# QC - EQA Equalization + Alignment S33

Module of the KLIPPEL ANALYZER SYSTEM (QC Version 7, dB-Lab 212)

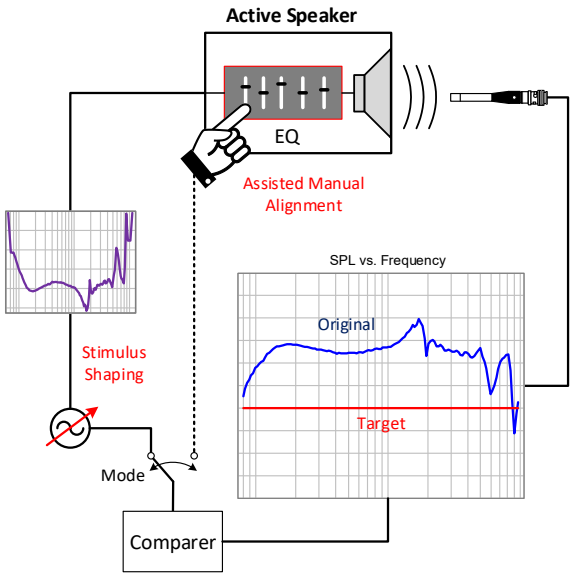
Document Revision 2.8

## FEATURES

- Aligns frequency response or sensitivity automatically
- Determines equalization curve
- Sweep or single tone mode
- Automatic or manual mode
- Adjust sound pressure, voltage or displacement

## BENEFITS

- Achieve custom frequency response
- Ensure consistent excitation
- Adjust sensitivity of DUT
- Assist manual adjustment
- Optimal EQ filter setting




The QC Equalization + Alignment is a versatile tool for adjusting the level or frequency response of transducers, audio systems or electronics.

Stimulus shaping is applied to automatically achieve a user defined target response. The resulting level profile may be used for applications like microphone testing with equalized sound sources.

In manual mode, the operator is assisted in adjusting controls like gain or EQ filters with minimal time and learning effort.

### Applications

- Quality control of microphones and headsets (sound source equalization)
- Amplifier compensation
- Factory setting of audio systems (sensitivity, EQ)

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| Item Number | 1234-245 |

## CONTENT

# 1 General Information

## 1.1 Summary

The EQA was designed as a flexible and simple tool for tuning the frequency response and level of audio devices. Both, single tone and sweep stimulus signals are provided for this purpose.

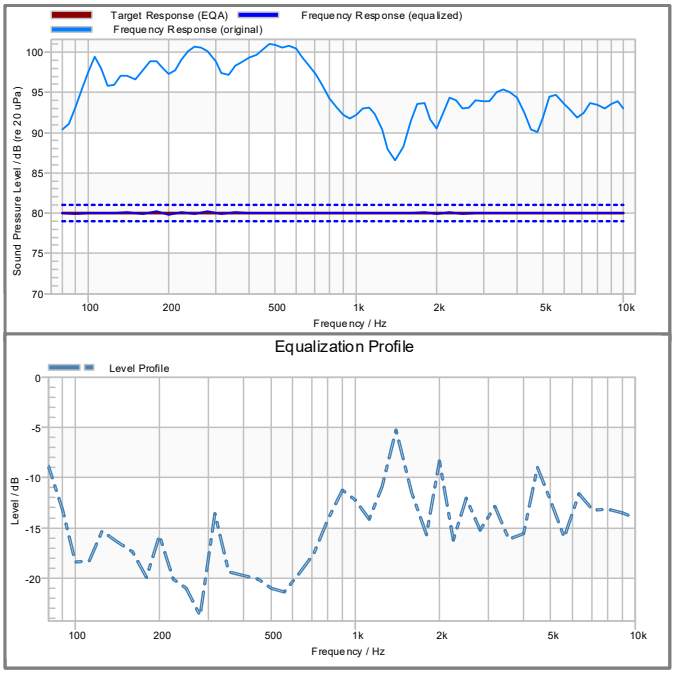
The actual alignment may be performed automatically using stimulus level (profile) or manually by adjusting external controls. In both cases the measurement is repeated until the desired target response is achieved within the specified accuracy limits.

