

## PRELIMINARY PRODUCT INFORMATION – BETA VERSION

### FEATURES

- Dedicated solution for long-term, power and accelerated life tests
- Any transducer: woofers, micro-speakers, headphones
- Passive Audio Systems
- Reveals destruction process in detail
- User-defined failure limits
- Monitors up to 32 DUTs simultaneously
- Internal and external stimuli
- Stimulus shaping/filtering
- Voltage Control at amplifier output
- Voltage stepping, ON/OFF Cycling
- Monitors data of user-defined, external sensors (e.g., temperature & humidity)
- Control of peripheral devices (e.g., heating chambers)

*Klippel Endurance Test (KET)* Solution provides a simple-to-use, cost-efficient soft- and hardware solution to run multi-channel long-term, power and accelerated life tests for typical quality assurance (QA) applications such as validation checks or type approvals.

Test signals can be defined flexibly using predefined stimuli as well as arbitrary wave files. Level stepping and cycling is available for any signals. Each DUT is monitored individually. Failures can be automatically detected by checking against user-defined limits. Open and short circuits are detected by general limits; thus, a destroyed device is detected immediately. A “Death Report” reveals details of monitored states at the highest available rate for a limited time just before the failure was detected.

The solution is Windows®-PC based and includes a power amplifier, control and analysis software as well as an easy interface to connect external sensors and control peripheral devices such as heating chambers.

32 DUTs can be measured using one PC. Even a higher channel number up to max. 64 channels, depending on PC performance and Dante® Interfaces, is possible (see references). Each DUT test can be individually started, muted and terminated. Each DUT can have its own test signal and configuration. The current test status of all DUTs can be visualized in a dashboard. Status information can be easily accessed via any browser device in the network. Dante® technology is used for streaming data via (wired) network connection.



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1000-720, 1000-721

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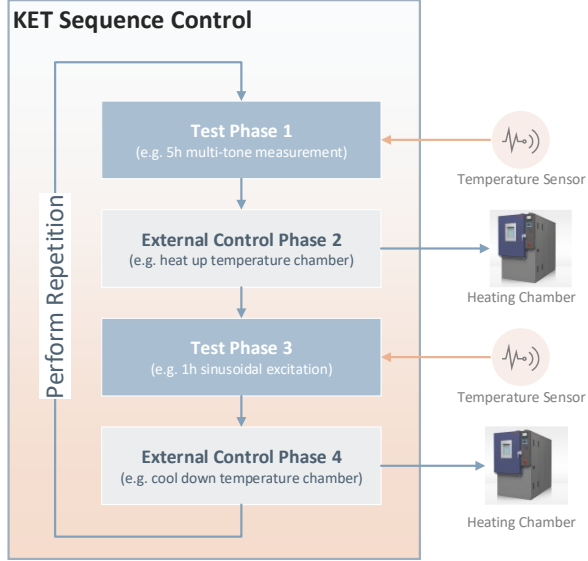
**Abbreviations**

- KET Klippel Endurance Test
- DUT Device under test
- V/I voltage / current
- Hi-Z High impedance
- tbd to be defined (in a later document revision)

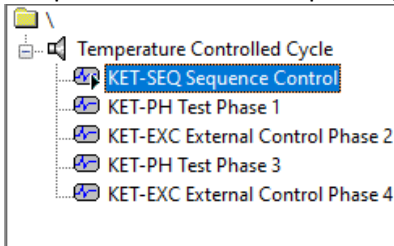
**1 Overview**

**1.1 Principle**

<p>General Setup</p>	<p>KET is a multichannel test system for monitoring long-term tests.</p> <p>A dashboard controls and monitors each device under test (DUT). Each DUT can be tested independently with a user-defined test sequence and stimulus. Thus, any DUT may have its own test signal. Also, parallel testing of DUTs (batch testing) having the same test signal is available.</p> <p>A test sequence consists of one or more test phases (e.g., for different stimuli). A cost-efficient smart amplifier with U/I sensing provides detailed data for each DUT and test step. The KET software provides a detailed analysis of DUT properties over time.</p>	
<p>Test Sequence</p>	<p>KET test phases are managed by a special operation “KET Sequence Control”. It performs KET phase operations (e.g., for measurement or external control) in a user-defined sequence and controls hardware setup, and looping configuration.</p>	



In this example, 4 test phases are configured for a typical stress test at different temperatures. The corresponding dB-Lab object reflects this sequence:



KET-Dashboard

Multiple KET channels are managed by the KET Dashboard. It provides an overview of all test channels (status, results), test creation and execution as well as error handling. See the Examples section for more information.

