

Power Test with bypassed stimulus from CD AN 59

Application Note to the KLIPPEL R&D SYSTEM

The accurate measurement of the voice coil temperature, input power and other state variables is one of the most important requirements accelerated life testing and on-line monitoring of loudspeakers using synthetic or ordinary audio signals. This application note is an add-on to AN 27 considering the specifics for test setups where no direct input channel connection is available and the test signals have to be stored on a CD or USB device.

That Application Note gives step-by-step instructions how to define the test setup and to perform a power test on loudspeaker systems using the PWT Module of the KLIPPEL R&D System. It shows the hardware setup and gives valuable hints how to find a good setup in order to obtain optimal result.

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Document Revision 1.0

updated August 26, 2013

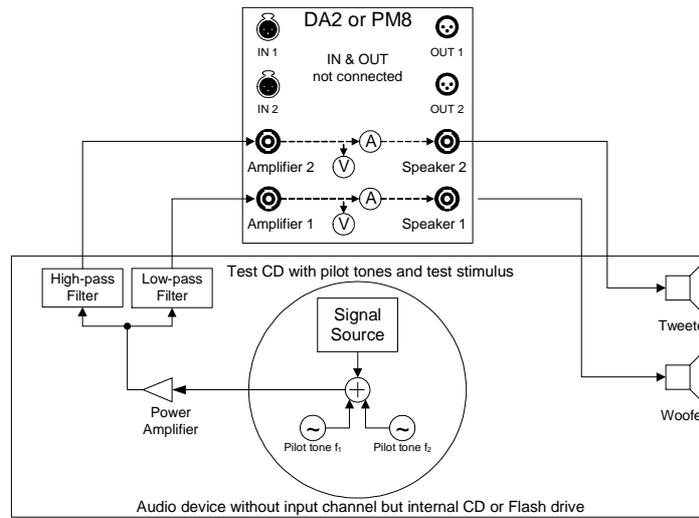
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Scope of the test

Device under test



The power test is applied to audio devices without input channel (e.g. mobile devices). The loudspeaker systems comprising multiple loudspeaker transducers (e.g. woofer, tweeter) excited by a passive or active crossover and power amplifiers. Any artificial test or ordinary audio signal (e.g. music) can be used as stimulus.

Objectives

- The main purpose and targets of the power test are
- measurement of voltage and current at the transducers
- monitoring of voice coil resistance R_e versus time
- calculation of the increase of voice coil temperature versus measurement time
- calculation of real input power P_{real} and power P_{Re} dissipated in the voice coil dc resistance R_e
- manual controlling the amplitude of the stimulus at the signal source
- additional targets of the power tests are
- thermal protection of the transducer
- On-Off cycling to measure the cooling curves

Voice coil Temperature

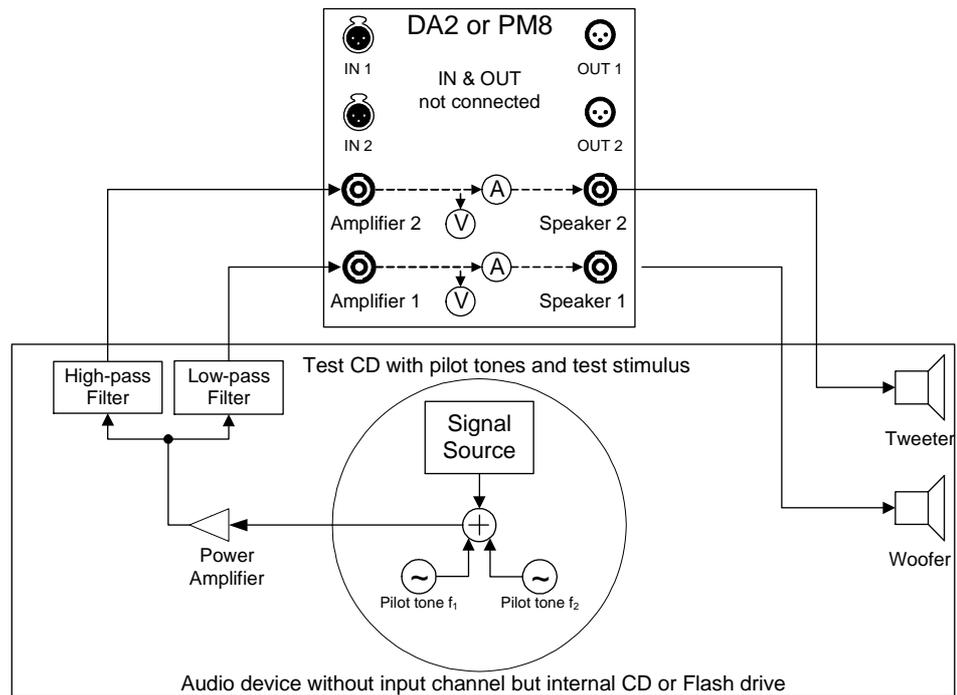
The variation of the voice coil temperature can be calculated from the dc voice coil resistance monitored from the electrical signals (voltage and current) at the transducer terminals. The dc resistance can be derived from the minimum of the electrical input impedance at a particular measurement frequency f_p . The DUT has to be analyzed before the power test to define meaningful frequencies for the pilot tones for the different drivers of the system (woofer / midrange / tweeter). AN 27 explains how to define the frequencies for the pilot tones.

