

QC End-of-Line Test System

C3

Basic, Standard, Programmable & Stand-alone Version

Version 6.0, R&D Version dB-Lab 210, Document Revision 6.0

FEATURES

- Ultra-fast testing at physical limit
- Highly sensitive rub & buzz testing
- Ambient noise detection
- Easy limit calculation, grading, limit import
- Supports 3rd party audio interfaces
- Automatic detection of golden reference units
- Impedance, frequency response
- Polarity, mean level
- THD, 2nd – 5th order distortion,
- T/S parameter (R_e , f_s , Q_{ts} , ...)
- Enclosure parameters f_b , Q_b
- Customizable test sequences
- Easy test management and synchronization
- Multi-language user interface
- Automatic detection of “golden reference units”
- Extraction tool for data export
- Production indices (C_{pk} , P_{pk})
- Process control rules (Nelson/Weco)
- Yield and single value statistics
- Operator and engineer access level
- Rugged hardware, 19” frame
- Integrated voltage & current sensors (50 A, 200 V)
- Simple integration into assembling line by digital interface
- Auto-detection of amplifier gain
- Full update compatibility of test generated with earlier versions (> QC 2.8)

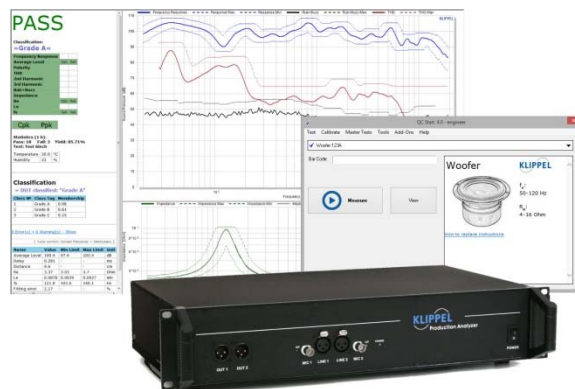
Certain system configurations may not include all features listed above

BENEFITS

- 100% production testing
- Ensure consistency of production
- Process control
- More reliable than human ear testing
- Comprehensive defect detection
- Simple and intuitive operation
- Seamless integration in production process
- Compatible to Klippel R&D system
- Flexible, modular solution to match your company needs
- Simple customization with dedicated infrastructure

APPLICATIONS

- Transducers (woofer, tweeter ...)
- Headphones, Micro speaker
- Balanced armature speaker
- Active / passive audio systems
- 3rd party audio interface
- Multi-channel systems
- Microphones
- Incoming goods inspection



Article numbers

4001-000; 4002-000; 4003-000; 4002-100

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1 Overview

1.1 Concept

The KLIPPEL QC System is a comprehensive hardware and software solution dedicated to the quality control of

- electro-acoustic transducers (e.g. micro-speakers, woofers, tweeters),
- passive systems (speaker box, headphones) and
- active audio systems (speaker system, tablet, smart phone, car).

The robust *Production Analyzer* hardware is designed for operation in production environments. It can be integrated in a fully automated line as well as operated manually. 3rd party audio devices and interfaces can be tested or used for testing, alternatively.

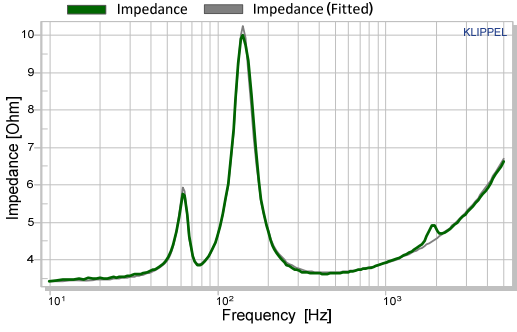
The software has two basic access levels (operator and engineer). An intuitive user interface (available in different languages) and smart limit setting algorithms are implemented to shorten training and setup periods for operators and engineers.

The KLIPPEL QC System is highly flexible. Test sequences comprise measurement steps with individual stimuli. This allows shortest test cycles using most critical signals for testing at the physical limits.

The QC System is able to detect defective units reliably even if the symptoms are not audible in a noisy production environment while focusing on the ultimate goal to increase the yield rate in manufacturing. End-of-line testing provides valuable diagnostic information for detecting the root cause of the problem and allows solving problems as soon as possible.

1.2 Results

<p>Frequency Response</p>	<ul style="list-style-type: none"> • Frequency response – magnitude and phase • Windowed impulse response • Average level • Multi-point/band levels • Acoustic phase • Polarity 	
<p>Distortion</p>	<ul style="list-style-type: none"> • THD (absolute, relative) • 2nd – 5th harmonic • Rub & Buzz – transient defect distortion • Incoherence 	