KET Channel Name	Type Name	Test Name	Serial Number	State	Phase	Remaining Time	Current (peak)	Current (rms)	Power	Voltage (peak)	Voltage (rms)
Mezzo.0066300 DUT#1	New Test	#1	running	KET-PH Test Phase	1 day, 15:59:24	0.06 A	0.01 A	0.00 W	0.35 V	0.10 V	
Mezzo.0066300 DUT#2	New Test	#2	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.39 V	0.10 V	
Mezzo.0066300 DUT#3	New Test	#3	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.44 V	0.10 V	
Mezzo.0066300 DUT#4	New Test	#4	running	KET-PH Test Phase	1 day, 15:59:24	0.06 A	0.01 A	0.00 W	0.42 V	0.11 V	
Mezzo.0066300 DUT#1	New Test	#5	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.35 V	0.10 V	
Mezzo.0066300 DUT#2	New Test	#6	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.43 V	0.10 V	
Mezzo.0066300 DUT#3	New Test	#7	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.41 V	0.10 V	
Mezzo.0066300 DUT#4	New Test	#8	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.38 V	0.10 V	
Mezzo.0066304 DUT#1	New Test	#9	running	KET-PH Test Phase	1 day, 15:59:24	0.09 A	0.01 A	0.00 W	0.35 V	0.10 V	
Mezzo.0066304 DUT#2	New Test	#10	running	KET-PH Test Phase	1 day, 15:59:24	0.08 A	0.01 A	0.00 W	0.44 V	0.10 V	
Mezzo.0066304 DUT#3	New Test	#11	running	KET-PH Test Phase	1 day, 15:59:24	0.08 A	0.01 A	0.00 W	0.44 V	0.10 V	
Mezzo.0066304 DUT#4	New Test	#12	running	KET-PH Test Phase	1 day, 15:59:24	0.08 A	0.01 A	0.00 W	0.43 V	0.10 V	
Mezzo.0066305 DUT#1	New Test	#13	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.41 V	0.10 V	
Mezzo.0066305 DUT#2	New Test	#14	running	KET-PH Test Phase	1 day, 15:59:24	0.06 A	0.01 A	0.00 W	0.41 V	0.10 V	
Mezzo.0066305 DUT#3	New Test	#15	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.40 V	0.10 V	
Mezzo.0066305 DUT#4	New Test	#16	running	KET-PH Test Phase	1 day, 15:59:24	0.07 A	0.01 A	0.00 W	0.41 V	0.10 V	
Mezzo.0066306 DUT#1	New Test	#17	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.47 V	0.11 V	
Mezzo.0066306 DUT#2	New Test	#18	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.37 V	0.10 V	
Mezzo.0066306 DUT#3	New Test	#19	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.34 V	0.10 V	
Mezzo.0066306 DUT#4	New Test	#20	running	KET-PH Test Phase	1 day, 15:59:25	0.05 A	0.01 A	0.00 W	0.41 V	0.10 V	
Mezzo.0066311 DUT#1	New Test	#21	running	KET-PH Test Phase	1 day, 15:59:24	0.06 A	0.01 A	0.00 W	0.38 V	0.10 V	
Mezzo.0066311 DUT#2	New Test	#22	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.45 V	0.10 V	
Mezzo.0066311 DUT#3	New Test	#23	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.40 V	0.10 V	
Mezzo.0066311 DUT#4	New Test	#24	running	KET-PH Test Phase	1 day, 15:59:24	0.06 A	0.01 A	0.00 W	0.40 V	0.10 V	
Mezzo.0066315 DUT#1	New Test	#25	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.34 V	0.10 V	
Mezzo.0066315 DUT#2	New Test	#26	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.43 V	0.10 V	
Mezzo.0066315 DUT#3	New Test	#27	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.41 V	0.10 V	
Mezzo.0066315 DUT#4	New Test	#28	running	KET-PH Test Phase	1 day, 15:59:24	0.06 A	0.01 A	0.00 W	0.42 V	0.10 V	
Mezzo.0066316 DUT#1	New Test	#29	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.35 V	0.10 V	
Mezzo.0066316 DUT#2	New Test	#30	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.41 V	0.10 V	
Mezzo.0066316 DUT#3	New Test	#31	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.41 V	0.10 V	
Mezzo.0066316 DUT#4	New Test	#32	running	KET-PH Test Phase	1 day, 15:59:24	0.05 A	0.01 A	0.00 W	0.41 V	0.10 V	

1.2 Results

Result Charts can be configured for providing the time course of rms and peak values for:

- Voltage, Current, Power, Input resistance, Temperature
- External sensors (e.g., temperature sensors in heating chambers)

A high-resolution death report provides details during the destruction of a DUT.

## 2 Examples

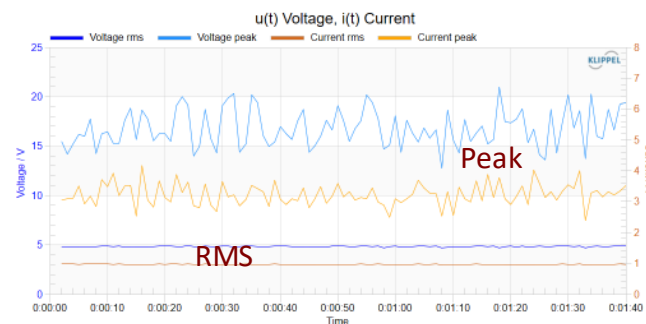
### 2.1 Woofer continuous 100h test according to IEC 60268-21 (cl 17.1; 18.1) Rated maximum input value; Rated maximum sound pressure

**Continuous testing**

The simplest test is continuous playback of test stimuli for a defined duration. Monitoring power, temperature, voltage and current reveal steady state performance for given environmental conditions. Thermal equilibrium may take hours to settle, especially for larger woofers. For mass production, a statistical investigation of the fault rate may be required regularly. KET eases this process considerably using multi-channel tests and template-based setups applied to a given number of DUTs. This setup is available as template in dB-Lab and dashboard:  
KET Rated maximum sound-pressure level; IEC 60268-21

**Voltage and Current**

Power amplifiers used for KET are voltage driven, thus, the actual voltage at amplifier output can be monitored and compared with the specified level in setup.

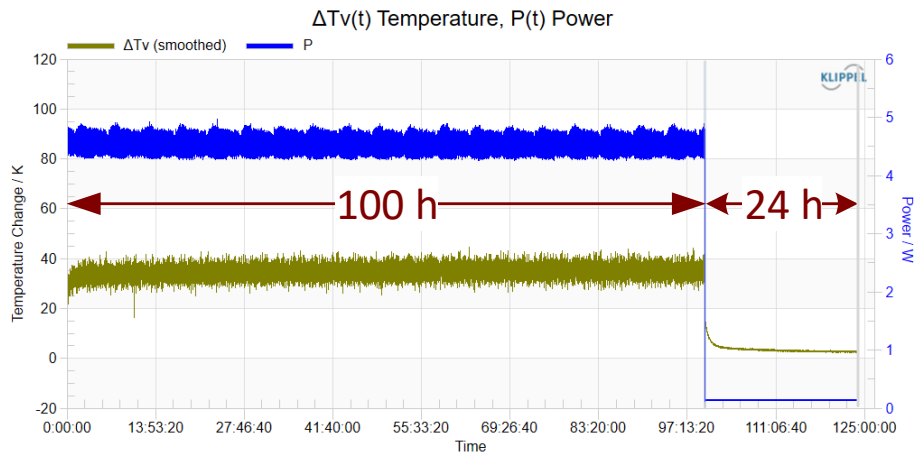


Current and voltage are provided as rms and as peak values. Potential clipping or power compression can be checked in the chart *Device Compression / Limiter*.