To keep the resistance measurement operative even if the audio signal provides not sufficient spectral power at frequency f_p it is recommend to add an additional pilot tone at all measurement frequencies f_p . This also keeps the temperature measurement operative if the external audio signal is switched off.

For applications where the KLIPPEL hardware cannot be used for the generation of a series of pilot tones audio editing software can be used to create the pilot tones and store it on a CD.

Hardware Setup

Recommended Setup



Steady-states pilot tones generated by external generators can also be mixed with the signal used in power testing. Here the frequencies of the external pilot tones have to correspond with frequency of the internal pilot tones used in the asynchronous analyzer. The pilot tone may be stored in a wavefile and mixed with the stimulus (2nd wavefile) in the audio stream. Or can be mixed and exported to a test CD.

During the designation of test setup for a certain audio device a temporarily added input channel would speed up the process a lot. If possible add an input channel and use procedure described in AN 27. For the final application a stored test signal file on a CD or flash storage device is fine.

Feeding the Klippel measurement device Distortion Analyzer or Power Monitor into the signal path between internal power amplifier and loudspeakers is a requirement for this procedure.

The crossover filters could also be placed behind the DA / PM8.

Therefore different test runs are needed to measure woofer and tweeter.

The woofer could also be driven with the full range signal without low-pass filter.

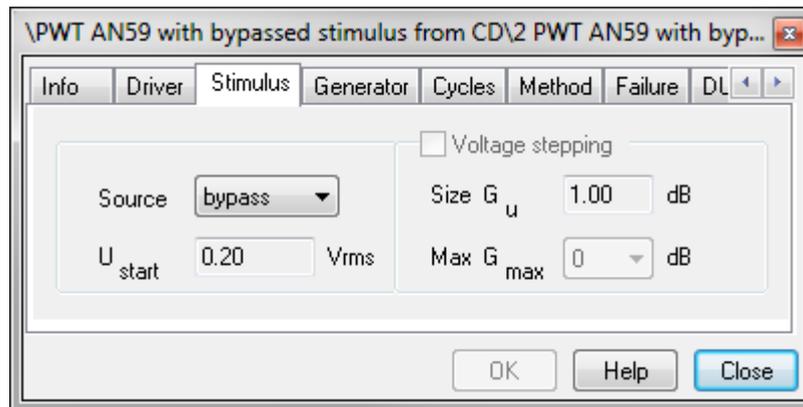
Can only be used in Temperature mode (PWT lite) with bypassed stimulus.

Requirements	<p>1st CD track with pilot tones only must be created for the PWT temperature reference measurement step.</p> <p>2nd CD track must contain pilot tones + test signal. Different version with different volume conditions could be used to find the best setup.</p> <p>Pilot tone for the woofer must be set above the low frequency roll off of the amplifier or must be boosted to compensate the amplifiers low frequency roll off. Checking for a reliable pilot tone level detected at the speaker terminals is important during the setup of the test. In the PWT State window the measured pilot tone level can be checked at "u_pilot". This should be done with pilot tone only stimulus.</p>
Remarks	<p>This setup is a compromise if it is not possible to influence the mix of the pilot tones and test stimulus during the measurement.</p> <p>At any device with an audio input channel a setup from AN 27 should be preferred. A software or hardware mixer should be used to adjust the levels of pilot tones and test stimulus.</p> <p>To adjust the pilot tone frequencies and levels for creation of a final test CD a large number of trials could be needed.</p> <p>If only one final PWT track should be used this track needs the pilot tones only at the beginning for at least the time the Temperature Reference Mode takes.</p> <p>To speed up the initializing two tracks will be needed:</p> <p>The 1st track with pilot tones used during the Temperature Reference Mode. When the PWT On mode starts it can be skipped manually to the 2nd track with pilot tones and test signal.</p>

Step-by-Step Instructions

Hardware Setup Setup the hardware as discussed in the previous chapter.
See RnD System Hardware Manual for details how to connect the measurement device.

Pre-measurements **Defining the PWT test level:**
The test level has to be controlled by the external source for Power Tests with *bypassed* source.



In this special application with CD source there are two options to control the test level.

It is recommended to set the gain (Volume) at the DUT to a defined position (maximum) and defining the PWT test level by an attenuation of the CD signal. CD signal gain G_{CD} (the recording level at the CD) should be between -20 dB and 0 dB. G_{CD} is the headroom to a full scaled CD signal.

If the overall system gain (output voltage of the CD Player and gain factor from the amplifier) is known G_{CD} can be calculated to realize the target test level at the loudspeaker.

