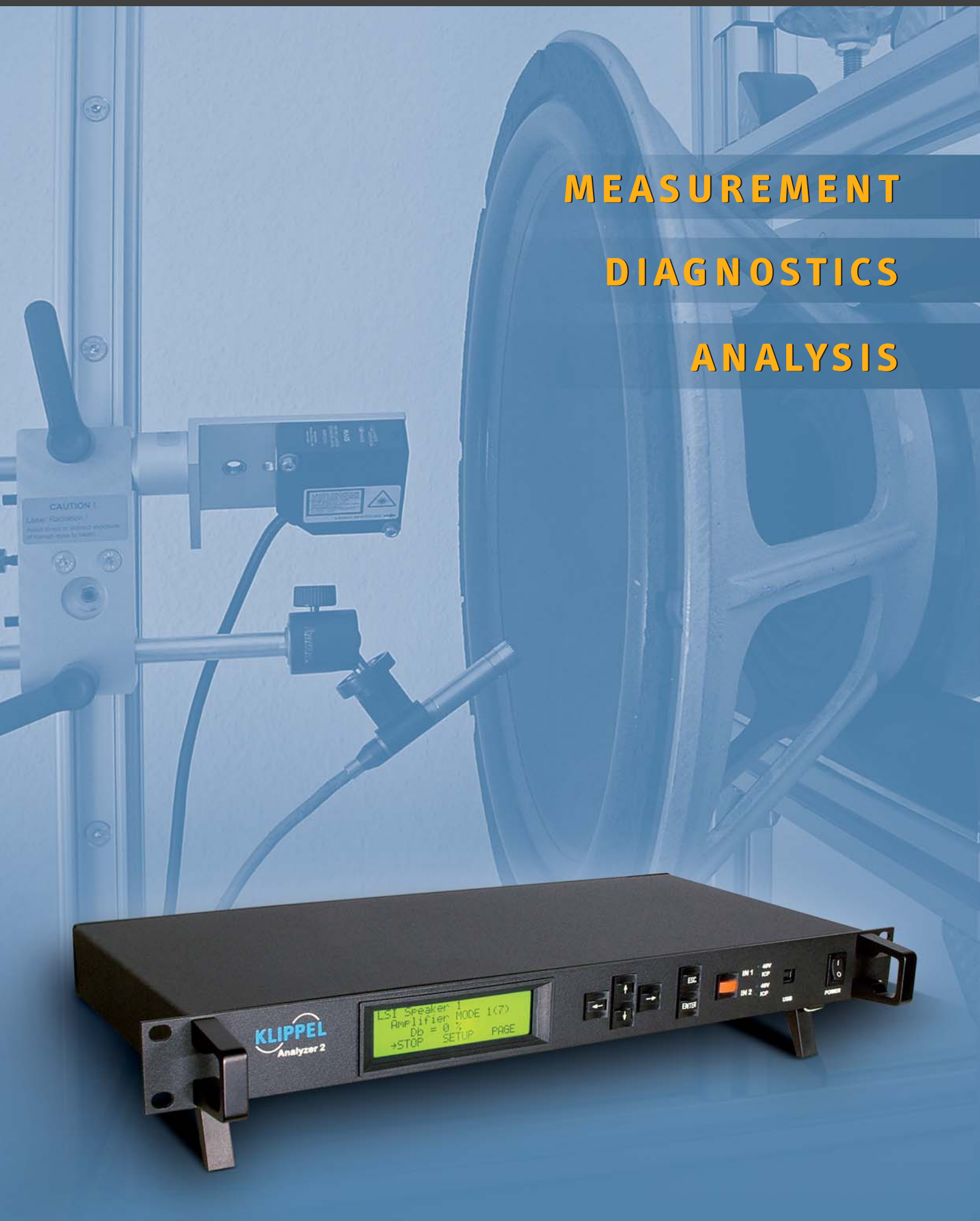
KLIPPEL® R&D SYSTEM

MEASUREMENT

DIAGNOSTICS

ANALYSIS



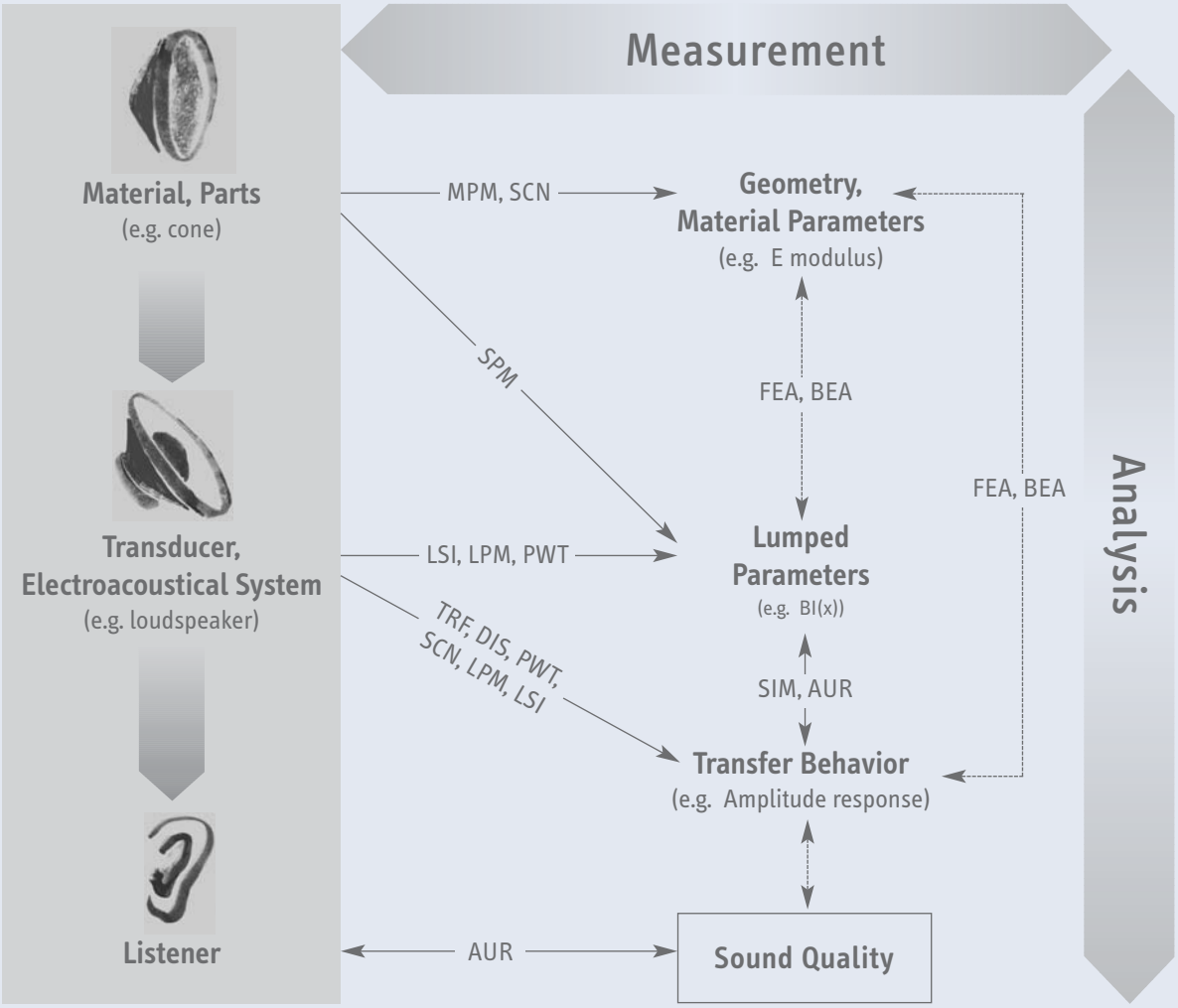
KLIPPEL R&D SYSTEM

More than a measurement system

IDEA

- Accelerate product development
- Combine measurement and analysis
- Provide comprehensive data
- Perform transducer diagnostics
- Comply with international standards

The KLIPPEL R&D SYSTEM is a modular system comprising a suite of tools dedicated to the development of transducers (e.g. woofers) and complete electro-acoustical systems (loudspeakers). Modules are provided for measuring the linear transfer function in the frequency and time domain and for assessing the large signal performance (e.g. distortion). Advanced techniques identify the linear (T/S parameter), nonlinear and thermal parameters of the lumped parameter model representing complete systems, transducers and suspension parts at small and high amplitudes.