**Voice Coil Resistance**

The electrical resistance  $R_e$  of the voice coil increases with the instantaneous voice coil temperature. A sudden increase indicates a loose connection or a broken coil. A sudden decrease may be caused by a shortcut of the windings in the gap. Open circuit and shortcut conditions are automatically detected and abort the running test.

**Temperature Input Power**



The voice coil temperature is closely related to the real input power supplied to the transducer. Note the dual Y axis in the chart. Both state variables plotted versus measurement time give important information for defining admissible maximal input power. For a continuous playback test the steady state temperature for the given level can be assessed.

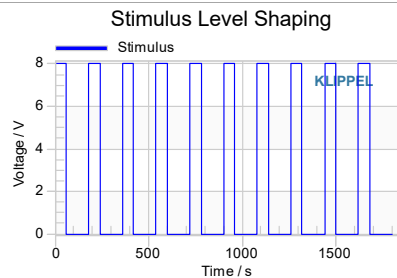
**2.2 Midrange cycling 30 minutes test according to IEC 60268-21 (cl 18.4) Long-term maximum sound pressure level**

**Accelerated Stress Test**

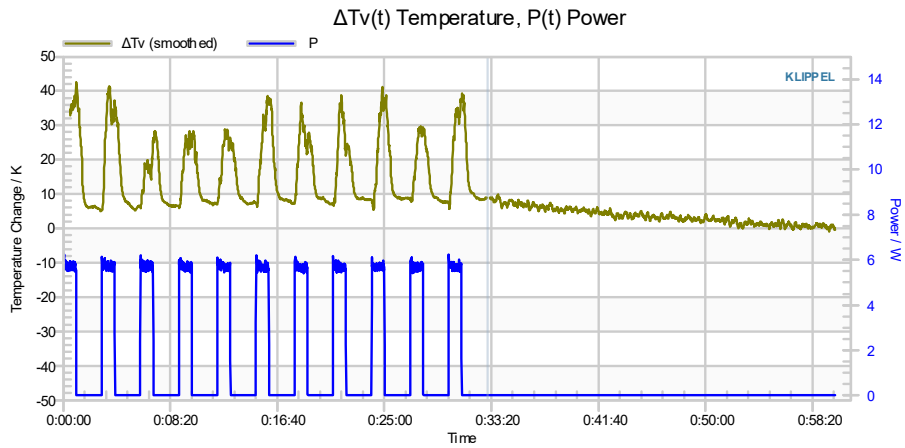
Special profiles of excitation level and/or environmental conditions are used to accelerate the life cycle of a transducer. Fast changes in conditions stress the DUT and simulate a typical load scenario of product life in a much shorter time. One typical test (which is also used to determine the *long-term maximum sound pressure level* according to IEC 60268-21 cl. 18.4) is alternating high level with resting (cooling down). KET provides many options to alternate or step up/down the level for any kind of stimulus. Templates provide predefined setups according to international standards for easy setup and use. This setup is available as template in dB-Lab and dashboard:  
KET Long term maximum sound-pressure level; IEC 60268-21

**Voltage Cycling**

This test consists of 10 loops of a heating phase of 60 seconds at a maximum power level, followed by 120 seconds cooling phase with low or no input power. Arbitrary level profiles are supported in KET.



**Temperature, Input Power**



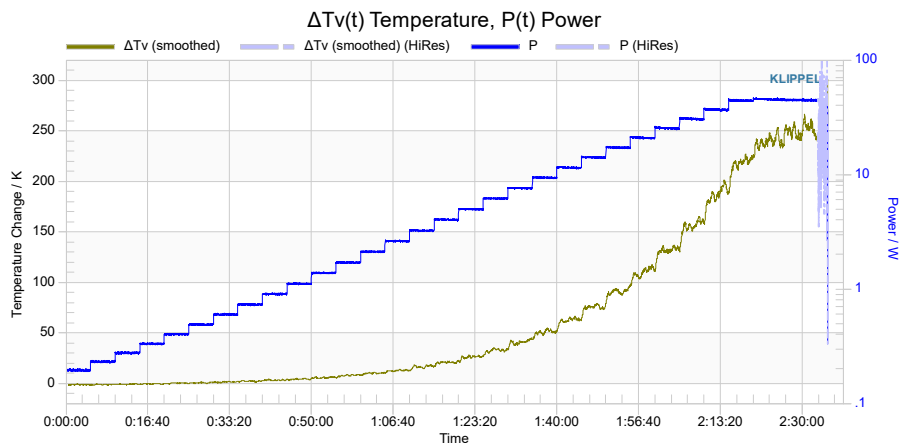
Note the dual Y axis in the chart. After the cooling phase, the voice coil temperature quickly heats up, increasing the input resistance of the DUT and therefore reducing the input power within the On-phase. A maximum temperature of 40 K on top of the starting temperature (in the example 25°C, which was measured using an external USB temperature sensor in parallel to the test). The maximum (average) voice coil temperature was therefore about 65° C.