## 1.2 Principle

Automatic Mode (Equalization)

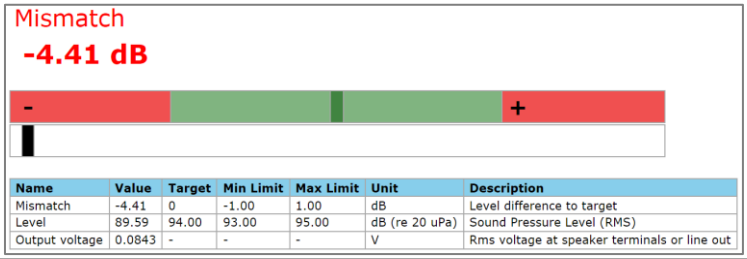
**Frequency Response (Sweep)**

- Perform first measurement at safe level
- Calculate difference curve between response and target response
- Invert difference curve to derive equalization level profile
- Measurement is repeated applying the determined profile
- The deviation between resulting response and target response is calculated
- The EQ curve is refined in further loops, if required




**Level (Single Tone)**

- Perform first measurement at safe level
- Calculate difference to target level
- Adjust stimulus level
- Repeat until target level is achieved within tolerance




| Name | Value | Target | Min Limit | Max Limit | Unit | Description |
|---|---|---|---|---|---|---|
| Mismatch | -4.41 | 0 | -1.00 | 1.00 | dB | Level difference to target |
| Level | 89.59 | 94.00 | 93.00 | 95.00 | dB (re 20 uPa) | Sound Pressure Level (RMS) |
| Output voltage | 0.0843 | - | - | - | V | Rms voltage at speaker terminals or line out |

Manual Mode (Alignment)

- Measurement is repeated automatically
- External control parameters are adjusted by the operator while the measurement is looped

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| | • Measured response is checked against the target response (within defined tolerance)<br>• As soon as the target response is achieved, the measurement is stopped |
| Assisted Mode[5)] | • During initialization stage the general characteristic of the device controls (e.g. equalizer) regarding the magnitude response are determined by an algorithm<br>• The control characteristics is applied to other similar units (product line)<br>• In every measurement loop the operator is instructed to set a certain control to a certain position<br>• This iterative process is carried on until all controls are set optimally within the accuracy limits |
| Multi-channel Data Aggregation | Some test applications require spatial averaging of multiple microphone's responses (e.g. equalizing and measuring the audio system response inside a car using a microphone array). For this purpose, the EQA provides the option to aggregate most of the test parameter results, such as frequency response based on multi-channel responses.<br>Most of the result parameters are integrated using power average neglecting the phase information.<br>*Note: this feature requires a multi-channel 3rd party capture device or open loop testing based on audio files.* |

### 1.3 Limitations

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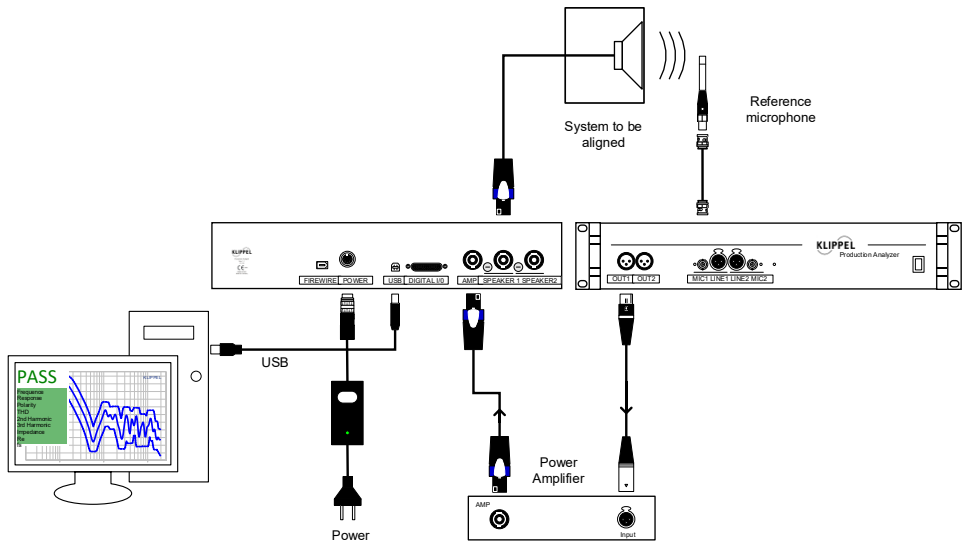
| | • Physical limits of the system under test determine the achievable frequency range and level - maximal input voltage is specified to protect the device<br>• Forcing a system to reproduce high levels out of specified target bandwidth may cause significant distortion and damage<br>• Equalizing the acoustic response at high frequencies requires exact positioning of the reference microphone<br>• Accuracy of equalization is defined by the frequency response of the used reference microphone<br>• Applying a very steep correction curve (voltage profile) may cause significant harmonic distortion – mind narrow band resonances and acoustical cancelations |