<p>Impedance and T/S Parameters</p>	<ul style="list-style-type: none"> • Impedance – Magnitude and Phase • Points/bands extracted from impedance magnitude • Thiele/Small parameters: $R_e, f_s, Q_{ts}, Q_{es}, Q_{ms}$, • Other linear parameters: $L_e, C_{mes}, L_{ces}, R_{es}, Q_b, f_b$ (box) • Additional T/S parameters (added mass): $B_l, M_{ms}, V_{as}, K_{ms}, C_{ms}, R_{ms}$ 	 <p>The plot shows Impedance [Ohm] on the y-axis (ranging from 4 to 10) versus Frequency [Hz] on a logarithmic x-axis (ranging from 10¹ to 10³). A green line represents the measured Impedance, and a grey line represents the Impedance (Fitted). A prominent resonance peak is visible at approximately 100 Hz, reaching a magnitude of about 10 Ohms. The KLIPPEL logo is in the top right corner.</p>																																																																																					
<p>Test Verdict</p>	<ul style="list-style-type: none"> • Individual Pass/Fail decision for selected measures • Overall PASS/FAIL verdict • Individual quality grades • Overall grade • Process control verdicts 	<p>PASS</p> <p>New Golden DUT found</p> <table border="1"> <thead> <tr> <th>Grade</th> <th>Cpk</th> <th>Ppk</th> <th>Rules</th> <th></th> </tr> </thead> <tbody> <tr><td>left - Impedance</td><td></td><td></td><td>Rules</td><td>Grade 1 100%</td></tr> <tr><td>right - Impedance</td><td></td><td></td><td>Rules</td><td>Grade 1 100%</td></tr> <tr><td>left - MODulation</td><td></td><td></td><td></td><td>100%</td></tr> <tr><td>right - MODulation</td><td></td><td></td><td></td><td>100%</td></tr> <tr><td>left - Frequency Response</td><td></td><td></td><td></td><td>Grade 1 100%</td></tr> <tr><td>left - Average Level</td><td></td><td></td><td>Rules</td><td>Cpk, Ppk 100%</td></tr> <tr><td>left - Polarity</td><td></td><td></td><td></td><td>100%</td></tr> <tr><td>left - THD</td><td></td><td></td><td></td><td>Grade 1 100%</td></tr> <tr><td>left - Rub+Buzz</td><td></td><td></td><td></td><td>Grade 1 100%</td></tr> <tr><td>right - Frequency Response</td><td></td><td></td><td></td><td>Grade 1 89%</td></tr> <tr><td>right - Average Level</td><td></td><td></td><td>Rules</td><td>Cpk, Ppk 100%</td></tr> <tr><td>right - Polarity</td><td></td><td></td><td></td><td>100%</td></tr> <tr><td>right - THD</td><td></td><td></td><td></td><td>Grade 1 100%</td></tr> <tr><td>right - Rub+Buzz</td><td></td><td></td><td></td><td>Grade 1 100%</td></tr> <tr><td>FreqResp - Difference Curve</td><td></td><td></td><td></td><td>100%</td></tr> <tr><td>FreqResp - Maximum Deviation</td><td></td><td></td><td></td><td>100%</td></tr> </tbody> </table> <p>Statistics (1 h): Pass: 16 Fail: 2 Yield: 88.89% SN: USB-54322 Test: By-4728</p>	Grade	Cpk	Ppk	Rules		left - Impedance			Rules	Grade 1 100%	right - Impedance			Rules	Grade 1 100%	left - MODulation				100%	right - MODulation				100%	left - Frequency Response				Grade 1 100%	left - Average Level			Rules	Cpk, Ppk 100%	left - Polarity				100%	left - THD				Grade 1 100%	left - Rub+Buzz				Grade 1 100%	right - Frequency Response				Grade 1 89%	right - Average Level			Rules	Cpk, Ppk 100%	right - Polarity				100%	right - THD				Grade 1 100%	right - Rub+Buzz				Grade 1 100%	FreqResp - Difference Curve				100%	FreqResp - Maximum Deviation				100%
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1.3 Demo Video

For a quick demo video (English or Chinese), please check the QC system - Interactive tour:

<http://www.klippel.de/our-products/qc-system/demo-videos.html>

1.4 Versions of the QC System

<p>QC Standard Set</p>	<p>The <i>QC Standard</i> set is the most common version of the <i>QC System</i>, setting new standards in speaker and audio system testing. The set consists of the <i>QC Standard</i> software and the <i>Production Analyzer</i> hardware. This comprehensive solution provides optimal flexibility and performance for various testing scenarios. For special requirements, functionality may be extended by a variety of add-on modules</p> <p>Most parts of this document refer to the <i>QC Standard Set</i>. Specifics or restrictions which apply to other versions of the <i>QC System</i> are highlighted explicitly. For a detailed comparison and feature list, also refer to the overview table in the appendix.</p>
<p>QC Basic Set</p>	<p>The <i>QC Basic Set</i> fulfils common demands of modern end-of-line testing while keeping an eye on the budget.</p> <p>The following restrictions apply compared to the <i>Standard</i> version:</p> <ul style="list-style-type: none"> • Only one measurement task type: combined <i>Sound Pressure and Impedance</i> task. • Task sequences limited to max. 3 tasks (steps). • Sweep Profiles (level and speed) are not available • Multiple reference DUTs not available (restricted to one) • No ambient noise detection • Most additional modules (<i>Motor & Suspension Check, Air Leak Detection..</i>) cannot be operated <p>The Basic system can be upgraded to the Standard version at any time, no separate installation is required.</p>
<p>QC Programmable Set</p>	<p>The programmable version of the QC system is based on <i>QC Standard Set</i>. It allows editing the actual measurement tasks in order to modify signal processing, result and limit calculation, the user interface and much more. The programming is based on a high-level language (Scilab®), which is comparable to MatLab®.</p>