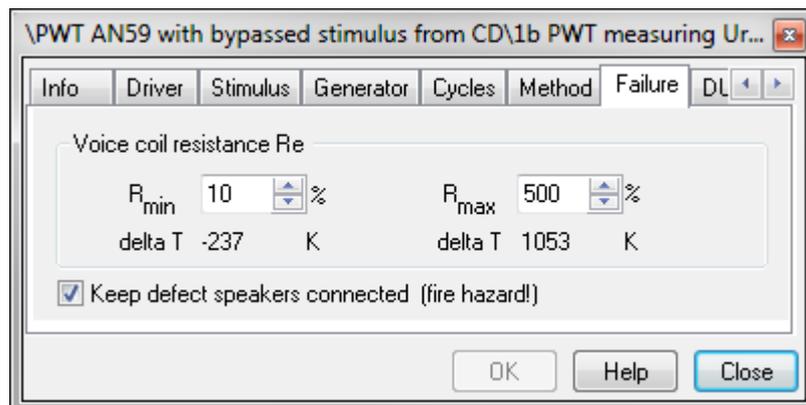
If the target test level should be determined by testing, following set of two pre measurements can be used.

- Use your target test signal and turn up the DUT gain (Volume) until target test level is reached.
- To measure the actual voltage or power template *PWT AN59 / 1a PWT defining target test level* can be used. Check voltage U_{rms} or P , P_n , P_{RE} in the PWT State window.

To make this DUT gain (Volume) setting transferable to other samples of this DUT the attenuation from the maximum gain (full Volume) would be helpful to know to, use this attenuation as CD signal gain G_{CD} .

1st step:

- Use a steady state test signal (sinusoidal tone in the pass band or noise signal) and measure U_{rms} by using template *PWT AN59 / 1b PWT measuring Urms at target gain*.
- Leave DUT gain (Volume) at the position of the previously determined target gain.
- Start the -20 dB attenuated steady state signal. (-20 dB to get less output than with the target test signal.)
- Start the PWT operation and check the voltage at the loudspeaker $U_{rms-20dB}$ in the *State* window.
- The “Keep defect speaker connected (fire hazard!)” option in the PWT must be selected because no pilot tone in this pretest will cause the software to stop otherwise.



2nd step:

- Turn up the DUT gain (Volume) to the maximum.
- Repeat the test with same signal but attenuated to -40 dB.
- Use template *PWT AN59 / 1c PWT measuring Urms at max gain*
- Calculate $G_{CD} = 20\log_{10}(U_{RMS-20dB} * 10) - 20\log_{10}(U_{RMS-40dB} * 100)$ from the displayed values in the state window. Take care that the values are taken from the PWT mode “Interval On” after the initialization.

Pilot tone frequencies:

Determine the optimal frequencies of the pilot tones according AN 27. An overall impedance measurement including the crossover is recommended. Additional impedance measurement of each channel (woofer, midrange, and tweeter) with and without the influence of the crossover could give helpful information about the system.

In general: Place the woofer pilot tone as low as possible to get the lowest possible influence from the back EMF of the driver. The minimum in the Power Test software is 2 Hz. Start with 2 Hz and check if the desired pilot tone level can be reached.

Pilot tone levels:

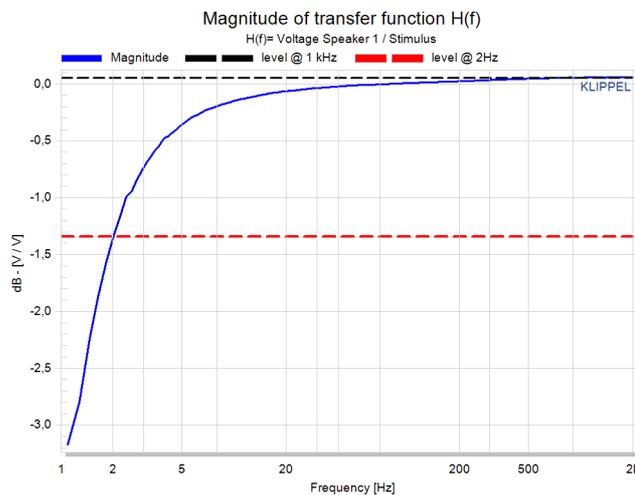
In general: The pilot tone level G_{PILOT} should be between -20 dB and -40 dB below the test signal level. Fast measurement speed requires a higher voltage than using the slow mode. The absolute minimum should be 50 mV in the slow mode and 100 mV in the fast mode when no test signal is supplied.

Note: The Power Test measured pilot tone level could be influenced by a probably frequency mismatch between external pilot tone frequency and analysis pilot tone frequency of the Power Test. The permissible frequency mismatch should be smaller than $\Delta f < 1$ Hz for pilot tone frequency $f_{pilot} < 8$ Hz and $\Delta f < 4$ Hz for a pilot tone frequency $f_{pilot} > 8$ Hz.

At the application: The frequency response (high pass characteristic) of the DUT or used amplifier influences the pilot tone level of the woofer channel. The attenuation A_{HP} of the woofer pilot tone can be measured with three different methods and should be compensated at the CD by increasing $G_{PILOT CD} = G_{PILOT} - A_{HP}$. $G_{PILOT CD}$ should not exceed G_{CD} . Increase pilot tone frequency if target G_{PILOT} could not be reached.