## 2 Requirements

### 2.1 Hardware

The EQA may be used for a variety of different applications. Therefore, the minimal hardware requirements depend on the particular application. For aligning an acoustic system, the following minimal requirements apply.

Scheme



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| Required Components | The following components are required for adjusting sound pressure of an audio device:<br>• KLIPPEL Analyzer 3 (e.g. *LSX* configuration), KLIPPEL Production Analyzer, or 3rd party audio interface (e.g. sound card, Bluetooth speaker)<br>• PC<br>• Optional: power amplifier or *KA3 Amplifier Card* or *QC Card* for passive systems<br>• Optional: reference measurement microphone |
| **2.2 Software** | |
| | Running the EQA requires the *QC Standard* (Item No. 4005-001) or *QC Stand-alone* (Item No. 4005-500) software version 6 or higher or dB-Lab QC in R&D version 210 or higher.<br>The EQA feature scope in QC Versions 4 and 5 differs from this specification. |
| **2.3 Further Requirements** | |
| Acoustic Environment | The performance of the EQA may be susceptible to ambient noise disturbance if sound pressure is measured. In this case it is recommended to perform the measurement in a properly shielded or calm environment. |

# 3 Settings

Several selected setup parameters of the EQA task are listed in this section. Further parameters are listed in section *Setup Parameters*.

## 3.1 Configuration

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| Maximal Loops | This parameter defines the maximal number of iterations allowed to achieve target response until the measurement is aborted. |
| Matched Loops | As soon as the target response is achieved, this parameter defines the number of additional measurement loops to refine and verify the results. Especially in *Manual* mode this ensures a stable final state of the device controls. |
| Export Params[4)] | In *Automatic* mode the resulting equalization settings may be exported to a plain ASCII text file. Two options are provided<br>• *Voltage (Profile)* – export level profile (EQ curve) and corresponding voltage<br>• *all* – export all stimulus and processing settings<br>The resulting parameter file (**.klpar*) may be used to apply equalization settings to the QC Standard *Sound Pressure* which is capable of automatic import. Also reimport into EQA is possible to apply sensible start settings to speed up equalization |
| Import Settings | Settings import is closely related to parameter export. The settings file generated by export |

## 3.2 Stimulus

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| Max. Voltage (rms)[4)] | This value defines the maximal stimulus RMS voltage (signal or amplifier output) that may be applied to during equalization process. In *Log Sweep* mode, the resulting level profile is defined relative to this voltage (attenuation vs. frequency). |
| Initial attenuation[4)] | Stimulus voltage attenuation (relative to *Max. Voltage*) applied during first run. |

## 3.3 Processing

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| Windowing of IR[1)] | Select window type used for impulse response windowing<br>• No windowing<br>• von Hann<br>• Hamming<br>• Blackman<br>• Kaiser |

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| | • Kaiser 6<br>• Tukey 50<br>• Tukey 25<br>• Rectangle<br>• Cosine3<br>*Additional parameters (align to delay, offset, length, right half only) are available if windowing is applied.* |
| Response - Mode | Select calculation mode for sweep frequency response (if impulse response windowing is not applied) as well as single tone response.<br>• Full Signal: response contains fundamental and harmonic components<br>• Fundamental: response contains only fundamental component |

### 3.4 Limits

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| Add task result | The EQA is not a dedicated test task but an auxiliary measurement module. Thus, it does not support regular testing limits; all tolerances are defined within the regular setup parameters. However, the equalization verdict may be propagated as a general test results which is interpreted by the *Control:Finish* task and thus contributing to the test verdict list. |