**2.3 Woofer destructive testing**

**Destructive Testing**

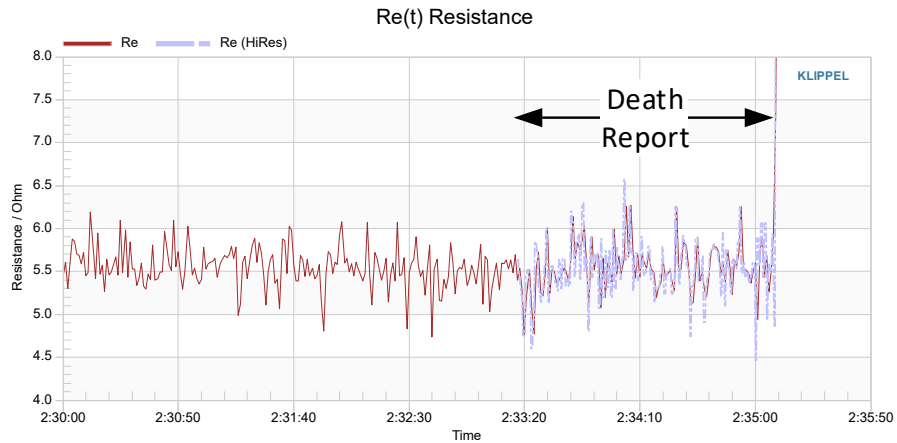
Most devices undergo thorough testing within their specified limits, but it's important to also test their maximum capabilities. Klippel Endurance Testing (KET) is a useful tool for determining the highest allowable power and coil temperature. The test automatically stops if the device is damaged or exceeds individual power, current, or temperature limits. The final 100 seconds of the test provide detailed information about the device's behavior during this crucial phase. This setup is available as template in dB-Lab and dashboard: KET Destructive Testing

**Temperature, Input Power**



In this example, the test level is increased every 5 minutes by 1 dB steps up to a maximum test level of 25V / 45 W. Note the logarithmic y-axis for power. The device under test, a small automotive woofer that is specified with a 12V max rms level, withstands more than twice that specified level for about 5 minutes. The coil temperature at the breakdown was measured at about 250°C. Note, that the coil temperature is averaged over the coil, usually the outer parts of the coil are less cooled and may be considerably hotter than the inner parts.

**Death report**



A death report provides high-resolution data just before a detected failure. A ring buffer of 100 seconds length stores results at the highest available rate, here about 200ms. This may reveal the root causes for a malfunction. In this example, the coil suddenly broke and the resistance jumped up quickly causing an open circuit failure.

**2.4 Thermal stress tests**

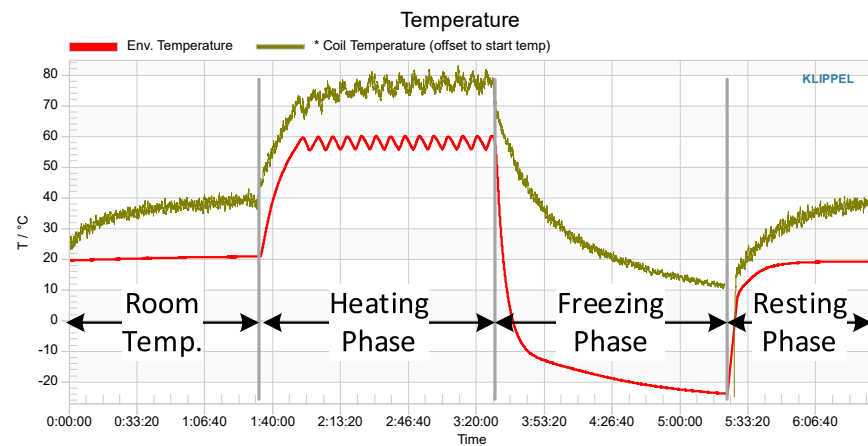
**Monitoring of External Data**

External sensors, such as temperature or humidity sensors, can provide sensor data to KET. A software interface (KET-Store) accepts data and meta information to be monitored in KET software.  
A ready-to-use python or VBS script can be provided for the USB temperature and humidity sensor (Art.-Nr. 2800-011), which is available from Klippel.

**Heating Chamber Control**

Heating chambers can be controlled by the External Control Phase, which allows starting external, user-defined scripts (e.g., batch files, python scripts). External sensor data can be monitored during the control phase. Note, that KET measurements are not available during the control phase.


**Temperature Profile Test**



A temperature sensor (red) measures the environmental temperature in a climate chamber while the voice coil temperature is plotted in brown. The test consists of 4 phases at room temperature, a heating phase, a freezing phase, and a resting phase, about 90 minutes each. Here the environmental heat and cold add additional thermal stress to the voice coil and the DUT, resulting in high coil temperature even at moderate excitation levels.  
In this example, the external temperature sensor is automatically queried using an open API for any kind of sensor and included in result charts. Thus, other

	<p>conditions using almost any digital sensor can be monitored and integrated into KET. Moreover, a software interface is available to control climate chambers or other instruments of torture for DUTs for automatic long-term tests with specific test profiles. As always after endurance testing, compliance with expected behaviour shall be verified. <u>Note that</u> room temperature offset (20°C) was added to the measured coil temperature increase allowing comparison on an absolute scale.</p>
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### 3 Requirements