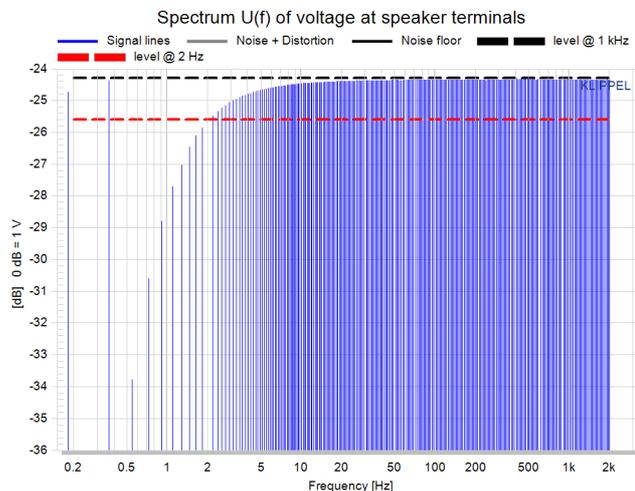
1st method using the TRF module:

- Using the TRF template *1d measuring A_HP with the TRF* and calculate the attenuation by the usage of the cross cursor.



2nd method using the LPM module:

- Using the LPM template *1e measuring A_HP with the LPM* and calculate the attenuation by the usage of the cross cursor. Ignore the two lowest lines that are amplified for a precise Re measurement to compensate the high pass characteristic.



3rd method using the PWT module:

- Using the PWT template *1f measuring A_HP with the PWT pilot tone only* and calculate the attenuation by checking the voltage of the pilot tone and a second tone in the pass band.
- Create two CD tracks. The 1st with a 2 Hz pilot tone and a 2nd with an 1 kHz pass band tone, both at -20 dB below previously determined G_{CD} .
- Leave the DUT gain (Volume) turned full on and start the 1st CD track.
- Start the PWT measurement *1f measuring A_HP with the PWT pilot tone only* and measure U_{RMS}
- Stop the measurement after a some seconds in the *PWT interval on*
- Leave the DUT gain (Volume) turned full on and start the 2nd CD track.
- Start the PWT measurement *1g measuring A_HP with the PWT pass band tone only* and measure U_{RMS}
- Stop the measurement after a some seconds in the *PWT interval on*
- Check the difference between $U_{RMS \text{ pilot only}}$ and $U_{RMS \text{ pass band}}$. $A_{HP} = 20\log_{10}(U_{RMS \text{ pilot only}}) - 20\log_{10}(U_{RMS \text{ pass band}})$

PWT CD creation

Create a Power test CD with the following content. Use the previously determined values. Following chapter describes it step by step by using the free audio editing software AUDACITY.

1st CD track with pilot tones only for PWT Temperature Reference mode

- Pilot tone for the woofer channel normalized to $G_{PILOT\ CD}$
- Pilot tone for Tweeter channel normalized to G_{PILOT}
- The duration should be 5 min to have it longer than finally needed

2nd CD track with pilot tones plus test stimulus

- Use same pilot tones at the same levels from 1st track and enlarge it by the total length of the Power test stimulus.
- Normalize the Power Test Signal to G_{CD} and add it to the pilot tones.

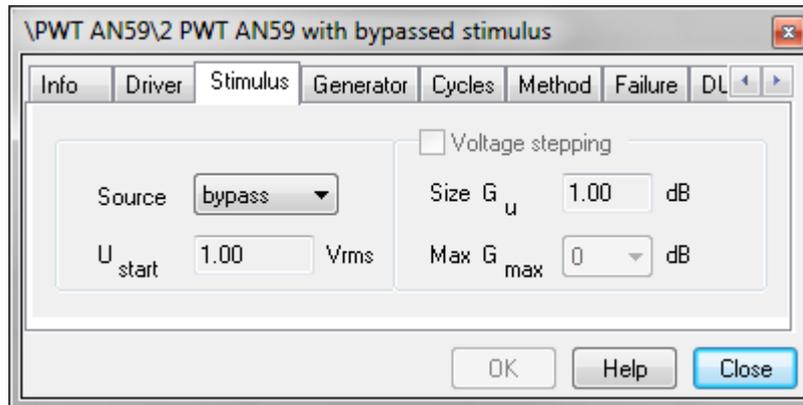
(Normalizing the final mix to G_{CD} will cause too low pilot tones!)

It is recommended to create different tracks with different signals. Testing the system with a steady state signal, stepped in level to see how the voice coil temperature measurement works at each channel is recommended before music or any other signal will be used.

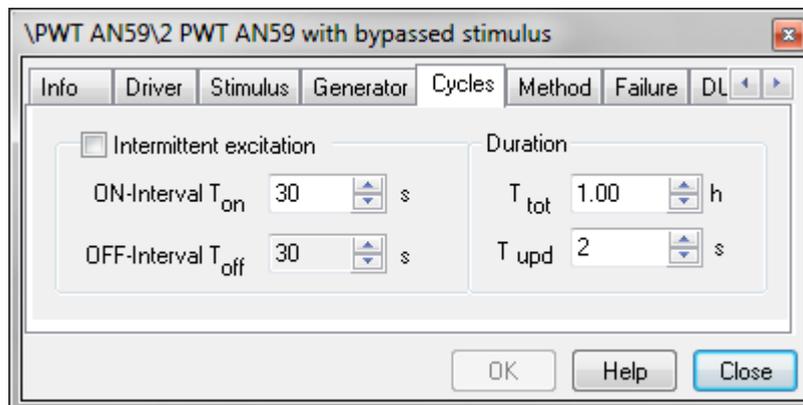
Finally both tracks can be combined, after the maximum time for the Temperature Reference mode has been determined