## 4 Parameter, Limits and Results

### 4.1 Setup Parameters

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **CONFIGURATION** | | | | | |
| Task Mode | - | • Automatic<br>• Manual<br>• *Assisted*[5)] | | | |
| Adjusted Parameter | - | • Frequency Response<br>• Peak Envelope Curve<br>• Bottom Envelope Curve<br>• Envelope Curve (peak to peak)<br>• Total RMS<br>• Absolute Peak<br>• Peak-to-peak | | | |
| Measured Quantity | - | • Auto (inherit from sensor type)<br>• Voltage | | | |
| Target response[1)] – target frequency response | $L_{\text{trgt}}(f)$ or $y_{\text{rms, trgt}}(f)$ | | | | dB or sensor unit |
| Tolerance Profile[1)] – relative tolerance for target response | $\Delta L_{\text{trgt}}(f)$ or $\Delta y_{\text{rms, trgt}}(f)$ | | | | dB or sensor unit |
| Target level[2)] | $L_{\text{trgt}}$ | - | - | - | dB |
| Target value[2)] | $y_{\text{rms, trgt}}$ | 0 | - | - | sensor unit |
| Tolerance max[2)] – upper target tolerance | $\Delta L_{\text{max}}$ or $\Delta y_{\text{max, trgt}}$ | | | | dB or sensor unit |
| Tolerance min[2)] – lower target tolerance | $\Delta L_{\text{min}}$ or $\Delta y_{\text{min, trgt}}$ | | | | dB or sensor unit |
| Maximum Loops – max. number of test runs for equalization | $i_{\text{max}}$ | 1 | 20 | - | - |
| Matched Loops – number of test runs for verification | $i_{\text{match,min}}$ | 1 | 2 | - | - |
| **STIMULUS** | | | | | |

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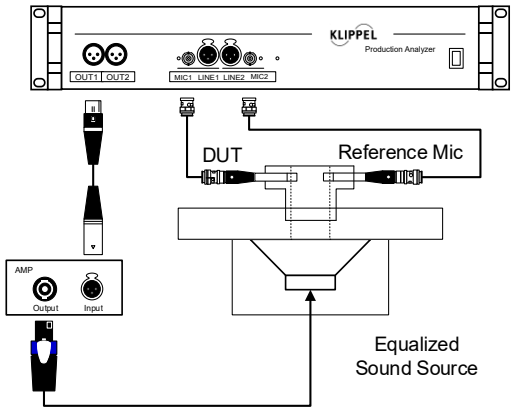
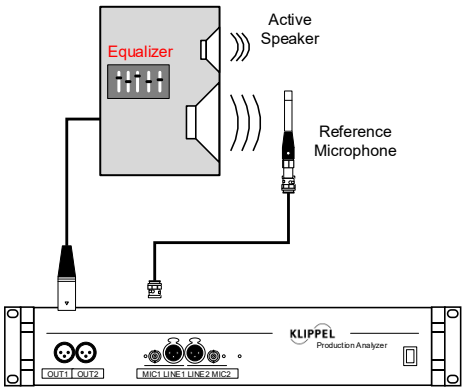
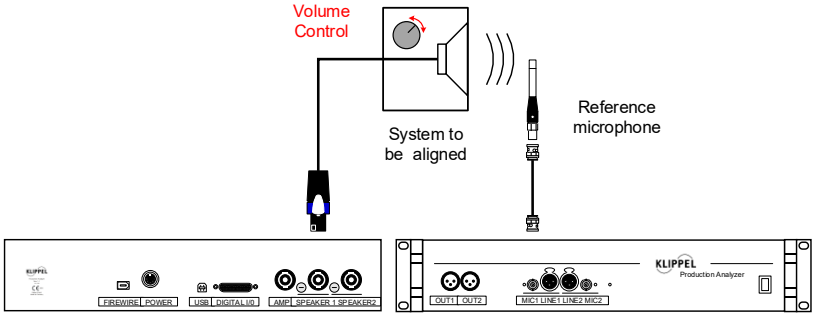
|---|---|---|---|---|---|
| Stimulus Signal | - | • Single tone<br>• Log. sweep | | | |
| Start[1] -Start frequency of sine sweep | $f_{\text{start}}$ | 1 | - | 80200[6] | Hz |
| Stop[1] – Stop frequency of sine sweep | $f_{\text{stop}}$ | 1 | - | 80200[6] | Hz |
| Frequency[2] – Test tone frequency | $f_{\text{test}}$ | 4 | 1000 | 80200[6] | Hz |
| Time – Measurement time | $t$ | 0.2 | 1 | 20 | s |
| Voltage (rms)[3] – stimulus voltage | $u_{\text{rms,stim}}$ | 0 | 1 | 200 | V |
| Max Voltage (rms)[4] – stimulus voltage | $u_{\text{rms,stim,max}}$ | 0 | 1 | 200 | V |
| Initial attenuation[4] – attenuation relative to *Max Voltage* for first run | $a_0$ | - | -40 | 0 | dB |
| **PROCESSING** | | | | | |
| Resolution – frequency response resolution | $R$ | 1 | 20 | 200 | pts/oct |
| RBz Highpass[1] – high pass order of *Rub&Buzz* filter | $N_{\text{hp,rbz}}$ | 5 | 10 | 100 | - |
| Input Gain – analog mic input pre-amp gain | $G_{\text{pre,mic}}$ | -70 | 0 | 30 | dB |