<b>3.1 Hardware</b>	
<b>PC</b>	<p>Standard PC running the software, not included in KET-solution, See <a href="#">PC-Requirements</a> on Klippel Website for details.</p>
<b>Power Amplifiers</b>	<p>The power amplifier (<i>Powersoft Mezzo</i> series), is included in the KET solution.</p> <p>This picture illustrates a typical 32-channel KET hardware rack (front and rear) equipped with 8 Mezzo power amplifiers and one dedicated network switch in a KET network. Gaps between amplifiers are intended for thermal reasons.</p> <div style="display: flex; align-items: center;">  </div> <p style="text-align: center;">Rack setup for 32 channels (front and rear)</p>
<b>Network / Audio Distribution</b>	<p>Ethernet port for Dante® network, controlled by PC running Klippel KET software. A shared network is possible as long as audio streaming is reliable. For higher channel setups, a separate network is recommended.</p>
<b>Dongle</b>	<p>License USB key for PC running Klippel KET software, included in KET-solution</p>
	<p>No dedicated test hardware (Klippel Analyzer) is required.</p>
<b>Optional Sensors</b>	<p>Data of external sensors (e.g., a temperature sensor in a climate chamber) can be imported and displayed in the KET software. A software interface as well as example scripts are provided.</p>
<b>3.2 Software</b>	
<b>dB-Lab</b>	<p>Klippel Frame Software executing tests, included in KET-solution</p>
<b>Dante® Interface</b>	<p>A virtual or physical Dante® compatible soundcard is required. A license for the DVS (Dante® Virtual Soundcard) is included in the KET package by request.</p>
<b>KET Dashboard</b>	<p>Overview and control of all running tests, included in KET-solution</p>
<b>License</b>	<p>A software license enables the operation of a defined number of channels that can be operated in parallel.</p>



## 4 Limitations

### 4.1 Devices under Test (DUTs)

Any electro-mechanical transducer (with electrical input)

- Bare transducer (Pro Audio, HiFi, Automotive, Micro-speaker, Headphones, TV speaker...)
- Audio systems with external power amplifier (passive)
- 70 or 100 V installation speaker or systems

Electrical networks

- Cross-Over circuits

Parameter	Symbol	Min	Typ	Max	Unit
Voice coil resistance (DC):	$R_e$	2	2 - 8	$\infty$ (Hi-Z), e.g., a capacitor in series with a tweeter	$\Omega$
Resonance frequency*:	$f_0$	10		10 k	Hz

\* Pilot tone must be set up properly to avoid interference by back-induced voltage

### 4.2 Power Amplifier

Supported power amplifier: [Mezzo Series](#) by Powersoft. See Appendix for technical data.

### 4.3 Acoustical

None, a sound shielded power test room is recommended. Be aware of fire hazards.

## 5 Setup

<b>Number of DUTs</b>	<ul style="list-style-type: none"> <li>• Restricted by license and available amplifier channels</li> <li>• 32 DUTs per PC DVS (Dante® Virtual Soundcard)</li> </ul>																																																						
<b>Stimulus</b>	<table border="1"> <thead> <tr> <th></th> <th><b>Level Profile</b></th> <th><b>Frequency (Range)</b></th> <th><b>Crest Factor / dB</b></th> <th><b>Cycling (On/Off)</b></th> <th><b>Stepping</b></th> </tr> </thead> <tbody> <tr> <td>Wave File</td> <td>Yes</td> <td>-</td> <td>-</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Pink Noise</td> <td>Yes</td> <td>Yes</td> <td>6 - 18</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>White Noise</td> <td>Yes</td> <td>Yes</td> <td>6 - 18</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>IEC Noise</td> <td>Yes</td> <td>Yes</td> <td>(fixed)</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Multi-Tones</td> <td>Yes</td> <td>Yes</td> <td>6 - 18</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Single Tone</td> <td>fixed</td> <td>fixed</td> <td>3, fixed</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Two Tones</td> <td>Yes</td> <td>fixed</td> <td>(fixed)</td> <td>Yes</td> <td>Yes</td> </tr> <tr> <td>Sine Chirp</td> <td>Yes</td> <td>Yes</td> <td>3, fixed</td> <td>Yes</td> <td>Yes</td> </tr> </tbody> </table>		<b>Level Profile</b>	<b>Frequency (Range)</b>	<b>Crest Factor / dB</b>	<b>Cycling (On/Off)</b>	<b>Stepping</b>	Wave File	Yes	-	-	Yes	Yes	Pink Noise	Yes	Yes	6 - 18	Yes	Yes	White Noise	Yes	Yes	6 - 18	Yes	Yes	IEC Noise	Yes	Yes	(fixed)	Yes	Yes	Multi-Tones	Yes	Yes	6 - 18	Yes	Yes	Single Tone	fixed	fixed	3, fixed	Yes	Yes	Two Tones	Yes	fixed	(fixed)	Yes	Yes	Sine Chirp	Yes	Yes	3, fixed	Yes	Yes
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Sine Chirp	Yes	Yes	3, fixed	Yes	Yes																																																		
<b>Cycling</b>	The stimulus may be switched on and off during the power test to simulate variations in the voice coil temperature and the mechanical load. The user may define the cycles or the time scheme.																																																						
<b>Stepping</b>	<p>The voltage <math>U(t)</math> at the terminals may be set to a user-defined RMS value. This value may be constant during the measurement or increased automatically (lin/log/user-defined).</p> <p><b>Note:</b> For user-defined wave files, the digital RMS value of the test signal must be provided (in dBFS) to use this feature.</p>																																																						
<b>Wave File</b>	The supported sample rates of wave files depend on the Dante® system sample rate (by default 48 kHz). Any sample rate lower or equal to the system sample rate are supported. Down sampling is not supported due to possible loss of information. In this case a manual down sampling is required (e.g., by Audacity® tool).																																																						
<b>KET Channel</b>	<p>KET channels can be defined by the user globally. Connected devices are auto-detected. A KET channel comprises:</p> <ul style="list-style-type: none"> <li>• Name</li> <li>• Dante audio channel for stimulus distribution to the power amplifier</li> <li>• IP address of power amplifier for data access</li> </ul>																																																						
<b>Analysis</b>	<ul style="list-style-type: none"> <li>• Recorded states (e.g., current, voltage, power, <math>R_e</math>, temperature)</li> <li>• Failure limit for voltage, current, power, temperature</li> <li>• Imported measurement data vs. time (e.g., environmental sensor data)</li> <li>• Death report (High-speed sampling before limit violation or malfunction)</li> </ul>																																																						