PWT measurement

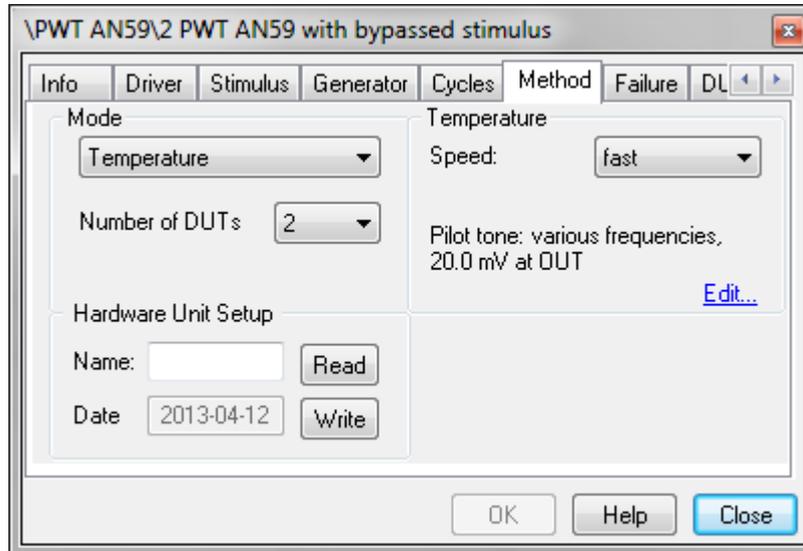
- Use template 2 *PWT AN59 with bypassed stimulus* or create an empty object and insert a PWT operation.
- Select the property page *Stimulus* and select as source *bypass*.



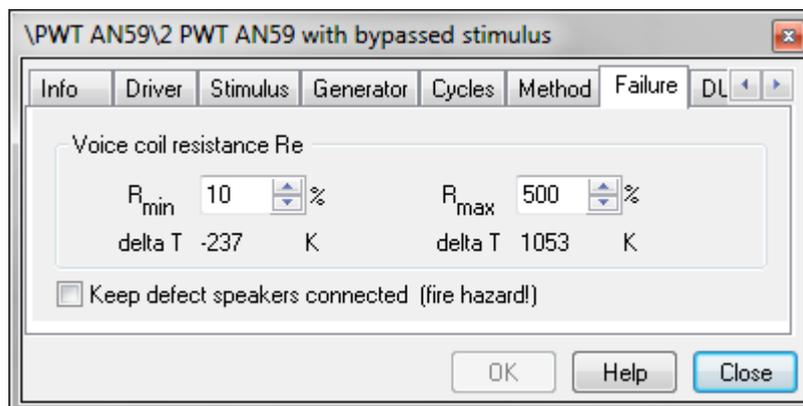
- Select the property page *Cycles* and specify the total length T_{tot} of the power test and the sample rate T_{upd} under *Duration*. Select T_{tot} accordingly the length of the CD tracks. T_{upd} could be long for steady state test signals and should be short for music like stimulus



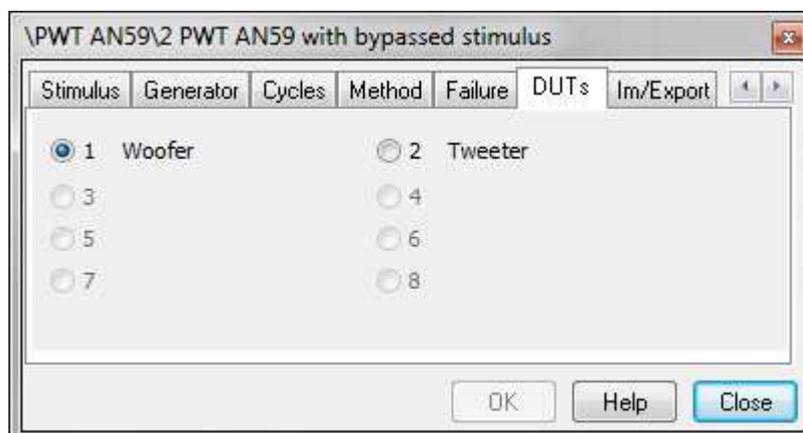
- Select the property page *Method* and select *Temperature* as preferred measurement mode and specify the number of *DUTs* (2 for monitoring a woofer and tweeter). Select the *Speed* of the temperature measurement (*fast* gives the highest temporal resolution). Press *EDIT* to activate the manual pilot tone adjustment. Specify the frequencies accordingly the pilot tone frequencies on the CD. The amplitude doesn't matter as it is defined on the CD.



- Select the property page *Failure* and specify the permissible variation of the voice coil resistance and voice coil resistance to remove the transducer from the power amplifier in case of thermal overload or electrical defect. It is possible but not recommended to disable this functionality.



- Select the property page *DUTs* for labeling the channels and switching the displayed results.



- Start CD track 1 with pilot tones only
- Start PWT operation
- Check in the *State* window if pilot tone voltage is measured at the desired level.