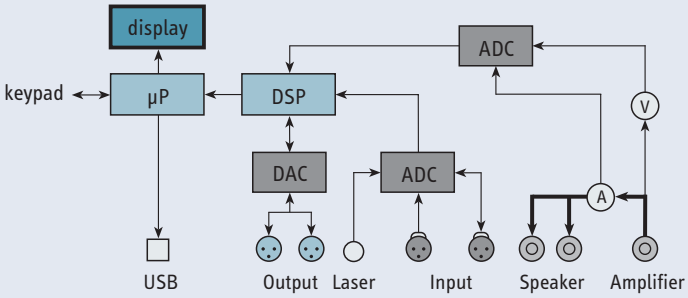
Basic properties of the loudspeaker material (E modulus, loss factor) are measured dynamically and form the basis for investigating the impact of the cone geometry on the mechanical vibration. The KLIPPEL R&D System complements other design tools (FEA, BEA) and supports the comparison of predicted and measured results. The lumped parameter analysis is an effective way for calculating the loudspeaker output for any test signal and audio input and evaluating design choices before the first prototype is finished. The new auralization technique fills the gap between objective assessment and subjective evaluation of sound quality.

DISTORTION ANALYZER

An universal hardware platform for many tasks

- Measure electrical, mechanical and acoustical signals
- Simulate loudspeaker performance in real time
- Perform long term measurement
- Simplify the hardware setup in your lab

The Distortion Analyzer is the universal platform dedicated to transducer measurements. It allows high-quality signal acquisition, up to 48 kHz at a SNR > 100 dB. Sensors are provided to measure terminal voltage (<240 V) and current (<50 A) at two speakers. The hardware may be operated as a stand-alone unit or controlled via USB-interface from a PC. Equipped with a Laser sensor the Distortion Analyzer becomes an universal displacement meter.

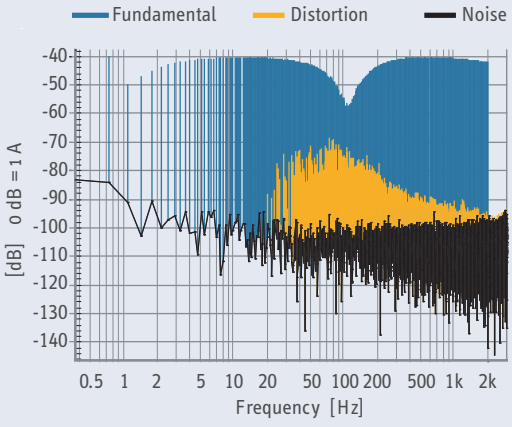


LINEAR PARAMETER MEASUREMENT

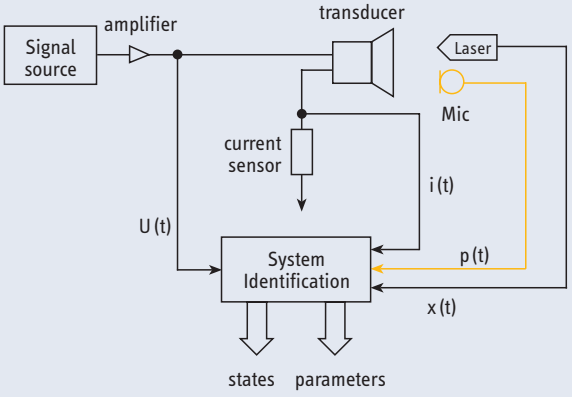
Measure parameters at highest precision

- Speed up with one-step measurement
- Detect limits of small signal domain
- Verify parameter accuracy
- Measure all kinds of transducers

The software module LPM measures linear T/S and other transducer parameters such as visco-elastic creep factor of the suspension and para-inductance of the voice coil at higher frequencies. Voice coil displacement measured by a laser displacement sensor allows direct identification of the mechanical parameters, dispensing with a second measurement using additional mass or enclosure.



A multi-tone signal detects distortion and noise floor simultaneously and checks the validity of results.