	For most custom requirements, the <i>Programming Mode</i> is too powerful. There are alternative tools provided to customize the standard functionality while keeping the benefit of regular updates by Klippel. Using custom <i>Feature Libraries</i> , many features can be added in encapsulated containers. Please see separate specification <i>S36 Qc Feature Libraries</i> .
QC Stand-alone Software	<p>This version of the QC System is a software-only package based on <i>QC Standard</i> version. It is dedicated to testing applications which do not require the particular features of <i>Production Analyzer</i> hardware (e.g. voltage/current sensors for impedance testing, Digital IO interface). Any 3rd party audio interface may be used as measurement device instead.</p> <p>The <i>QC Stand-alone</i> software version is very suitable for mobile testing applications (e.g. installed speaker diagnostics, rental companies, car audio system ...) or electronics testing. Only acoustical or line level tests are supported. All impedance based test tasks and add-on modules are not supported.</p> <p>The following restrictions apply compared to the <i>QC Standard Set</i>:</p> <ul style="list-style-type: none"> • Impedance measurement (terminal voltage and current) is not available • No power amplifier handling (gain check not supported) • Some add-on modules are not supported (e.g. <i>Motor+Suspension Check</i>) • <i>Production Analyzer</i> cannot be operated <p>The customer is responsible for selection, installation, configuration and robustness of 3rd party audio interfaces. A list of recommended audio interfaces is available separately. Klippel provides limited support for recommended audio interfaces only.</p>
QC Remote Configuration	<p>The <i>QC Remote Configuration</i> is a software-only distribution which cannot be used for measurement. It allows modifying QC test settings and limits on any PC without having any measurement hardware connected.</p> <p>See specification <i>S14 QC Remote Setup</i> for more information.</p>
QC tasks in R&D Software version	<p>QC Tasks can also be used within the Klippel R&D software (dB-Lab 210 and higher). Thus QC test functions can be used in R&D setups in parallel to the R&D modules. Test sequences may contain both, R&D and QC operations.</p> <p>Each task to be used requires a license. Also tasks that are included in QC Standard package (SPL, IMP, SPL-IMP task) require a license.</p> <p>The following restrictions apply in this version:</p> <ul style="list-style-type: none"> • The dedicated user modes for operators is not available. The user has Engineer Rights implicitly. • Limits can be calculated and applied based on one reference unit. Statistical limit generation is not available. • Up to three measurement tasks in a QC test sequence are available. • Any add-on modules can be used with a valid license. Check the R&D price list for available tasks and options. Available features are specified in the appendix. • QC Start tool is not available. All data management can be done using dB-Lab.

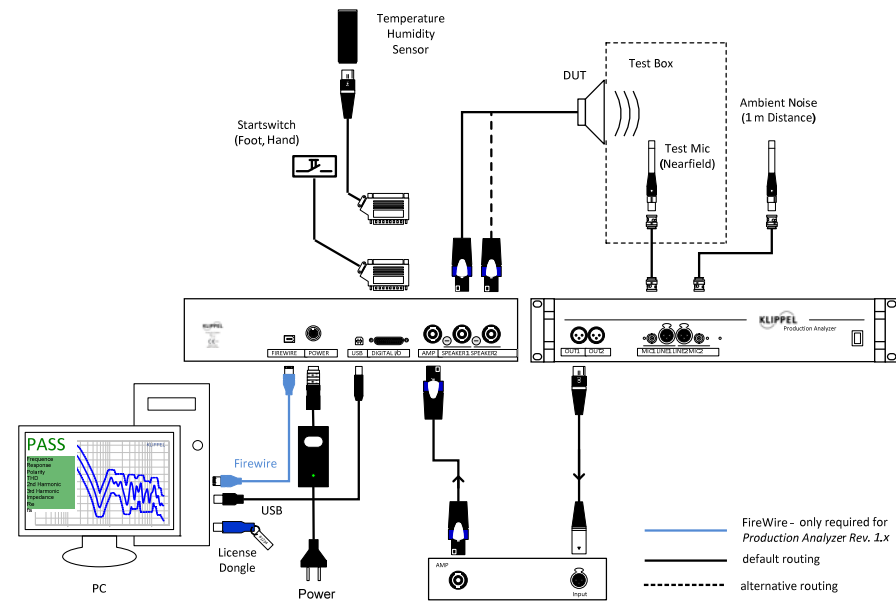
1.5 Scope of Delivery

Any <i>QC Set (Basic, Standard or Programmable)</i> comprises the following components (does not apply for the <i>QC Stand-alone Software</i> version which is only delivered with a USB license dongle):	
<ul style="list-style-type: none"> • <i>Production Analyzer</i> hardware (Specification H4) • Cable set <ul style="list-style-type: none"> ○ 1 USB cable: 3m <i>(for PA 1.x: 1 FireWire cable: 1,8 m)</i> ○ 1 Signal cable: XLR cable <i>(OUT Production Analyzer → LINE IN amplifier): 1m</i> ○ 1 Amplifier cable <i>(OUT amplifier → IN Production Analyzer): 1,5m crimped ferrule + 2 separate Speakon connectors</i> 	<p>Art. Nr.</p> <p>4000-100</p> <p>2920-001</p> <p>-</p> <p>2300-103</p> <p>2300-017</p>

	<ul style="list-style-type: none">○ 1 General purpose speaker cable including alligator clips: 4 wire; 2,2m• 1 Power supply with country specific power cable• 1 USB license dongle• 1 User handbook (manual)• Software (software features depend on system configuration; see Appendix)	2300-005 2000-020 2500-000
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2 Applications

2.1 Transducer Testing with QC Standard Set



This is a typical setup for transducer end-of-line testing using QC Standard Set.

The setup includes:

- Production Analyzer hardware
- Test and ambient noise microphones
- Power amplifier
- Optional accessories and IO (footswitches, climate sensor, assembly line control)
- Windows PC
- USB License Dongle
- Test enclosure (optional)

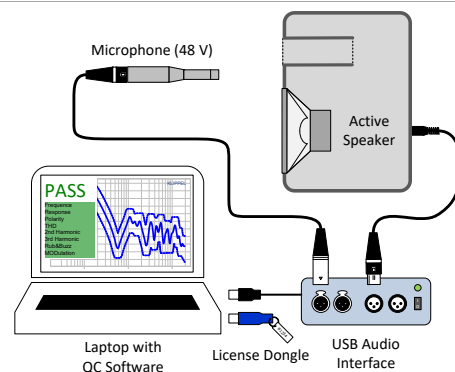
An external power amplifier is used to drive the speaker under test which is mounted on a test enclosure. The sound pressure response is picked up by a near field microphone. Production noise corruption is identified using a dedicated ambient noise microphone placed outside of the test box. The setup includes an additional sensor to monitor temperature and humidity variation and a foot switch for hands-free test start.

