go to the "SPL & Phase" window, where you can see the measurement results as a frequency response.

4. You can adjust how the signal is displayed:

    - Octave smoothing: A smoothed spectrum makes interpretation easier. Choose, for example, 1/12 smoothing in the Graph menu.

Harmonic Distortion window:

1. Perform a measurement (e.g., a sweep frequency test) by selecting the Measure icon or Tools -> Measure, then open the Distortion tab from the menu.

2. Here you can view a spectrum that shows:

    - Total sound pressure (SPL).

    - Bands assigned for harmonic distortion (e.g., 2nd harmonic, 3rd harmonic, etc.).

3. THD and THD+N are calculated and presented graphically.

4.4 Summary: Performing spectrum analysis

1. Open the RTA window to analyze the frequency distribution in real time by pressing the RTA icon.

2. Perform a measurement using the Frequency Response window for more detailed results by pressing the Measure icon.

3. Use harmonic distortion analysis tools (Distortion) to isolate distortion and noise.

4. Adjust FFT parameters and display settings according to your needs.

5 Interpreting the measurement results

5.1 Measurement Info: SNR (Signal-to-Noise Ratio)

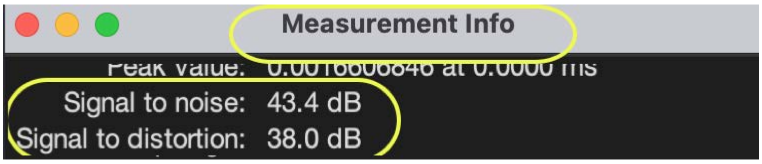
SNR indicates the signal level relative to background noise. Dampers can reduce mechanical vibration, thereby lowering the level of background noise and improving the SNR.

Interpretation:

- A higher SNR with dampers indicates that they have reduced the effect of noise.
- A good SNR is generally at least 60 dB, and improvements are worth examining especially in low frequencies (20–200 Hz).

Where to find it:

- SNR is visible in the Measurement Info window, which opens with the measurement file (Tools->Info).



Kuva 3: Measurement Info: SNR (Signal-to-Noise Ratio)

5.2 Measurement Info: SDR (Signal-to-Distortion Ratio)

SDR describes the signal level relative to harmonic distortion. Dampers can reduce harmonic distortion caused by resonances and vibrations.

Interpretation:

- A higher SDR value indicates a cleaner sound. A good SDR is usually at least 80 dB.
- Changes in low frequencies (20–200 Hz) are particularly important because resonances and vibrations often become prominent in this range.

Where to find it:

- SDR is also visible in the Measurement Info window.

5.3 RTA window: THD (Total Harmonic Distortion)

THD measures the ratio of harmonic distortion relative to the signal. Dampers can reduce the effect of vibration, thus lowering the THD value.

Interpretation:

- THD $< 1\%$ is considered good. A reduction in the low-frequency range (20–200 Hz) with footers indicates that the footers reduce vibration-induced distortion.

Where to find it:

- In the RTA (Real-Time Analyzer) window, THD is displayed in real-time analysis per frequency band.
- Basic distortion screen:

Kuva 4: RTA window: THD (Total Harmonic Distortion)

5.4 RTA window: THD+N (Total Harmonic Distortion plus Noise)

THD+N measures both harmonic distortion and background noise together with respect to the signal. Dampers can reduce both, especially in the low-frequency range.

Interpretation:

- A lower THD+N value indicates improved sound quality because both distortion and noise have decreased.
- Especially in the low-frequency range, THD+N values can reveal the effectiveness of the dampers.