5.1 Analysis Setup Parameters					
Parameter	Symbol	Min	Typ	Max	Unit
Frequency of pilot tone to measure resistance	$f_{PT}$	2	5	22 k	Hz
Regular update interval	$t_{upd}$	1			s
Death report update interval	$t_{death}$		0.2		s
Death report duration	$T_{death}$		60		s
Material of voice coil	<ul style="list-style-type: none"> <li>• Copper (<math>\alpha = 0.0038 \text{ K}^{-1}</math>)</li> <li>• Aluminum (<math>\alpha = 0.0039 \text{ K}^{-1}</math>)</li> <li>• User-defined</li> </ul>				
Initial Resistance	<ul style="list-style-type: none"> <li>• Measured at the start of the test (1<sup>st</sup> phase only), if resistance or temperature are requested.</li> </ul>				
<b>Failure Limits</b>					
Voltage (Max)	$U_{Lim}$	0	10	(depends on amplifier capabilities)	V
Current (Max)	$I_{Lim}$	0	1		A
Power (Min, Max)	$P_{Lim}$	0	10		W
delta Temperature* (Max)	$\Delta T_{Lim}$		300	1000	K
Min resistance ref. to initial state	$R_{e,Min}$	20	50	80	%
Max resistance ref. to initial state	$R_{e,Max}$	120	300	500	%
Short circuit detection	$R_{e,Short}$		20		%
*Temperature calculated based on $R_e$ variation considering specified voice coil material.					

## 6 Results

### 6.1 Dashboard

KET Channel Name	Type Name	Test Name	Serial Number	State	Phase	Remaining Time	Current (peak)	Current (rms)
Mezzo.00663314 DUT#1	Example	Destructive Test	01324	running	KET-PH	5:50:21	1.29 A	0.33 A
Mezzo.00663314 DUT#2	Example	Destructive Test	01324	running	KET-PH	5:50:26	0.89 A	0.24 A
Mezzo.00663302 DUT#1								
Mezzo.00663302 DUT#2								
Mezzo.00663302 DUT#3								
Mezzo.00663302 DUT#4								

The **Dashboard** is a control panel for managing multiple KET tests. It uses a table-like layout to give an overview about all tests (running, stopped or paused) and is the hub tool for creating new tests. Every row represents one test object operated at one KET channel, which can be labelled by the user.

The *Dashboard* manages routing setup and the measurement process, as well as linking to a detailed data history (in dB-Lab).

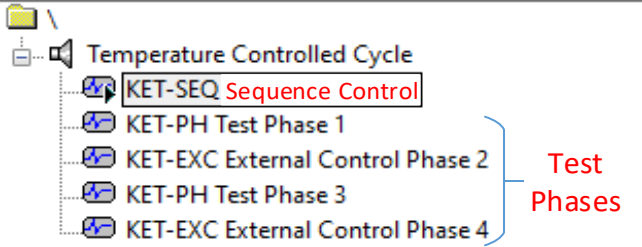
The current state and a comprehensive list of information is updated in real-time for any DUT. Tests can be easily created using KET-test templates and assigned to available channels.

A read-only *Dashboard* is available from any connected PC in the network and allows remote monitoring.

<b>Visualization</b>	<ul style="list-style-type: none"> <li>• KET channel, Type Name, Test Name</li> <li>• State (running/stopped, alive/dead)</li> <li>• Active test phase</li> <li>• Time elapsed/remaining</li> <li>• Selected states (e.g., <math>U_{rms}</math>, <math>U_{peak}</math>, <math>P_{rms}</math>, <math>T</math>)</li> <li>• Link to KLIPPEL test database (history, charts, setup)</li> </ul>
<b>Control</b>	<ul style="list-style-type: none"> <li>• Start</li> <li>• Finish / Abort</li> <li>• Pause</li> </ul>
<b>Replacing DUTs</b>	KET supports measurements of different loudspeaker types started and finished with arbitrary start times. DUTs may be replaced without affecting other running measurements. This means that every running test is independent and can be started and stopped at any time.

### 6.2 Test Organization

<b>Test Result Storage</b>	Test results are stored in a Klippel database and can be viewed using dB-Lab. Reports and test templates (Klippel standard features) can be used. Due to parallel testing, it is strongly recommended to use one database for each DUT. Measurements of the same DUT can be stored in one database.
<b>Test Phases</b>	Each endurance test consists of one or more <i>Test Phases</i> (steps in a test sequence) that are independently defined as <b>KET Test Phase</b> operations. Test phases can be used to <ul style="list-style-type: none"> <li>• apply different stimuli to a DUT,</li> <li>• separate results for different environmental conditions (e.g., temperature),</li> </ul>

	<ul style="list-style-type: none"> <li>• break-in DUTs without storing results,</li> <li>• recover DUTs to recover from stress and much more.</li> </ul> <p>For each test phase, the user can define which states are to be monitored. Those states are displayed versus time in charts and provide a full data history.</p> <p>Test phases can be stored as and created by operation templates. Test phases are stored as operations in a dB-Lab database.</p>
<p><b>Test Sequence</b></p> <p><b>KET Sequence Control</b></p>	 <p>One or multiple <b>Test Phases</b> are defined as a <i>Test Sequence</i>. A test sequence is defined by any KET phase operations in one dB-Lab object and its position (top-down).</p> <p>The test sequence is managed by a <b>KET Sequence Control</b> operation.</p> <p>A KET Sequence Control operation manages a full endurance test consisting of one or multiple test phases. The complete test sequence can be stored as an <b>Object</b> template to be used in the KET Dashboard to create new tests.</p>
<b>Results</b>	<p>Any result shown in the dashboard is also available as a time course chart in the KET Sequence Control operation. Available results are rms and peak values of:</p> <ul style="list-style-type: none"> <li>• Voltage</li> <li>• Current</li> <li>• Power (apparent power; <math>P = i_{rms} \cdot u_{rms}</math>)</li> <li>• Input resistance</li> <li>• Temperature</li> <li>• External sensors (e.g., temperature sensors in heating chambers), and user-defined scripting are required.</li> </ul>
<b>Regular Sampling</b>	<p>During the Endurance Test selected states are sampled periodically and stored at an interval of 1 second.</p>
<b>Failure Detection</b>	<p>Several failure types of the driver will be detected automatically. The user also may specify a permissible variation of the selected states.</p> <p>A detected failure stops the complete test sequence and activates the Death Report feature.</p> <p>Generic failure types are Open Circuit (Hi-Z) and Short Circuit conditions.</p>
<b>Death Report</b>	<p>In addition to the regular sampling of 1 second all selected results are monitored internally at a higher rate and stored for a specified time (ring buffer). In case of a malfunction, this data of the particular DUT is added to the regularly sampled data. This allows a detailed analysis of the time just before a limit was violated or a failure was detected. Thus, valuable information for finding the root cause of a failure is available.</p>