DA

LPM

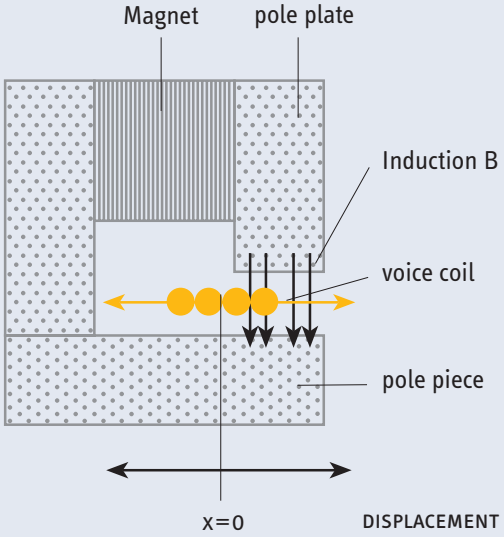
LARGE SIGNAL IDENTIFICATION

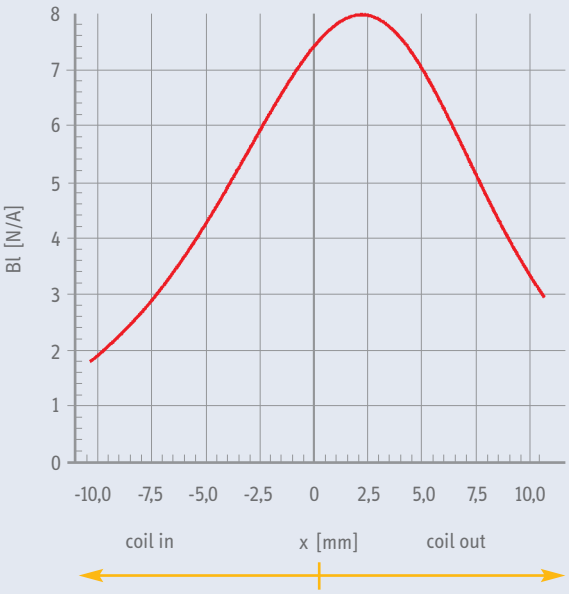
Shows the causes of distortion

- Measure linear, nonlinear and thermal parameters
- Analyze motor and suspension
- Check rest position of voice coil
- Separate distortion of each nonlinearity

The LSI software module measures the linear, nonlinear and thermal parameters of electro-dynamic transducers dynamically according to IEC standard PAS 62458. The transducer can be operated under normal working conditions (free air, sealed or vented enclosure) and is excited by an audio-like signal (noise). Different software modules are available for tweeters and woofers depending on the resonance frequency f_s and the enclosure:

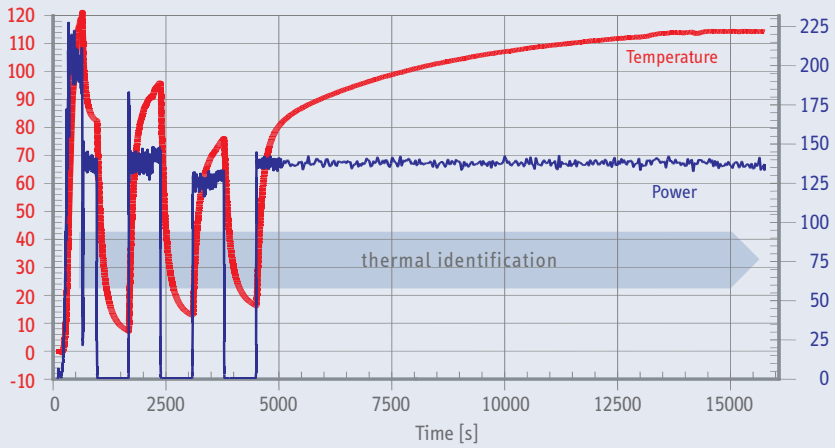
LSI Woofer (f_s < 400 Hz, free air)
LSI Box (f_s < 400 Hz, free air, sealed or vented box)
LSI Tweeter (f_s > 100 Hz, free air)





The force factor Bl(x), stiffness $K_{ms}(x)$ and inductance $L_e(x,i)$ are functions of voice coil displacement x and input current i. The nonlinearities determine the performance in the large signal domain, generate signal distortion (THD, IMD), limit the maximal output (SPL) and may cause instable behavior (dc displacement). The nonlinear curves have a close link to the practical design and are easy to interpret (e.g. voice coil offset).