Where to find it:

- In the RTA window, THD+N is displayed in the same frequency analysis as THD. It requires a stepped sine measurement; it does not appear with sweep measurements.
- In the main Distortion window if you have done a stepped sine measurement:

Kuva 5: RTA window: THD+N (Total Harmonic Distortion plus Noise)

THD+N (Total Harmonic Distortion + Noise) affects sound quality in many ways, as it measures both harmonic distortion and noise in the audio signal. Its impact on sound quality depends on its magnitude, the frequency range, and the listening environment. Below is a detailed overview:

1. Effect of harmonic distortion

    - Low THD values ($< 0.1\%$ or below -60 dB): At these levels, the signal quality is essentially unchanged, and the sound is perceived as very clean and natural. These values are considered acceptable in high-quality audio.

    - High THD values ($> 1\%$ or below -40 dB): Harmonic distortion adds extra frequencies to the signal that were not in the original. This can make the sound:

        - Harsh or unclear.

        - Artificial or “loud” in higher frequencies.

        - Less natural, especially in music and human voices.

2. Effect of noise

    - Noise can mask quiet details in the audio signal, especially in subtle parts of music or movies.

    - High THD+N can cause reduced dynamic range (difference between quiet and loud sounds), making the sound monotonous or unpleasant.

3. Differences in low and high frequencies

    - Low frequencies ($<$ 100 Hz): THD+N is less disturbing here because human hearing is less sensitive to harmonic distortion at low frequencies. However, high values can make the bass sound muddy or unclear.

    - High frequencies ($>$ 1 kHz): Human hearing is more sensitive to distortion at higher frequencies. THD+N can produce sharp, unpleasant sounds or degrade the naturalness of high tones.

4. Impact on music and speech

    - Music: THD+N can significantly affect the tone and harmony of instruments. For example, piano, violin, or guitar might lose their natural timbre and sound “plasticky” or less lively.

    - Speech: The human voice can sound less clear or unnatural if THD+N is high.

5. Listening fatigue

    - High THD+N can cause listening fatigue, since distortion and noise add extra strain to hearing. This is especially noticeable during long listening sessions.

6. Subjective experience

    - While scientifically high THD+N is usually considered negative, in some cases a small amount of harmonic distortion can add “warmth” or “pleasantness” in analog audio. This is typical, for example, in certain tube amplifiers.

Summary

- **Low THD+N** improves audio quality by providing a clean, natural, and detailed sound.
- **High THD+N** degrades audio quality by adding noise and distortion, which can make the sound harsh, unclear, or unpleasant.
- **The impact is greatest at higher frequencies**, where human hearing is most sensitive.

Controlling THD+N is crucial for achieving high-quality audio playback, especially in hi-fi and studio environments.

5.5 Clarity: C80 (Music Clarity Index)

C80 describes the clarity of music by examining how much of the sound energy arrives within the first 80 milliseconds relative to the energy arriving later.

Dampers can improve the C80 value by reducing reflections and resonances caused by vibration.

Interpretation:

- C80 $\geq$ -1 dB indicates good musical clarity. A higher C80 value after installing dampers suggests an increase in the proportion of direct sound relative to reverberation.

Where to find it:

- In the Impulse Response window, which provides clarity metrics (C50 and C80). Overlays:

Kuva 6: Clarity: C80 (Music Clarity Index)

5.6 Frequency Response

The frequency response shows how evenly a speaker reproduces different frequencies. Dampers can reduce low-frequency resonances that result from vibration transmitted to the surface.

Interpretation:

- A flatter frequency response with footers indicates that resonances have decreased.
- Pay particular attention to changes in the low-frequency range (20–200 Hz) before and after installing dampers.

Where to find it:

- The frequency response chart from the measurement results, select the "All SPL" tab.
- Basic:

Kuva 7: Frequency Response

- What does it show?
  - If vibration causes resonances, they often appear as irregularities in the response, such as peaks or dips at certain frequencies.
- Measurement result:
  - Look out for peaks or dips at low or mid frequencies (indicators of resonance). **But do not confuse resonances with room modes.**
  - Use the REW **Modal Analysis/Room Simulation** tool, which helps detect resonances between the room and the speaker. Provide the room dimensions (in meters), and the software calculates the theoretical modes. You can generate a result for measurement so you can examine the effect of modes in the frequency response chart.