### 6.3 Temperature Measurement

<b>Principle</b>	<p>The voice coil temperature is derived from the measured input resistance at a fixed frequency (pilot tone). Accuracy and noise depend on the used acquisition hardware.</p>
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	<p>Note that the coil temperature is not constant in all windings but depends on position due to convection and heat transfer [1][2]. The measured coil temperature is an average over all windings.</p>
<b>Reference Resistance</b>	<p>Resistance <math>R_{ref} = R_e(t_0)</math> at starting time <math>t = t_0</math>, which is assumed to represent the “cold” state of DUT</p>
<b>Increase of Voice Coil Temperature</b>	<p>The increase of the voice coil temperature during the test is expressed in Kelvin:</p> $\Delta T_v(t) = \frac{1}{\alpha} \left( \frac{R_e(\Delta T_v(t) + T_v(t_0))}{R_e(T_v(t_0))} - 1 \right) \approx \frac{1}{\alpha} \left( \frac{Z_e(f_p, \Delta T_v(t) + T_v(t_0))}{Z_e(f_p, T_v(t_0))} - 1 \right)$ <p>It is calculated by using the cold resistance as a reference and the thermal conductivity coefficient <math>\alpha</math> for the selected voice coil material. Copper (<math>\alpha = 0.0038 \text{ K}^{-1}</math>), aluminium (<math>\alpha = 0.0039 \text{ K}^{-1}</math>) or user-defined coefficients are available.</p>
<b>Pilot tone</b>	<p>The measurement of voice coil temperature is based on assessing the electrical input impedance at a specified frequency. This method requires voltage and current monitoring. The DC resistance measured at the loudspeaker terminals is the most accurate way of estimating the voice coil temperature but requires a DC-coupled amplifier. However, using a low-frequency tone <math>f_p</math> (2 Hz ... 10 Hz) is more convenient than a DC stimulus because an AC signal can pass the high-pass of the power amplifier. Loudspeaker systems, active or passive crossovers may require a pilot tone at higher frequencies. Setting the pilot tone in the minimum of the impedance curve is less accurate than monitoring the resistance at low frequencies close to DC but may be useful for DUTs with capacitive inputs (tweeter with serial C) or very low resonance frequency (subwoofer).          Temperature monitoring is always active when enabled, even when the test signal is off or very low to assess the cooling process.          For more details on setting up the pilot tone and optimizing temperature monitoring, see the KET user manual.</p>
<b>Temporal resolution</b>	<p>The time constants affecting the temperature measurement are also adjustable during measurement. The resolution can be set using the parameter <i>Temperature Speed</i> on the property page <i>Measures/ Limit: <math>\Delta T_v</math> Voice Coil Temperature</i>:          The mode <b>Slow</b> is default and recommended for</p> <ul style="list-style-type: none"> <li>• monitoring of slow thermal changes (woofer, subwoofer)</li> <li>• higher input resistance (headphones) <math>&gt; 8 \Omega</math></li> <li>• low test levels <math>&lt; 5 \text{ V}</math></li> <li>• too high-temperature variation in Medium or High Mode</li> <li>• temperature results are integrated over 30 s</li> </ul> <p>The mode <b>Medium</b> is recommended for applications with</p> <ul style="list-style-type: none"> <li>• too high-temperature variation in High Mode</li> <li>• temperature results are integrated over 5 s</li> </ul> <p>resonance frequencies <math>&gt; 100 \text{ Hz}</math></p> <p>The mode <b>High</b> is recommended for applications with</p> <ul style="list-style-type: none"> <li>• monitoring of fast thermal transients (tweeter, micro speaker)</li> <li>• dedicated noise stimulus for thermal testing</li> <li>• higher test levels <math>&gt; 5 \text{ V}</math> and higher test current <math>&gt; 1 \text{ A}</math></li> <li>• resonance frequencies <math>&gt; 100 \text{ Hz}</math></li> <li>• there is no additional integration implemented</li> </ul>