2.2 Active System Test with Audio Interface (QC Stand-alone Software)

The QC Stand-alone software can be used for testing the acoustical response of active speaker systems with just a laptop and a microphone connected to a USB audio interface.

This portable test setup can be applied for on-site testing of installed speakers and many other scenarios which require high mobility or a cost-efficient quality test solution.

Impedance and T/S parameter measurement is not available using 3rd party audio interfaces.



More Applications:

<http://www.klippel.de/our-products/qc-system/qc-applications.html>

3 Requirements

3.1 Hardware	
Additional Hardware Required	<ul style="list-style-type: none"> • 1 test microphone (see requirements below) • Power amplifier for passive DUTs (see document <i>Amplifier Requirements</i>) • 1 PC (see requirements below) • Fixture for DUT and microphone (not supplied by KLIPPEL) • for <i>QC Stand-alone Software</i> version: Audio interface – external sound card
PC Requirements	<ul style="list-style-type: none"> • Operating Systems: Microsoft Windows 7, 8 or 10 • Min. CPU requirements: Core 2 Duo 2.5 GHz or equivalent • 4 GB RAM, 2 GB free disk space, plus disk space for measurement results • Internet connection strongly recommended for online-support • 2 USB ports (USB 2.0 or higher) • 1 FireWire port (only for <i>Production Analyzer (USB + FireWire)</i> version 1.x) <p>See <i>KLIPPEL QC System PC Requirements</i> for more information</p>
Amplifier Requirements	<p>An amplifier is required for testing passive devices such as transducers.</p> <p>Any professional audio amplifier meeting the power and bandwidth requirements of the particular tests may be used.</p> <p>Find more information in <i>KLIPPEL Amplifier Requirements</i>.</p>
Microphone Requirements	<p>All <i>IEPE</i> powered microphones can be directly connected to the microphone inputs of the <i>Production Analyzer</i> without an additional power supply. Also other <i>IEPE</i> powered sensors such as accelerometers may be used as well.</p> <p>Microphones with 48 V phantom power supply or 200 V polarization may be connected to the line inputs using external power supply.</p> <p>Phantom powered microphones are suitable for testing with 3rd party audio interfaces with phantom power supply instead of the <i>Production Analyzer</i> hardware (<i>QC Stand-alone Software</i>)</p> <p>For measurements in a closed test box a low sensitivity microphone is required since sound pressure level exceeds 130 dB easily.</p>
3.2 Test Environment	
Fixture	<p>A suitable test jig is required to ensure consistent and reproducible test conditions (e.g. distance between DUT and microphone). The test fixture should not cause any parasitic vibration induced by the device under test.</p> <p>The test fixture is highly specific for particular applications; therefore it is not provided by KLIPPEL. For 3rd party vendors of fixtures and test enclosures see <i>AN 46 Test Enclosure for QC</i>.</p>
Test Enclosure	<p>In order to ensure optimal sensitivity for acoustical tests in a noisy production environment, it is highly recommended to provide acoustical shielding (test enclosure). This may be omitted when testing in low background noise environment (labs). A box enclosure must have a sufficient size depending on the device to be tested and the sound pressure limit of the microphone (see <i>AN 46 Test Enclosure for QC</i>).</p>
Ambient / Production Noise	<p>The background noise level in a production environment can easily mask the symptoms generated by a defective DUT (Device under Test). Typically impulsive noise in production is so high that even the box enclosure and an additional isolated test cabin / enclosure do not provide sufficient attenuation.</p> <p>The KLIPPEL QC System can be configured to detect corrupted measurements. A second microphone is required to measure the ambient sound pressure. The operator is warned in case of excessive ambient noise.</p> <p>This feature is not available in QC Basic.</p>

4 Hardware

4.1 Production Analyzer

The *Production Analyzer* is the main measurement platform of the QC System. It is delivered with all versions of the *QC System Set (Basic, Standard, Programmable)*.



The device provides the following features:

- AD/DA conversion:
 - 48 / 96 / 192 kHz / 24 Bit
 - SNR > 100 dB
- Analog sensor hardware:
 - Two channel speaker monitoring
 - Voltage and current sensors (up to 200 V peak / 50 A peak)
 - Different sensitivities available
 - Fuses in speaker channels for overload protection
 - Two channel microphone Input
 - Built in IEPE microphone power supply
 - Symmetrical line input and output
- PC-controlled operation via USB
- GPIO connector for integration, accessories and remote control

Please refer to *H4 – Production Analyzer Hardware* for detailed specification.

The QC Stand-alone Software version does not support this device.

4.2 Optional Hardware & Accessories

KLIPPEL offers a variety of optional hardware and accessories for the QC System:

- Power amplifier for passive DUTs (see document *Amplifier Requirements*)
- Additional microphone for ambient noise detection
- Multiplexer (BNC-Mic, XLR or Speakon)*
- Accessories
 - Temperature and humidity sensor*
 - Bar code reader
 - Foot switch*
 - Manual sweep controller
- Microphone calibrator
- Microphone power supply
- Ear & mouth simulators (G.R.A.S.)
- Additional speaker cable
- Speaker cable extension

A complete hardware set for your testing application can be supplied by KLIPPEL on request.

