

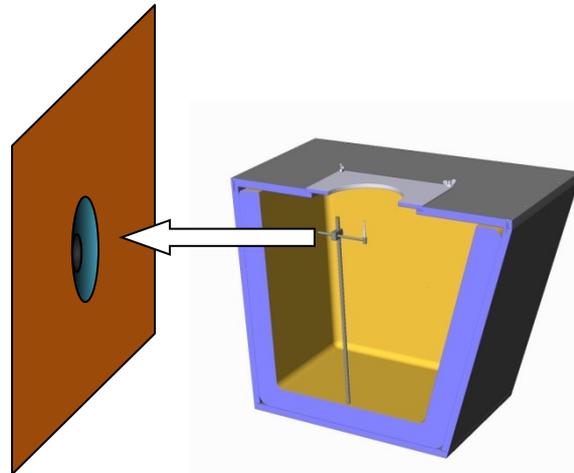
One of the most discussed issues in transducer end-of-line testing is the transfer of setup and the comparability and mapping of test results for the 3 typical test scenarios:

- R&D (e.g. ISO conform test baffle)
- QC (e.g. test enclosure)
- Final application (e.g. car, stereo system)

This application note provides an approach for the on-line mapping of results for different test conditions (such as two of the above mentioned) for fundamental and harmonic distortion of any frequency response.

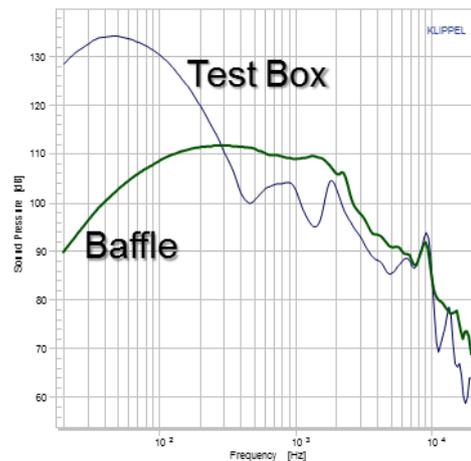
One typical application is applying test limits defined in a baffle to a QC test performed in a test enclosure.

Detailed step by step instructions are given as well as restrictions and traps are explained.



Baffle

QC Test Box



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## Background

### Mapping Results

Mapping measurement results of speakers (transducers) between various measurement conditions is a common request. This is normally a typical job for off-line post-processing of result data for small quantities of DUTs.

An application that requires on-line mapping / equalization is mass production of one product from multiple contract manufacturers (CM). The client defines limits using test conditions in well-defined standard conform environments since the actual used conditions are not always known in advance and difficult to unify. Forcing all CM to use one specific test environment would increase cost and effort.

Using on-line input equalization the test results measured in a particular test environment of each CM may be mapped to the known standard environment defined by the buyer. Consequently, the buyer can easily compare all test results, even if measured under different conditions. Statistical tools can be better applied to check product variance and tolerance.

Also each CM does usually have a standard conform R&D test lab, where the product development and pre-production cycles can be tested and verified. A continuous comparison and validation between mapped results in mass production and sample checks in the test lab is strongly recommended ensuring the consistency of this approach.

Note, that there are systematic problems and restrictions (see **Restrictions**) due to the different operating conditions. However, an approximate mapping of the results is possible and beneficial in some cases. The actually used test environment shall be openly communicated avoiding potential conflicts in advance.

### Used Example

Acoustical measurement results depend on the measurement conditions (room, test enclosure, microphone position ...).

An example used in this application note is the mapping of the fundamental and absolute harmonic components of test results

- acquired in a QC environment using a test enclosure
- to a standard measurement condition (e.g. IEC baffle in an anechoic room).