## 7 Feature Comparison

Feature	Klippel Endurance Test (KET)	Power Test (PWT) – Deprecated
<b>Max. Num DUTs</b>	32 (64)	8 (using Power Monitor 8) 2 (using Distortion Analyzer)
<b>Signals</b>	Voltage / Current No Displacement	Voltage / Current (PM8) + Displacement (1 DUT only, DA2)
<b>Sample Rate</b>	Up to 192 kHz (depends on Amp)	48 kHz
<b>Sources</b>	Internal (predefined stimuli)	
	External audio signal	
	Any wave-file (PC playback), length restricted	Bypass Mode (Analog input) (Monitoring any amplifier output)
	Any stimulus generated by MTON	-
<b>Stimuli (internal)</b>	<ul style="list-style-type: none"> <li>• Pink Noise</li> <li>• White Noise</li> <li>• IEC / EIA</li> <li>• Multi-tone</li> <li>• Two-tone</li> <li>• Chirp</li> </ul>	<ul style="list-style-type: none"> <li>• Pink Noise</li> <li>• White Noise</li> <li>• IEC / EIA</li> <li>• Two-tone</li> <li>• Chirp</li> </ul>
<b>Voltage Control</b>	For any internal stimuli. For Wave-Files: <ul style="list-style-type: none"> <li>• By digital RMS value</li> <li>• User defined</li> </ul>	For internal and external sources. Not available for Bypass mode
<b>Voltage Stepping</b>	Linear, Exponential, User defined	Linear, Exponential
<b>Intermittent Excitation</b>	Yes	Yes
<b>Stimulus Crest Factor</b>	User-defined (6 – 18 dB)	User-defined (6 – 18 dB)
<b>Filter for stimulus</b>	6/12/24/48/∞ dB	6/12 dB
<b>Sampling Interval</b>	1s (0.2s for 100s death report)	1s for 1 DUT (Minimum, used for death report) 8s for 8 DUTs (Minimum)
<b>States</b>	U / I / P / R / T	U / I / P / R / T / X (1 channel only)
<b>Nonlinear Identification</b>	No (planned in future)	PWT-Pro only
<b>Pilot Tone</b>	Yes (for internal and wave files)	Yes (for internal, and external)
<b>Failure Criteria</b>	I / R <sub>e</sub> / P / T	R <sub>e</sub> (T)

## 8 Appendix: Compatible Amplifier Specification

**Supported Amplifiers:** Mezzo series 322AD, 324AD, 602AD, 604AD

Mezzo amplifiers are configured during the installation and setup process. There is no need to modify amplifier settings except if special customer needs require it. Armonia+<sup>®</sup> software provided by [Powersoft](#) may be used to change the standard setup. Note that Klippel Support may provide help for standard settings only.

<b>8.1 Mezzo Power Amplifier 604 AD*</b>					
<b>Parameter</b>	<b>Symbol</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Unit</b>
Output power per channel (4 channels used)	$P$			150 @ 2 - 16 $\Omega$	W
Single channel power	$P_{\text{single}}$			400 @ 4 $\Omega$ 600 @ 8 $\Omega$	W
Maximum continuous output power	$P_{\text{cont}}$			75	W
Maximum peak voltage	$U_{\text{peak}}$			142	V
Output Frequency Range @ $\pm 0.5$ dB	$f_{\text{Out}}$	20		20k	Hz
Maximum output current	$I_{\text{peak}}$			15.6	A
Output Crosstalk @ 1kHz	$L_{\text{cross}}$		-60		dB
Signal Noise Ratio	$L_{\text{SNR}}$		102		dB(A)
Power supply	$V$	100		240 VAC @ 50-60 Hz	V
<b>8.2 Mezzo Power Amplifier 324 AD*</b>					
<b>Parameter</b>	<b>Symbol</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Unit</b>
Output power per channel (4 channels used)	$P$			80 @ 2 - 16 $\Omega$	W
Single channel power	$P_{\text{single}}$			320 @ 4 - 8 $\Omega$	W
Maximum peak voltage	$U_{\text{peak}}$			142	V
Output Frequency Range @ $\pm 0.5$ dB	$f_{\text{Out}}$	20		20k	Hz
Maximum output current	$I_{\text{peak}}$			15.6	A
Output Crosstalk @ 1kHz	$L_{\text{cross}}$		-66		dB
Signal Noise Ratio	$L_{\text{SNR}}$		100		dB(A)
Power supply	$V$	100		240 VAC @ 50-60 Hz	V



**8.3 Mezzo V/I Measurement (any model)**

Parameter	Symbol	Min	Typ	Max	Unit
V/I Frequency Range @ ±1 dB	$f_{Ana}$	20		20 k	%
Voltage Accuracy @ 1kHz	$E_{Volt}$		5		%
Current Accuracy @ 1kHz	$E_{Curr}$		5		%
Pilot tone frequency for Re and Temperature monitoring	$f_{pilot}$	2		20 k	Hz

\*Specified values are defined by [Powersoft](https://www.powersoft.com). They are listed here for convenience. Please check the detailed specification at <https://www.powersoft.com>.

**9 References**

<b>9.1 Related Modules</b>	<a href="#">Power Testing (PWT)</a> <a href="#">Multi-Tone Measurement (MTON)</a> <a href="#">Tone Burst Measurement (TBM)</a>
<b>9.2 Manuals</b>	<a href="#">KET Manual</a>
<b>9.3 Website</b>	<a href="https://www.klippel.de/products/klippel-endurance-test.html">https://www.klippel.de/products/klippel-endurance-test.html</a>
<b>9.4 Application / TecNotes</b>	TN16 - KET - KLIPPEL Endurance Testing HW setup
<b>9.5 Literature</b>	[1] W. Klippel, "Nonlinear Modeling of the Heat Transfer in Loudspeakers," J. of Audio Eng. Soc. 52, Volume 1, 2004 January. [2] Henricksen, "Heat Transfer Mechanisms in Loudspeakers: Analysis, Measurement and Design," J. of Audio Eng. Soc., Volume 35, No. 10, 1987 October.
<b>9.6 Audinate / Dante® Resources</b>	Hardware Dante® Interfaces: <a href="https://www.audinate.com/products/manufacture-products/dante-pcie-card">https://www.audinate.com/products/manufacture-products/dante-pcie-card</a>
<b>9.7 Standards</b>	CEA-CEB19, CEA-2006-A, CEA-2019 IEC 60268-5, IEC 60268-7, IEC 60268-21, IEC 60268-22, IEC 62458, IEC WD 63034 BS EN 54-24 AES2

Find explanations for symbols at:

<http://www.klippel.de/know-how/literature.html>

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