**These hardware components can only be used with the Production Analyzer hardware*

5 Software

5.1 Task Philosophy

There are 3 basic steps in a QC measurement:

- Measurement
- Limit check
- Setting test verdict and classification or quality grade

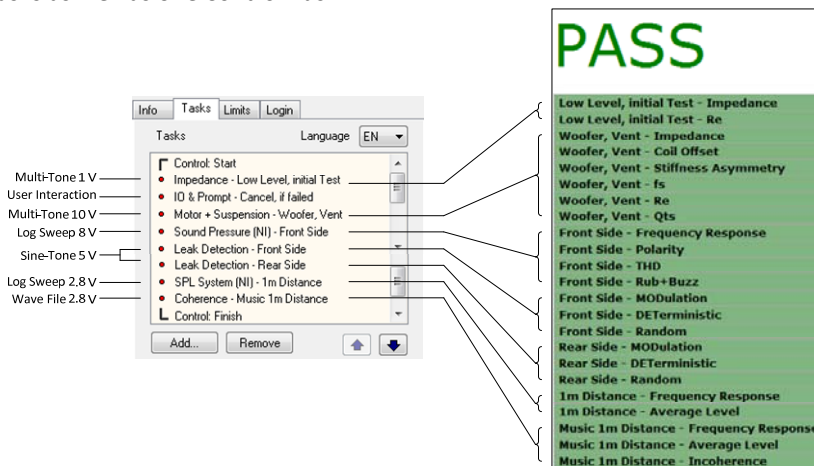
Since in most cases several test steps are required (e.g. low-level impedance, high-level sound pressure), multiple **Measurement Tasks** may be applied in test a particular sequence. Each measurement task has its own:

- Test signal,
- Data acquisition and analysis,
- Limit check,
- Limit calculation,
- Setup parameters,
- Signal processing and
- Graphical output.

The tasks-specific test results and verdicts are forwarded to the **Control Task**. This special framework task

- collects all PASS/FAIL and grading results,
- generates the overall PASS/FAIL and grading result
- performs result classification
- leads online statistics and checks control rules
- performs data logging

Therefore, each measurement sequence consists of multiple measurement and auxiliary tasks as well as one *Control Task*.



There is no restriction in the number of tasks to be used for one measurement sequence in QC-Standard version.

The QC software comes with a selection of predefined tasks covering most standard applications. A variety of add-on modules is available for specific testing applications.

An intuitive user interface provides access to the setup of the test signal, data analysis, limit setup and the result output.

5.2 Available Tasks

Sound Pressure (SPL)*

Using log. sine sweep excitation, the following measures can be tested:

- Fundamental (Frequency Response)
- Average Level
- Multi-point/band levels
- Phase

	<ul style="list-style-type: none"> • Polarity • THD • 2nd – 5th harmonic • Rub & Buzz • Production Noise Detection
Impedance (IMP)*	<p>Using log. sine sweep or multitone excitation, the following measures can be tested:</p> <ul style="list-style-type: none"> • Impedance - Magnitude • Impedance - Phase • Points/bands extracted from impedance curve • T/S Parameters • Voltage Magnitude, Phase, THD+N • Current THD+N
SPL+IMP	<p>Using log. sine sweep excitation, the following measures can be tested:</p> <ul style="list-style-type: none"> • Fundamental (Frequency Response) • Average Level • Multi-point/band levels • Phase • Polarity • THD • 2nd – 5th harmonic • Rub & Buzz • Production Noise Detection (not available in <i>QC Basic</i>) • Impedance – Magnitude • Impedance - Phase • Points/bands extracted from impedance curve • T/S Parameters (limited set in <i>QC Basic</i>)
IO Task	<p>The <i>IO & Prompt</i> is an auxiliary task providing multiple ways of interaction with the operator or the hard- and software environment.</p> <p>The following actions are available</p> <ul style="list-style-type: none"> • User Message • Cancel test • Wait for digital input • Run batch file • Set digital output • Wait for specified time <p>Those actions can be triggered by different conditions:</p> <ul style="list-style-type: none"> • Digital input state • Verdict of preceding tests (Pass / Fail / Noise) <p>Additionally, the IO Task provides ambient temperature and humidity check against user-defined limits (requires optional sensor).</p> <p>See separate specification <i>S34 – IO & Prompt Task</i> for more information.</p>
Preconditioning	<p>For pre-excitation of the device under test, the following stimuli are available:</p> <ul style="list-style-type: none"> • Log. sine sweep • Sine tone • Custom (wave file)
Control	<p>General settings for the complete test sequence can be defined in the <i>Control</i> task:</p> <ul style="list-style-type: none"> • Execution mode (Synchronization to external sources, wave file mode) • Routing • Configuration of the Control Panel (operator interface) • Serial number handling • Data logging

5.3 Limit Handling

Limit Check	The limit check compares the measured values with limits. Each measurement task offers own limits for all provided measures. The results of this check are provided to the <i>Control</i> task to derive an overall verdict (see below).
PASS/FAIL Verdict Grades	All task-specific pass/fail verdicts (individual measures) and quality grades are forwarded to the <i>Control Task</i> , which derives the overall test verdict and grade classification. Additionally, warnings may be generated, e.g. in case ambient noise corruption has been detected.
Limit Calculation	<p>The limit calculation is performed in a special mode, which is accessible via <i>QC Engineer</i> mode only. It is not accessible for the Operator (see access modes below).</p> <p>Limits and quality grades can be defined using</p> <ul style="list-style-type: none"> • absolute limits • tolerances related to reference measurements (average or max) • statistics based on variation of reference DUTs • external file (imported limits) <p>or a combination of these methods.</p> <p>An arbitrary number of reference measurements may be recorded to define limits statistically. All reference measurements are displayed in the result windows and may be (de)selected or deleted from the reference pool.</p>
Golden DUTs and Limit Calibration	<p>One or more “Golden Units” may be selected from the reference DUT pool in <i>Limit Calculation Mode</i> automatically. These units best represent the statistical average of the reference pool and may be used for on-line limit calibration to account for systematic drifts (e.g. due to climate variation).</p> <p>Additionally, new <i>Golden DUTs</i> can be detected automatically during testing using <i>Online Golden DUT Detection</i>.</p>