<b>Restrictions</b>	<p><b>Linear Response:</b></p> <p>Equalization of the fundamental component (linear response) is straight forward and is only susceptible to <u>noise problems</u> if the responses deviate too much (due to notches or peaks in the frequency response curve). This can be avoided by using a wide smoothing (1/3<sup>rd</sup> oct. recommended) and careful microphone positioning.</p> <ul style="list-style-type: none"> <li>• A low noise measurement microphone shall be used.</li> <li>• Each point in the response curve shall be at least 40 dB above the noise floor of the test system and microphone. (The noise floor can be easily determined by measuring a mounted DUT which is not connected.)</li> </ul> <p><b>Harmonic Distortion:</b></p> <p>The generation of nonlinear distortion strongly depends on driver's operating conditions and states (pressure <math>p(t)</math>, current <math>i(t)</math> and displacement <math>x(t)</math>). In most cases the cone displacement is the dominant cause of distortion. If the operation conditions are strongly modified (operation in free field vs. using a small test enclosure) the generated distortion will become incomparable as a consequence.</p> <p>Equalizing all states is not possible since the generation of harmonic distortion is a nonlinear process defined by multiple states.</p> <p>By using this mapping technique, it is assumed that the displacement (as dominant cause of distortion) does not change significantly due to the operation conditions. See the Quick Test below ensuring this basic assumption.</p> <p><b>Other Results:</b></p> <p>Higher harmonics and Rub&amp;Buzz are strong non-linear symptoms and depend even more on changed states than lower order harmonics. This approach cannot be applied to such results.</p>
<b>Quick Test</b>	<p>A quick test for a free air <math>\leftrightarrow</math> box enclosure mapping is suggested:</p> <ol style="list-style-type: none"> <li>1. Check the DUT resonance frequency <math>f_0</math> in free air or baffle condition</li> <li>2. Check the DUT resonance frequency <math>f_0</math> using the same test level in a test enclosure condition.</li> <li>3. If the deviation is less than 10%, the distortion generation is approximately comparable and an equalization of harmonic distortion is sensible.</li> </ol> <p>The background of this simple test is the reduction of excursion due to the additional stiffness of the air volume of the test enclosure. This reduction is reflected in the change of resonance frequency.</p>

## Work Flow

**General Comments** For the calculation of the equalization matrix tests in both environments must be carefully performed using:

- A statistically sufficient number of DUTs representing the variability of the production (at least 10 pcs recommended) from normal production
- All DUTs shall be checked carefully for any defect
- All tests must be performed with identical DUTs
- The tests should be done together within a short time (days or so) to avoid longterm variation of the DUTs
- All DUTs shall have performed a break in test (if not specified, 1h noise at 50% of specified full power shall do)
- Do not use DUTs from special tests (high power, environmental stress...)
- Repeat the calculation on a regular basis until you have a good confidence for low variation.
- The identical test setup shall be used.
- Optional: the voltage level or even the voltage profile may be used to compensate the displacement difference.
- The mode for harmonic distortion calculation must be set to absolute!

Relative harmonic distortion and their inherent dependence on the fundamental response result in wrong equalization settings. Of course relative harmonics may be used for the regular testing applying the equalization data (derived from absolute harmonics measurement).

**Overview** The process to obtain the EQU matrix comprises the following steps:

1. Selecting a representative pool of DUTs (e.g. 15 drivers).
2. Measurement of fundamental and 2<sup>nd</sup> ... 5<sup>th</sup> harmonics in standard conditions (e.g. baffle) with data logging
3. Measurement of fundamental and 2<sup>nd</sup> ... 5<sup>th</sup> harmonics under production test conditions (e.g. QC test box) with data logging
4. Calculation of an EQU matrix using logged result database files.
5. Applying the EQU matrix in the on-line QC system.

**1. DUT pool** The selection of drivers for the measurements is the basis for this approach. The drivers should not have any defects (they are used here as multiple "golden" units).

**2. Standard Condition Measurements**

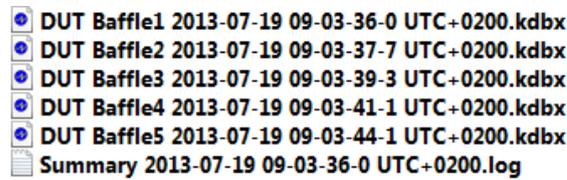
The complete pool is measured under standard conditions. The serial number prefix is used to identify these measurements.