Symbol	Value	Unit	Comment
Date	2013-04-18		
Time	13:48:20		
Serial number	223		
Mode	PWT interval on		
Record	10/33		
t	00:00:27	h:min:s	measurement time
Time remaining	00:29:58	h:min:s	recalculated at thermal mode(a)
DUT 1	alive		
Selected DUT	1		
u_pilot	0.142455	V	Amplitude of pilot tone at speaker terminals
freq_pilot	2	Hz	Frequency of pilot tone for temperature measurement

- Check in the *State* window when the *PWT interval on* mode starts

Symbol	Value	Unit	Comment
Date	2013-04-18		
Time	13:39:46		
Serial number	223		
Mode	PWT interval on		
Record	10/28		
t	00:00:27	h:min:s	measurement time
Time remaining	00:29:58	h:min:s	recalculated at thermal mode(a)

- Skip to CD track 2 with pilot tones and test signal

- It is recommended to check the system with a stepped steady state signal before any music like test signal will be used. A steady state test signal with discrete voltage steps allows easily checking if the voice coil temperature measurement give reliable results.

- Follow instructions for *Viewing and Interpreting Results (Diagnostics)* from AN 27 after the measurement has finished.

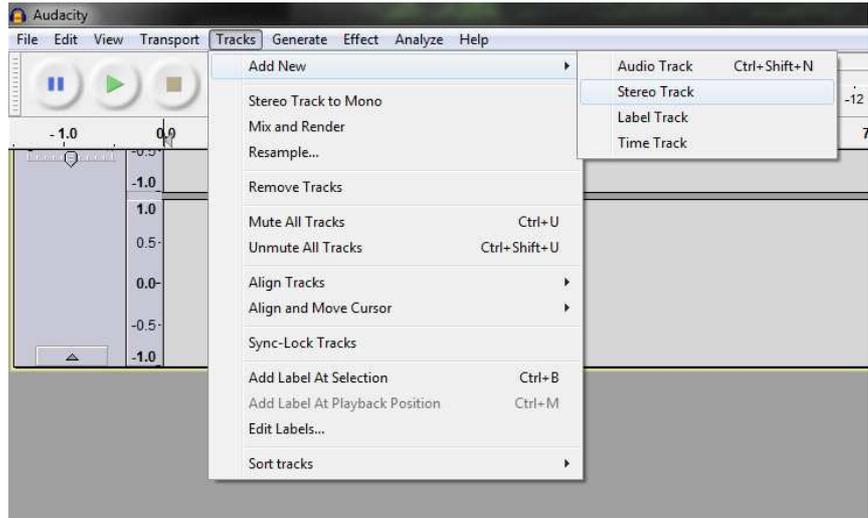
PWT CD creation with AUDACITY audio editing software

Procedure described by the use of the free audio editing software AUDACITY. The procedure in generale will be the same also with other audio editing tools. AUDACITY 2.0 was used for the following screen shots.

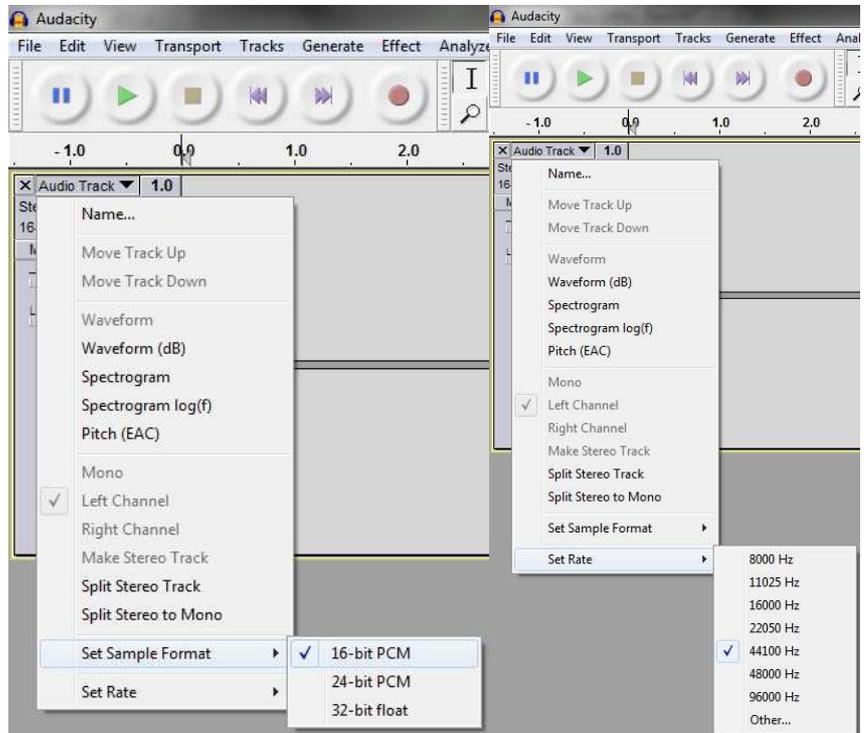
Test Signal Source Files The Audio tracks need to be grabbed from the CD xx.cda to xx.wav (e.g. with audiograbber)