The LSI also provides the history of the parameter variation and instantaneous state variables (temperature, power, displacement, etc.) versus time. This data is the basis for identifying the thermal parameters describing the heat transfer from the coil to the ambience considering conduction, radiation, forced convection cooling and the thermal capacities of the coil and magnetic system.



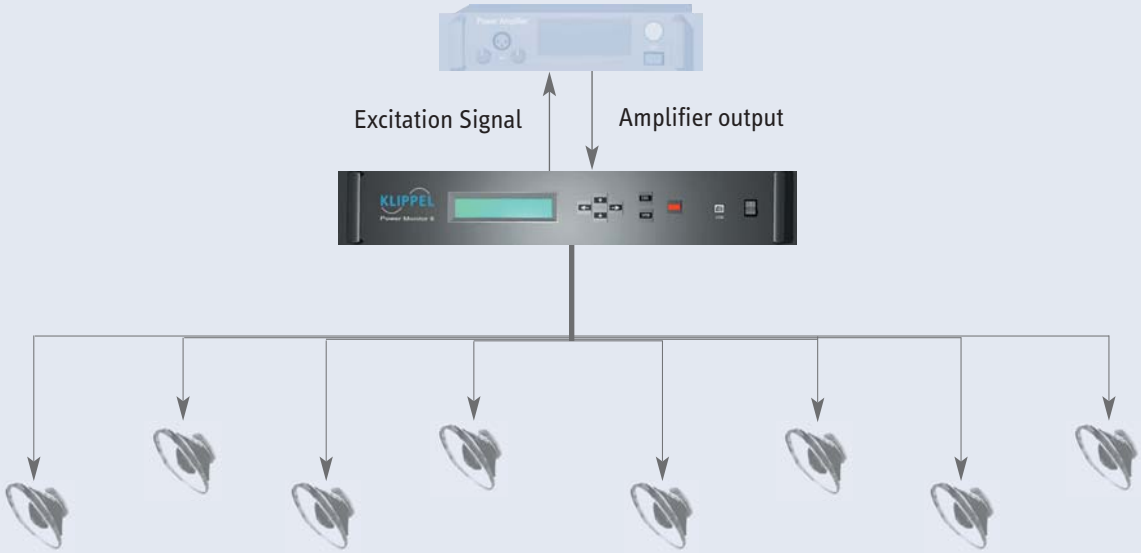
POWER TESTING

Perform systematic long term testing at the limits

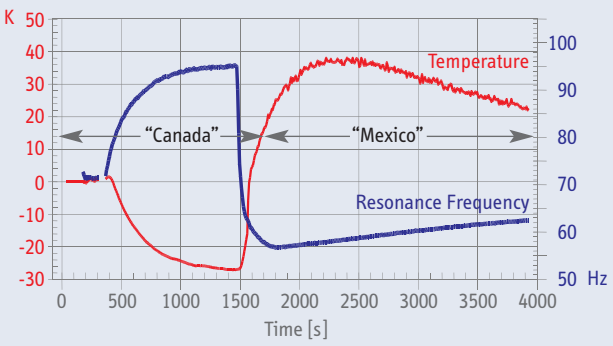
- Ensure durability and reliability of your product
- Separate initial and subsequent damages
- Specify limits of transducer (P_{max}, X_{max})
- Check influence of ambient conditions

The power test software (PWT) runs on the Distortion Analyzer (DA) and on the cost effective Power Monitor (PM8) monitoring up to 2 and 8 devices under test, respectively, simultaneously. Both platforms may be used as stand-alone units complying with IEC, EIA and other standards. An internal generator or an external stimulus may be used and the amplitude at the speaker terminals (step profile, ON/OFF cycle) is automatically controlled.