After configuring the task, the serial numbering can be set up. Here the prefix *Baffle* is used for the standard measurement conditions.

Activate the automatic serial number mode and enter the initial serial number:



Activating data logging is mandatory for post processing the data. The result folder should contain the logged databases and the summary text file.



**3. Measurements under Production Conditions**

Step two is repeated but under production measurement conditions. Data logging must be activated and the prefix must be adjusted.



Data logging may use the same folder as in step two.

**4. EQU Matrix Extraction**

(1) If not already installed, please install *db extract* version 1.304b or higher:

**For QC4 Customers:** Open QC-Start / Tools / Check installation. Select "Additional Modules" and install Extraction Tool software.

**For QC3 Customers:** A newer setup than the delivered tool is required:

- dbextractSetup1.304b

You may download the current version from the Klippel website / downloads / Software / dB\_Extract.

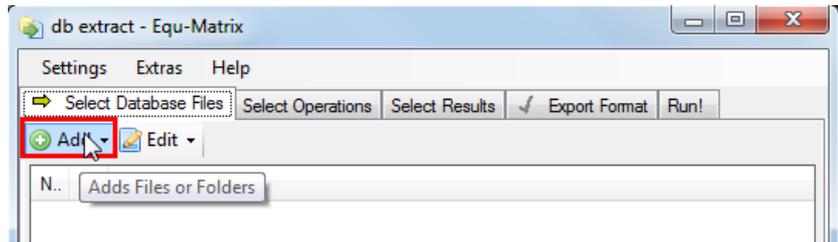


Start the *db extract* tool using the desktop icon:

(2) You need to install a special software setup for this application note:

- EQU Extraction\_v1.8 (installs the special *Equ-Matrix* setting)

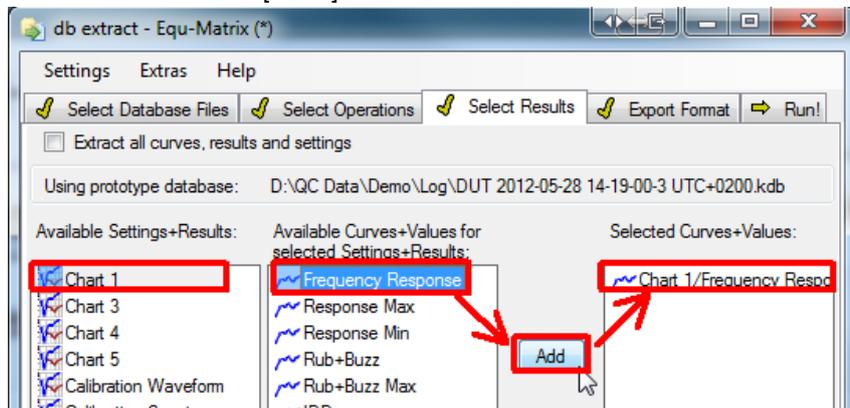
1. Load the settings from the Menu *Settings / Load Standard Settings / Equ-Matrix*.
2. Use the *Add* dialog to add the log files from steps one and two.



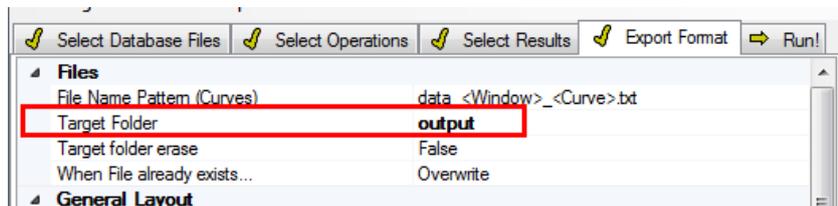
You can find the test results from the QC-Start *View / Current Test* menu. Navigate to the Log folder and copy & paste the path.

3. Check the Select Results settings:  
Add from Chart 1 *Frequency Response*  
Add from Chart 3 *2<sup>nd</sup> ... 5<sup>th</sup> harmonic*.