## 4.2 Measurement Results

| Measured Quantity | Symbol | Unit |
|---|---|---|
| Frequency Response[1] | $L_u(f)$<br>$L_p(f)$<br>$L_x(f)$<br>$L_a(f)$ | dB (re 1 V)<br>dB (re 20 µPa)<br>dB (re 1 mm)<br>dB (re 1 µm/s²) |
| Waveform (vs. instantaneous sweep frequency) [1)7)] | $u(f), p(f), x(f), a(f)$ | V, Pa, mm, m/s² |
| Waveform Envelope[1)7)] | $u_{\text{env}}(f), p_{\text{env}}(f), x_{\text{env}}(f), a_{\text{env}}(f)$ | V, Pa, mm, m/s² |
| Dynamic DC Component[1)7)] | $u_{\text{dc}}(f), p_{\text{dc}}(f), x_{\text{dc}}(f), a_{\text{dc}}(f)$ | V, Pa, mm, m/s² |
| Single Tone Response Level[2] | $L_u$<br>$L_p$<br>$L_x$<br>$L_a$ | dB (re 1 V)<br>dB (re 20 µPa)<br>dB (re 1 mm)<br>dB (re 1 µm/s²) |
| RMS (AC) | $u_{\text{rms}}, p_{\text{rms}}, x_{\text{rms}}, a_{\text{rms}}$ | V, Pa, mm, m/s² |
| Peak (AC, abs.) | $\lvert u_{\text{peak}}\rvert, \lvert p_{\text{peak}}\rvert, \lvert x_{\text{peak}}\rvert, \lvert a_{\text{peak}}\rvert$ | V, Pa, mm, m/s² |
| Peak-to-Peak | $u_{\text{pp}}, p_{\text{pp}}, x_{\text{pp}}, a_{\text{pp}}$ | V, Pa, mm, m/s² |
| Mismatch | $\Delta L$[2] or $\Delta L(f)$[1] | dB |
| Voltage[2] (applied single tone RMS voltage) | $u_{\text{stim,rms}}$ | V |
| Rub&Buzz[1]<br>(Impulsive Distortion) | $L_{u,\text{rbz}}(f)$<br>$L_{p,\text{rbz}}(f)$<br>$L_{x,\text{rbz}}(f)$<br>$L_{a,\text{rbz}}(f)$ | dB (re 1 V)<br>dB (re 20 µPa)<br>dB (re 1 mm)<br>dB (re 1 µm/s²) |
| Total Harmonic Distortion[1] | $L_{\text{THD}}(f)$ or $d_{\text{THD}}(f)$ | dB or % |
| Level Profile[1)4)] (attenuation curve for equalization) | $a_{\text{EQ}}(f)$ | dB |
| DC Voltage Profile[1)8)] | $u_{\text{dc}}(f)$ | V |
| Parameter file[4] (Level profile and related stimulus settings) | - | - |

# 5 Examples

| Several simple examples demonstrate the capabilities of the EQA task | | |
|---|---|---|
| Microphone Testing | For this application a reference microphone and the microphone under test (DUT) are coupled to the same volume stimulated by a sound source.<br>The EQA task is used to equalize the sound source ensuring consistent excitation of the DUT within the complete tested frequency range.<br>The frequency response difference curve of the two microphones as well as distortion may be tested against limits to derive PASS/FAIL verdict. |  |
| Adjust EQ of Active Speaker | Active audio systems like studio monitors provide a factory equalizer to fine-tune the frequency response and level at the end of the line.<br>The EQA is a valuable tool to assist the operator in adjusting these controls. In *Manual* mode the measurement is repeated until target response is achieved within specified tolerance.<br>Assisted[5)] mode takes it to a more advanced level by giving instructions to optimally adjust the controls within shortest time, even with untrained operators |  |
| Adjust SPL with Level Control | A simple application of the EQA is level adjustment of an active or passive speaker's response at a defined frequency or based on average level in a certain frequency band. Using a calibrated microphone, the desired target SPL is manually adjusted by the operator while the EQA compares the response to the target level and terminates the test when the target is reached within the specified tolerance. |  |