1st Track with pilot tones only

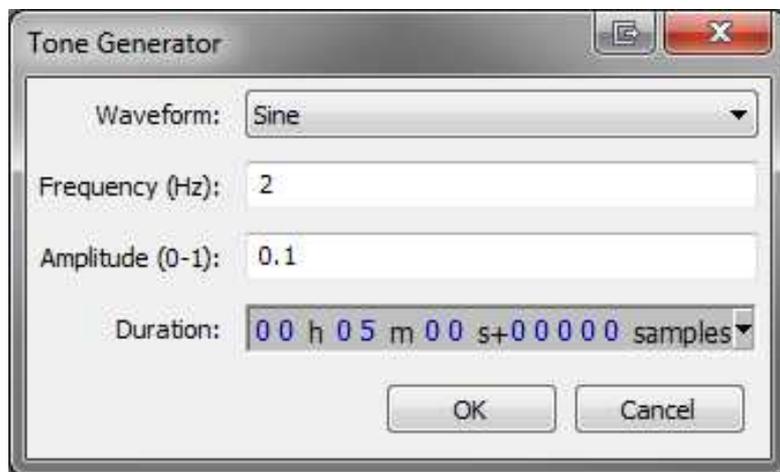
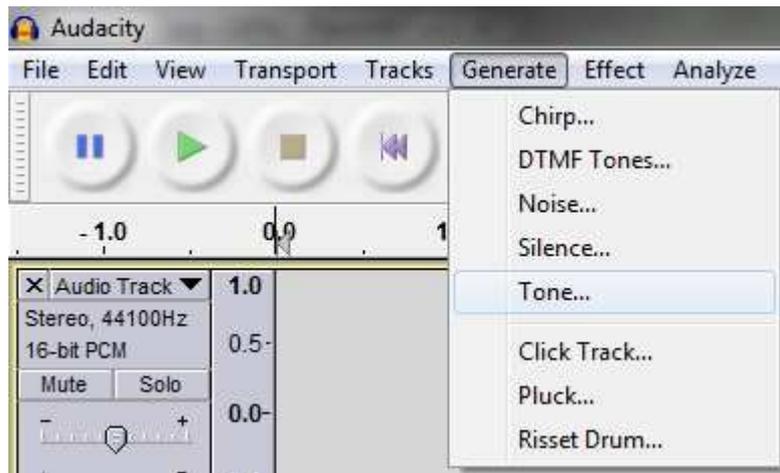
1. Start Audacity with an empty workspace. (File / New)
2. Track / Add new / Stereo Track



3. Set sample rate and format to 44.1 kHz / 16 bit PCM



4. Generate Woofer pilot tone: Sine / $F_{\text{Pilot Woofer}}$ / $G_{\text{PILOT CD}}$ / 5 min
(Use the same length as your test signal will have safes time later.)

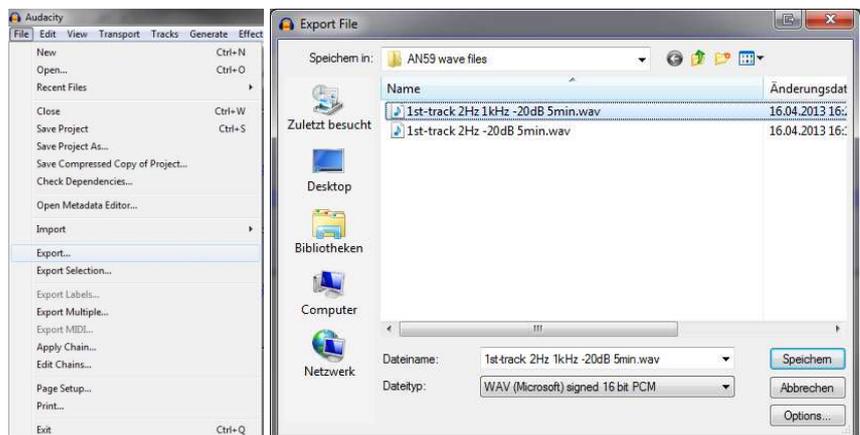


(Example: 2 Hz sine wave, amplitude = 0.1 = -20 dB, 5min)

Alternatively test tones can be generated at amplitude = 1 = 0 dB and the Normalize function can be used to easily adjust the test tones to any dB value.