**Note:** Depending on your test setup, harmonics labels may have an extension due to a visual shift. In this case, delete the existing harmonics curves and add the harmonics with [-XX%] extension from Chart 3.



4. Define the output folder for the result database of the extraction process. By default the output is written into the folder *output* in the settings file's location. This may be customized in the tab *Export Format* (On a Win7 system this is: C:\ProgramData\Klippel\DataExtraction\StandardSettings\EQU\_Extraction\Output).



5. Run the extraction process by pressing the *Run!* - Button in the tab of the same name. After the extraction a new database is created and automatically opened that shows curve information and the EQU matrix.
6. The EQU matrix may be manually copied into the clipboard by selecting the text area and right click + copy.  
**Note:** The EQU matrix is automatically copied into the clipboard after the extraction process or after running the script directly from dBLab.



7. In Chart 1 you can see the two curve sets from both conditions. In Chart 6 the difference of the average of the corresponding curve bulks is plotted.

**5. Insert the Matrix in QC**

1. Paste the matrix from clipboard into the EQU parameter of the SPL task.

<b>Processing</b>	
Resolution	20
Response - Smoothing	6
Response - EQU	
Level - Frequencies	[*]
Harmonics - Type	Relative (%)

By using the equalized data, the graphical display of measured data in QC environment using a test box appears as a measurement in a standard conform measurement condition (baffle).

2. To verify the proper operation, copy (Use *QC-Start / Test / Save as...*) the standard conform test under a new name such as "Equalized Test". Now measure in a test box environment but use the original limits from standard like test condition. The test should pass the equalized measures (Frequency Response, THD and 2<sup>nd</sup> ...5<sup>th</sup> harmonic distortion).

**Note:** Depending on the sequence of processing, inverting the EQU matrix may be required. Simply check the occurring box once the equ data is imported.

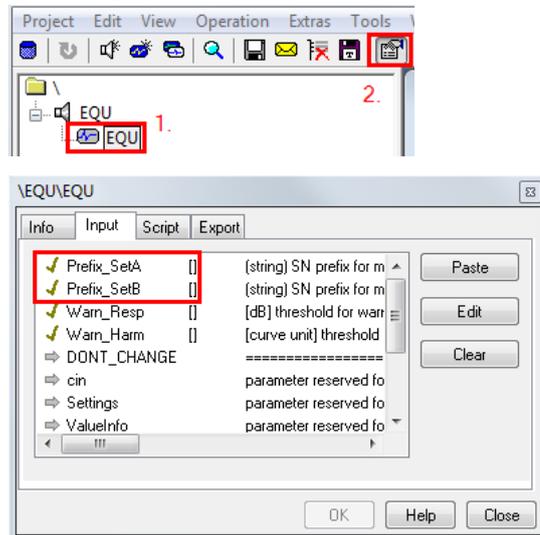
## Setup of the extraction process

**General**

When changing extraction parameters or the source files, the whole process (extraction + CALculation) must be repeated (step 4 above).

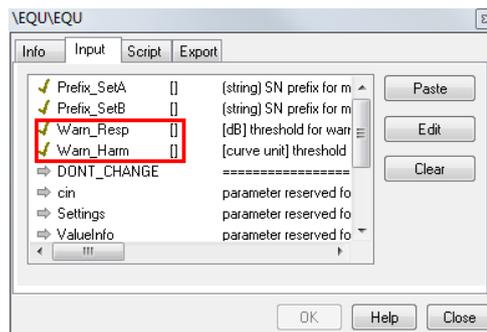
**Prefixes**

The prefixes of serial numbers may be defined in the filter database. By default, the first two prefixes are used for separating both conditions.



## Warning Limits

The warning limits may be defined in the result database.



The unit of the entered values is the unit of the measure (response or harmonics). Response is always in dB, harmonics are either in dB or in percent.

By default warning limits are set to 3 dB for the response and 3 dB or 3% for the harmonics.

## More Information

### References

QC User Manual  
Manual db extract

## Requirements

### Software

QC Standard version 3.2b Patch 3 or higher  
db extract 1.304b or higher

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