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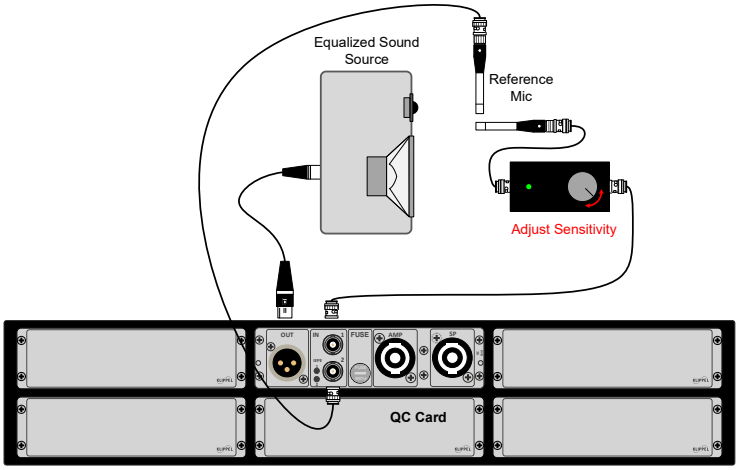
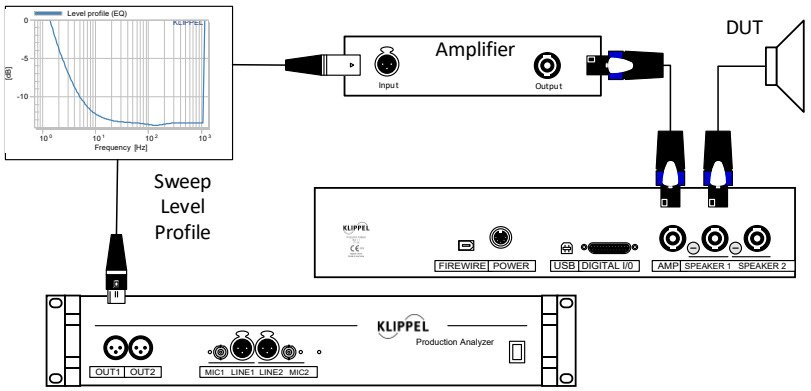
| Adjust Micro-phone Sensitivity |  <br>The EQA may be used for manual sensitivity adjustment at a defined frequency or based on average level over a full frequency band. This can be used to adjust preamplifier factory settings of a microphone or an audio device that provides integrated microphones (e.g. smart speaker).<br>In a first step (off-line or on-line), the sound source may be equalized or adjusted to a certain target level using a known reference microphone that has been calibrated using a microphone calibrator. A frequency response correction curve may be applied optionally. In the second step (the actual adjustment), the preamplifier or level controller is adjusted by the operator until the desired target output level/voltage of the DUT microphone is achieved. |
| Compensate Am-plifier LF Roll-off |  <br>Typical audio amplifiers suffer from a high-pass characteristic at very low frequencies resulting in gain decay. The EQA may be used to determine and compensate this characteristic. By this, consistent excitation of the DUT can be assured within the complete tested frequency range. |

## FOOTNOTES

1) Only available for *Stimulus - Log Sweep*
2) Only available for *Stimulus - Single Tone*
3) Only available for *Task Mode - Manual*
4) Only available for *Task Mode - Automatic*
5) This feature is not released yet.
6) Depends on selected sample rate
7) Requires *KLIPPEL Analyzer 3* or *Production Analyzer* with DC modification
8) Requires *DCX* (*Dynamic DC Check*) add-on and *KLIPPEL Analyzer 3* with *Amplifier Card* or *QC Card*

Find explanations for symbols at:
http://www.klippel.de/know-how/literature.html
Last updated: February 13, 2023