5.4 Access Levels

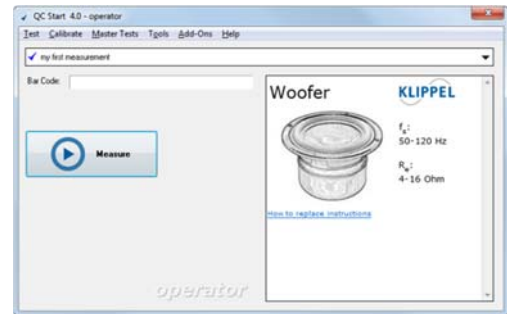
<p>Different user access levels are provided by any QC Software. By default two levels are provided:</p> <p>The QC Engineer Mode provides full access to test and limit settings.</p> <p>In the Operator Mode all settings are hidden and protected. It provides a simple interface and only necessary information to perform testing.</p> <p>In the optional 3rd level Programmer Mode all setups and also algorithms can be modified using a scripting language</p>	<pre> graph TD L3[Level 3: Programmer Mode (optional)] --> L2[Level 2: QC Engineer Mode] L2 --> L1[Level 1: Operator Mode] L3 --- A[Change Algorithms] L2 --- B[Change Setups] L1 --- C[Execute Tests] </pre>
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<p>Operator Mode (Level 1)</p>	<p>The <i>Operator Mode</i> provides an intuitive and simple interface for the following functionality:</p> <ul style="list-style-type: none"> • Test selection • Test start/repeat (using keyboard, barcode reader or switch) • Serial number definition • Report generation • Limit calibration (opt.) <p>This functionality may be extended or restricted depending on the access rights granted due to the settings defined by the <i>QC Engineer</i>. Basically the rights of the operators can be restricted to a minimum (e.g. start only) or enhanced for well-trained persons.</p> <p>The operator interface supports multiple languages. No special knowledge about the software and / or hardware is needed. This reduces the training time for new operators.</p> <p>Note: This access level is not available when tasks are used in a R&D installation.</p>
<p>Engineer Mode (Level 2)</p>	<p>The <i>QC Engineer Mode</i> allows setting up test sequences and modifying setup parameters of measurement tasks. This includes the setup of test signals, signal analysis, limit calculation, <i>Golden DUT</i> calculation, statistical post processing, or even result representation.</p> <p>Also the communication with the production line or operator can be set up in the Engineer Mode. Typical scenarios are setting and reading digital pins or showing instructions for the operator.</p> <p>This access level is the only available one in a R&D installation.</p>
<p>Programmer Mode (Level 3)</p>	<p>The <i>Programmer Mode</i> is only available in <i>QC Programming Version</i>. This mode is required to operate tasks, created or customized by the user. Additional tools and internal information are provided for the programmer.</p>

5.5 Further Features

<p>Multi-Language Support</p>	<p>The user interface of the QC software is available in different languages:</p> <ul style="list-style-type: none"> • English • Chinese (simplified) • Spanish • Portuguese • German • More languages are available on request
<p>Statistics</p>	<p>Basic online-statistics such as individual and overall yield with defined time window are provided by the QC test.</p> <p>For offline analysis, the dedicated <i>Yield Statistics</i> (see <i>S35 QC Yield Statistics</i>) provides simple and comprehensive statistical data (yield analysis, single value result analysis) as well as histogram and time course plots. <i>Yield Statistics</i> is included in QC version.</p>
<p>Serial Numbers</p>	<p>Serial numbers for the identification can be assigned to each test. Various schemes to define serial numbers are available:</p> <ul style="list-style-type: none"> • Keyboard or barcode scanner input • Automatic increase of serial numbers • Import from file
<p>Process Control</p>	<p>For online process control, process capability indexes (Cpk, Ppk) and control rules (aka. <i>Nelson/Weco</i> rules) are provided.</p>
<p>Data Logging</p>	<p>Measurement data can be stored in multiple forms:</p> <ul style="list-style-type: none"> • <i>Summary log file</i>: One line per test with results, verdicts, grades as well as meta information like time stamp, serial number and operator. • <i>Full Results</i>: All results, settings and meta-information are stored in a database (*.kdbx). This database can be opened at any time to visualize the particular test using <i>dB-Lab</i>. Reports can be generated or data can be exported using <i>db extract</i>. • <i>Wave file</i>: the recorded measurement signals may be stored as wave files