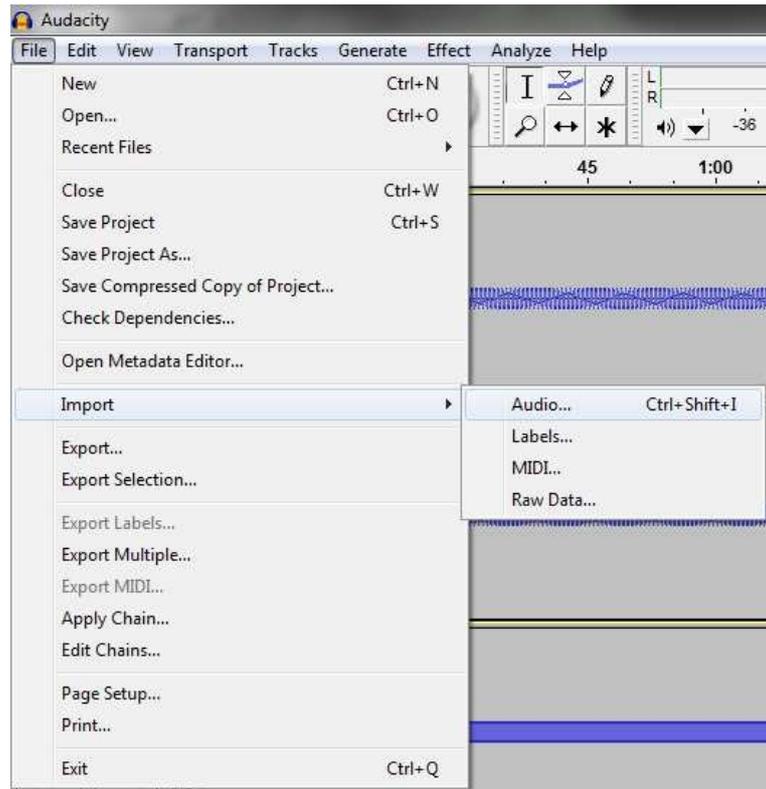
5. Repeat step 2 to 4 for the tweeter pilot tone
Generate Tweeter pilot tone: Sine / $F_{\text{Pilot Tweeter}}$ / G_{PILOT} / 5 min

6. File / Export / wave 16 bit PCM
(mixes all active tracks into one stereo track)



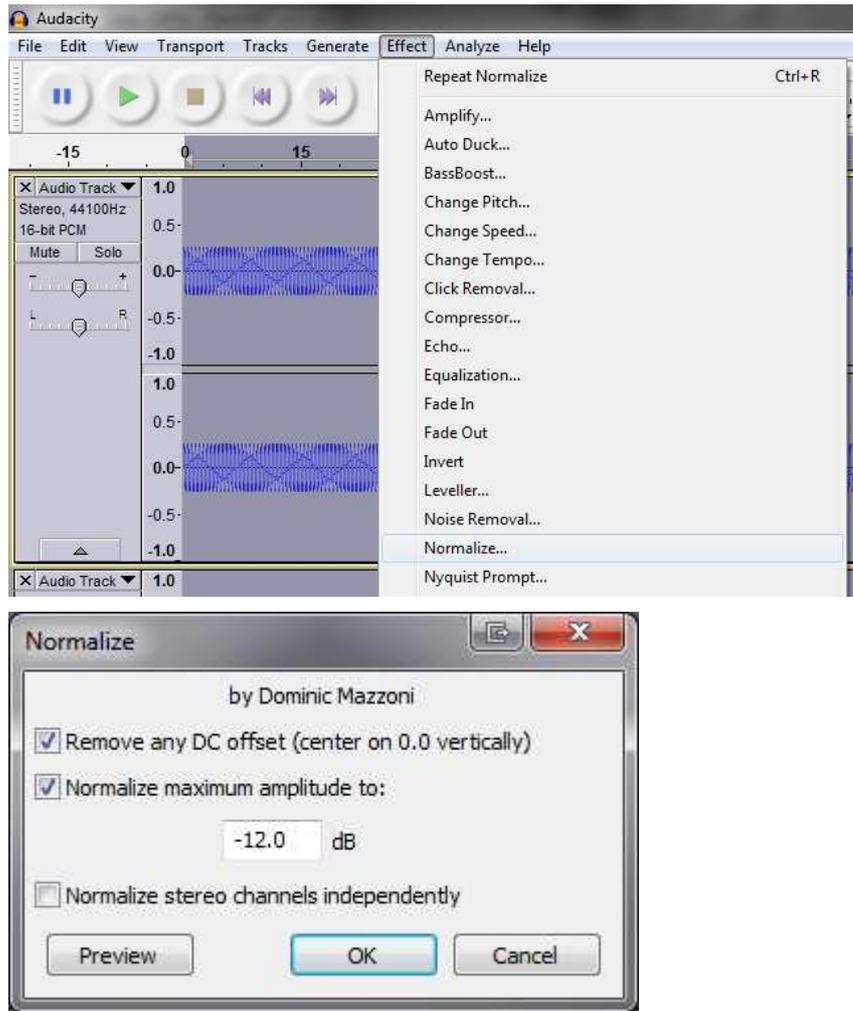
2nd Track with pilot tones + test signal

1. Use workspace from *1st Track with pilot tones only* and add test signal



Converter plugins will be needed for Wma or MP3 files. The software will link to the download sources.

2. Normalize the test signal track (select only the test signal track to keep the pilot tones at the previously set levels.)



3. File / Export / wave 16 bit PCM
(mixes all active tracks into one stereo track)

Burn the CD

4. Burn the exported wave tracks on a CD or store it on a USB device.
An external CD burning program will be needed.

More Information

Software Documentation	[1] Specification of the Power Test, see www.klippel.de [2] Manual of PWT Power Test [3] AN27 Power of Test Loudspeakers with Crossover
Software Templates	Related zip file contains: <ul style="list-style-type: none"> • PWT templates for the PWT pre- and main- measurements. • PWT example files. • Example wave files are available on request due to large file size.
Required Software Version	PWT with asynchronous pilot tones from an external source needs dB-Lab Release >= 206

Document Revision

1.0		2013-08
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