Kuva 8: Frequency Response

Practical example

Suppose your room is 5 m long, 4 m wide, and 2.5 m high. You enter these dimensions into REW, and the software calculates modes:

- Length mode: 34 Hz (343 m/s / (2 × 5 m)).
- Width mode: 43 Hz (343 m/s / (2 × 4 m)).
- Height mode: 69 Hz (343 m/s / (2 × 2.5 m)).

In the frequency response chart generated with the mode chart, you can see how strong these modes are and their impact on the response. If, for example, 43 Hz has a long reverberation time and high amplitude, you might consider adding a Helmholtz resonator to reduce that particular mode. **The dips and peaks from these modes in the frequency response should be noted as separate issues when searching for possible resonance problems.**

5.7 Impulse Response

The impulse response describes how direct sound and reflections reach the listener over time.

Dampers can reduce extra reflections caused by vibration or the speaker's surface.

Interpretation:

- A clearer impulse response without extra peaks indicates that dampers reduce distracting reflections.

Where to find it:

- In the Impulse Response window, which provides a detailed view of the arrival times of the sound.
- Basic:

Kuva 9: Impulse Response

- What does it show?
  - **Impulse Response** analyzes how the speaker or system reacts to a sudden impulse. Unwanted vibrations typically appear as an extended impulse tail.
  - **ETC (Energy Time Curve)** shows how energy decays over time.
  - **RT60** describes how long it takes for the sound to decay by 60 dB at a certain frequency.
- Measurement result:

– Check for extra energy peaks or slowly decaying sections in the impulse response.

– Vibrations usually appear as longer reverberation tails.

5.8 Noise Floor and resonances (SPL)

SPL and spectrum analysis show background noise and resonance peaks. Dampers can reduce low-frequency noise and resonances caused by vibration.

Interpretation:

- A lower background noise and fewer resonance peaks indicate the effectiveness of the dampers in controlling vibration.

Where to find it:

- In the All SPL window, where you can check noise levels and resonances per frequency band.
- Basic:

Kuva 10: Noise Floor and resonances (SPL)

5.9 Waterfall diagram / Spectrogram

- **What does it show?**
  - A waterfall or spectrogram analysis shows how the frequency response decays over time.
  - This can reveal **lingering resonances** in the system, which often indicate insufficient damping or mechanical issues.
- **Measurement result:**
  - Look for areas where certain frequencies decay slowly or remain “ringing” for an extended period. Take note of room modes. See the frequency response section.
- **Significance for vibration:**
  - Mechanical vibrations or cabinet resonances in speakers typically appear as clear peaks that do not decay quickly in these measurements.

5.10 Noise Floor

- **What does it show?**
  - The noise floor indicates the low-level, unwanted sound produced by the system, which could come from mechanical vibration.
- **Measurement result:**
  - Perform an **RTA (Real-Time Analyzer)** analysis without a signal. This shows the system's background noise.
  - Also check low frequencies in your measurements, typically 10–100 Hz, where vibration often appears as noise.
- **Significance for vibration:**
  - Mechanical vibration can cause noise, particularly at low frequencies. These can be detected by analyzing the spectrum of the background noise.

5.11 Overlays

Use Overlays - distortion to compare the before and after results (chart graphs).

Kuva 11: Overlays

6 Sharing your measurement results for others to analyze

When you want to share your measurement results for others to examine, share the .mdat file along with your preferences (save preferences to file) and the microphone calibration file, otherwise the charts may not be drawn correctly and numerical values may be incorrect for the interpreter.

The REW .mdat file should include both before- and after-measurements as well as both sweep and stepped sine measurements (i.e. at least those four) so that the analyst can have all the necessary measurement data from both measurement methods.

Pay attention to naming and describing each measurement: for example, naming them “before” and “after” or “sweep” or “stepped” will help the interpreter easily compare results directly.