<p>dB-Lab Framework Software</p>	<p>The dB-Lab framework software (which is also used for the <i>KLIPPEL R&D System</i>) provides the</p> <ul style="list-style-type: none"> • Database handling, • User interface and • Report generator. <p>Using the same environment as for R&D applications, a seamless integration is provided.</p>
<p>QC Start Tool</p>	<p>The QC Start is the central test management framework software providing the following functionality:</p> <ul style="list-style-type: none"> • Test selection (simple and fast access for operators) • Different access levels for engineer and operator - configurable access rights for operators • Template handling: new tests can be based on default or company specific templates for fast test setup • Synchronization of multiple lines – refer to section <i>Master Tests</i> • Calibration of peripheral hardware (microphones, amplifier) and 3rd party sound cards • Access to additional tools <ul style="list-style-type: none"> ○ <i>db extract</i> ○ Statistics ○ <i>Performance test</i> ○ Remote support ○ Setup check ○ Backup ○ Customization and custom tools <p>May be used as exclusive windows application (started automatically after booting Windows, Windows shuts down after exiting) to restrict access to other software.</p> <p>Note: The QC start tool is not available when tasks are used in a R&D installation.</p>
<p>db extract Tool (data export)</p>	<p>This tool allows extracting any curve data from stored measurement data. The export format may be specified freely. This allows interfacing with 3rd party tools for data processing such as <i>Microsoft Excel</i>.</p>
<p>Master Tests / Synchronizing multiple production lines</p>	<p>For synchronizing multiple test stations with identical test setups, <i>Master Tests</i> may be defined in a central network location. The local tests are updated by the <i>Master Test</i> automatically (settings, limits) at the beginning of each test session (login).</p> <p>It is also possible to adjust settings and limits from remote computers. For this option no measurement hardware is required, only a <i>QC Remote Configuration</i> license must be available.</p>
<p>User Administration</p>	<p>The access to the QC system can be controlled via user login names and passwords</p> <ul style="list-style-type: none"> • Based on <i>Windows</i> user management or • Using separate user management (including access level and passwords) <p>The operator rights can be restricted by the QC engineer who may set up the tests and the <i>QC Start</i> test management software accordingly.</p>
<p>Remote Monitoring/ Control</p>	<p>Using standard remote desktop tools (e.g. <i>Windows Remote Desktop</i> or <i>Teamviewer</i>) it is possible to monitor and the operator screen or control the QC system from a remote PC. A remote support module based on <i>TeamViewer</i> is integrated in the QC software for <i>KLIPPEL</i> support.</p>
<p>Customization – Feature Libraries</p>	<p>Feature libraries are the easiest and recommended solution for customized extensions. They are part of the custom library infrastructure that is provided by the QC System. This infrastructure allows customizing standard measurement tasks without actually modifying</p>



	<p>the source code of the tasks. Thus updating by regular software maintenance does not interfere with customized extensions.</p> <p>Specific features are implemented in individual feature libraries that can be linked into standard task scripts easily.</p> <p>See separate manual for more information.</p>
Software interfaces	<p>A dedicated software interface (<i>IOMonitor</i>) allows slave operation of the QC system controlled by a master software.</p> <p>An automation interface allows the access of test results by external software.</p>

*not available in QC Basic

6 References

Specifications	<ul style="list-style-type: none"> • A4 – Microphones • A6 – QC Accessories • A8 – Multiplexer • H4 – QC Production Analyzer • S14 – Remote QC Configuration Tool • S34 – QC IO & Prompt • S35 – QC Yield Statistics • S36 – QC Feature Libraries • S40 – db extract • F1 – dB-Lab <p>The documents can be downloaded here: http://www.klippel.de/our-products/qc-system.html</p>
Manuals	<ul style="list-style-type: none"> • QC User Manual • Manual IO Task • Manual dB-Lab • Manual db extract
Add-on Modules (Specifications)	<ul style="list-style-type: none"> • C6 – QC Linear Suspension Test • S13 – QC MSC - Motor + Suspension Check • S15 – QC Match Speaker Tool • S18 – QC Air Leak Detection • S20 – QC Meta Hearing • S21 – QC Production Noise Immunity • S18 – QC ALS - Air Leak Stethoscope • S31 – QC External Devices • S32 – SYN – External Synchronization • S33 – QC EQA - Equalization & Alignment • S39 – QC BAC - Balanced Armature Check <p>More information can be found here: http://www.klippel.de/our-products/qc-system.html</p>
Application Notes	<ul style="list-style-type: none"> • AN42 Tolerances of Resonance Frequency • AN43 Data extraction and post processing • AN44 Creating automated reports • AN45 Optimal Setup for Fixed Time • AN46 Test Enclosure for QC • AN48 Yield Statistics • AN52 Result Export to VACS • AN53 Fast Quality Control of Suspension Charts • AN62 Online Input Equalization • AN64 Housing Ground Check <p>Application Notes may be downloaded here: http://www.klippel.de/know-how/application-notes.html</p>
Applications	<p>Application examples:</p>

	<p>http://www.klippel.de/our-products/qc-system/qc-applications.html</p> <p>Demo Videos</p> <p>http://www.klippel.de/our-products/qc-system/demo-videos.html</p>
<p>Publications</p>	<p>W. Klippel, S. Irrgang, U. Seidel, "Loudspeaker Testing at the Production Line," presented at the 120th Convention of the Audio Eng. Soc., Paris, France, 2006 May 20-23.</p> <p>W. Klippel, U. Seidel, "Measurement of Impulsive Distortion, Rub and Buzz and other Disturbances," presented at the 114th Convention of the Audio Eng. Soc., 2003 March 22–25, Amsterdam, The Netherlands, Preprint 5734.</p> <p>Wolfgang Klippel (2011). End-Of-Line Testing, Assembly Line - Theory and Practice, Waldemar Grzechca (Ed.), ISBN: 978-953-307-995-0, InTech, : http://www.intechopen.com/articles/show/title/end-of-line-testing</p> <p>Find more scientific contributions here:</p> <p>http://www.klippel.de/know-how/literature.html</p>

7 Appendix

KLIPPEL QC SYSTEM - FEATURE OVERVIEW

Valid for QC Software Version 5 / dB-Lab version 210

June 2017

For details please see specifications under www.klippel.de.

	QC STANDARD	QC BASIC	QC Stand-alone Software	QC tasks in R&D 210
Measurements / Features of QC SYSTEM:				
Amplitude frequency response	✓	✓	✓	opt.
Windowing of impulse response	✓	✓	✓	opt.
Phase response	✓	✓	✓	opt.
Mean level(s) in frequency band(s)	✓	✓	✓	opt.
Polarity	✓	✓	✓	opt.
Time delay	✓	✓	✓	opt.
Electrical impedance	✓	✓	-	opt.
Resonance frequency f_s	✓	✓	-	opt.
Loss factor Q_{ts}	✓	✓	-	opt.
DC resistance R_e	✓	✓	-	opt.
Vented box parameters (Q_b, f_b)	✓	-	-	opt.
Pass / Fail statistics	✓	✓	✓	✓
Limits calculated automatically	✓	✓	✓	✓
Flexible data export	✓	✓	✓	✓
THD+ Noise	✓	✓	✓	✓
2nd-5th order harmonics (IEC and IEEE standard)	✓	✓	✓	✓
Rub & Buzz, loose particle, loose connection & drop out detection	✓	✓	✓	✓
Advanced limit algorithms (Jitter)	✓	✓	✓	✓
On- and Off-line statistics for yield and single value results, histogram analysis	✓	✓	✓	✓
External control of Klippel QC (IOMonitor)	✓	✓	✓	✓
3 rd party audio interface in/output	✓	✓	✓	✓
Measurement without Production Analyzer hardware	-	-	✓	
Real-time monitoring of microphone signal	✓	✓	✓	✓
IO Task (control digital interface, user interaction)	✓	✓	✓	-
Klippel Analyzer hardware control (mic power supply, volt / current measurement)	✓	✓	-	✓
Digital Interface (Results, Start switch)	✓	✓	-	✓
Ultra-fast testing (Speed Profile)	✓	-	✓	✓
Stimulus shaping (Level Profile)	✓	-	✓	✓
Ambient noise detection (2. microphone, considering test enclosure)	✓	-	✓	✓
Measure noise attenuation of test enclosure	✓	-	✓	✓
All linear T/S parameters	✓	-	-	✓
Force factor Bl (added mass)	✓	✓	-	✓
Moving mass M_{ms} (added mass)	✓	✓	-	✓
Select golden reference units (on-line and off-line)	✓	-	✓	-
Manual sine sweep with waveform and spectral analysis	✓	-	✓	✓
Process indices C_{pk}, P_{pk} , Process control (Weco, Nelson rules)	✓	-	✓	✓
Grading (multiple limits for grade classification)	✓	-	✓	✓

opt.: optional task; available with appropriate QC-task license

KLIPPEL QC SYSTEM - FEATURE OVERVIEW

	QC STANDARD	QC BASIC	QC Stand-alone Software	QC tasks in R&D 210
Optional Tasks:				
MHT Option: Meta-Hearing Technology				
Isolated Defect Distortion (IDD)	✓	-	✓	✓
Active compensation of regular distortion	✓	-	✓	✓
PNI Option: Production Noise Immunity				
Auto repeat + intelligent merging	✓	-	✓	✓
Full noise immunity	✓	-	✓	✓
MSC Task: Motor-and-Suspension-Check				
Voice coil offset	✓	-	-	✓
Suspension asymmetry	✓	-	-	✓
Force factor limited displacement	✓	-	-	✓
Compliance limited displacement	✓	-	-	✓
Port resonance frequency Q_b , f_b	✓	-	-	✓
BAC Task: Balanced Armature Check				
Armature offset	✓	-	-	✓
Linear parameters	✓	-	-	✓
High-speed testing	✓	-	-	✓
ALD Task: Air Leak Detection				
MODulated distortion - detect air leakage	✓	-	✓	✓
DETerministic distortion - detect driver defects	✓	-	✓	✓
Random distortion - detect loose particles	✓	-	✓	✓
Integration of MODulated and DETerministic distortion in SPL Task	✓	-	✓	✓
Noise immunity (auto repeat)	✓	-	✓	✓
ALS Task: Air Leak Stethoscope				
Localize air leakage and other defects	✓	-	✓	✓
Auralization of defect symptoms	✓	-	✓	✓
EXD Task: External Devices				
High-level GPIB support (IEEE 488 & 488.2)	✓	-	✓	✓
Control and include external measurement instrumentation equipment	✓	-	✓	✓
Flexible test sequence	✓	-	✓	✓
EQA Task: Equalization + Alignment				
Automatic source equalization (level profile)	✓	-	✓	✓
Manual and assisted alignment of voltage / level	✓	-	✓	✓
Manual and assisted alignment of frequency response	✓	-	✓	✓

KLIPPEL QC SYSTEM - FEATURE OVERVIEW

	QC STANDARD	QC BASIC	QC Stand-alone Software	QC tasks in R&D 210
LST Task: Linear Suspension Test				
Suspension part & passive radiator testing	✓	✓	-	✓
Resonance frequency of suspension part f_0	✓	✓	-	✓
Loss factor of suspension part Q_0	✓	✓	-	✓
Effective stiffness k_0	✓	✓	-	✓
Measure large parts using SPM hardware bench	✓	✓	-	✓
Mass deviation Δm (LST Pro only)	✓	✓	-	✓
Stiffness deviation Δk_0 (LST Pro only)	✓	✓	-	✓
MSP: Match-Speaker-Tool				
Find best matching pairs from pool of speakers	✓	✓	✓	✓
Find best matching DUTs to target curve	✓	✓	✓	✓
SYN Option: External Synchronization				
Synchronize measurements with 3 rd party audio devices	✓	-	✓	✓
Measure stand-alone sound sources	✓	-	✓	✓
Cope with varying delays	✓	-	✓	✓
WAVE export of stimulus sequence	✓	-	✓	✓
WAVE import and analysis of recorded responses	✓	-	✓	✓
Use stimulus or unique noise ID for synchronization	✓	-	✓	✓

8 Patents

Germany	P10214407; 102009033614
USA	7,221,167; 12/819,455
China	03108708.6; 201010228820.8

Find explanations for symbols at:
<http://www.klippel.de/know-how/literature.html>
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