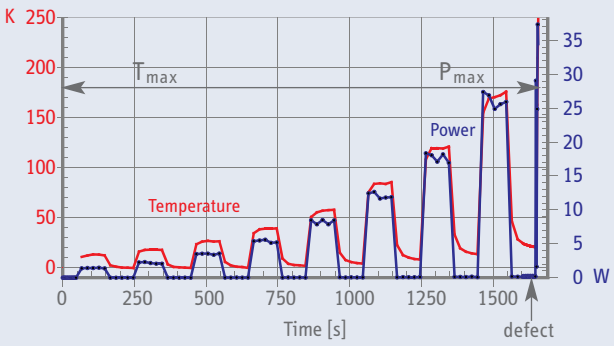
The state variables (voice coil temperature, power, displacement, etc.), as well as linear and nonlinear transducer parameters (Re, f_s, Q_{ts}, Bl(x), etc.) are identified by using current and voltage sensors only. All data are recorded in a history buffer at a sample rate defined by the user. An additional ring buffer for high resolution sampling is provided to monitor an eventual destruction process in detail (death report).



Speaker 1-8



Measurement of resonance frequency f_s and voice coil temperature ΔT_v while varying the ambient conditions in a climate chamber.



Measurement of the maximal input power P_{max} by using automatic amplitude increase (+1.5 dB) after each ON/OFF cycle.

PWT

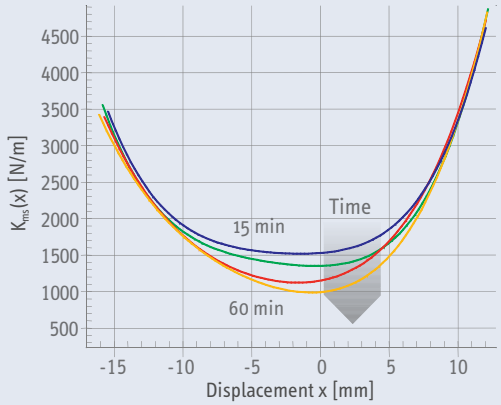
SUSPENSION PART MEASUREMENT

Evaluate spiders, surrounds, cones at small and high amplitudes

SPM

- Select best components
- Sustain high quality
- Investigate ageing and visco-elastic behavior
- Benefit from simple and robust testing

The Suspension Part Measurement (SPM) measures the stiffness of spiders, surrounds, cones and passive radiators (drones) according to IEC standard PAS 62459. The suspension part is excited pneumatically to measure the stiffness dynamically at low frequencies. A test bench and a clamping system comprising sets of rings, cones and cups are provided for nondestructive measurement of circular parts up to 222 mm. The measurements reveal the linear and nonlinear stiffness parameters, visco-elastic effects, aging and the dependency on ambient conditions (temperature and humidity).



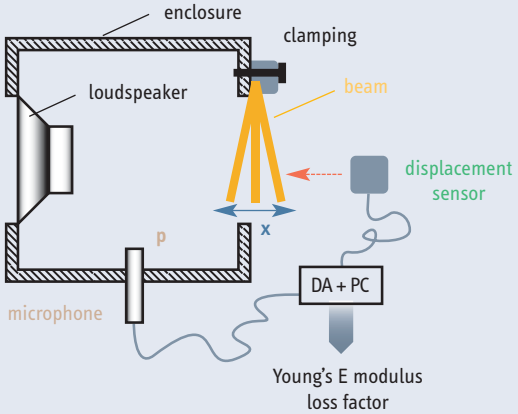
Non-reversible changes of the stiffness K(x) of a spider versus time (break-in) measured by SPM

MATERIAL PARAMETER MEASUREMENT

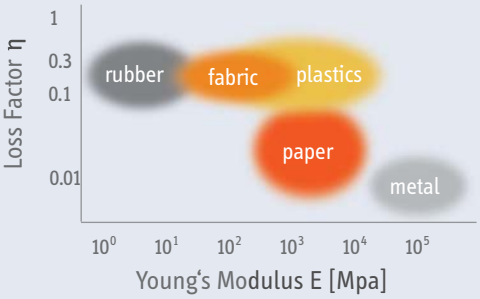
Evaluate raw materials

MPM

- Specify loudspeaker parts more precisely
- Provide input data for FEA
- Find optimal materials
- Maintain consistent products



The material parameter measurement module (MPM) measures the Young's E modulus and the loss factor η of the raw material used for loudspeaker design. The vibration beam technique (ASTM E 756-93) is modified to be capable for measuring also soft materials such as thin foils of plastic, rubber and any kind of paper and impregnated fabric. After cutting 1 cm strips the probes are clamped on one side and excited pneumatically by using the suspension part measurement bench.



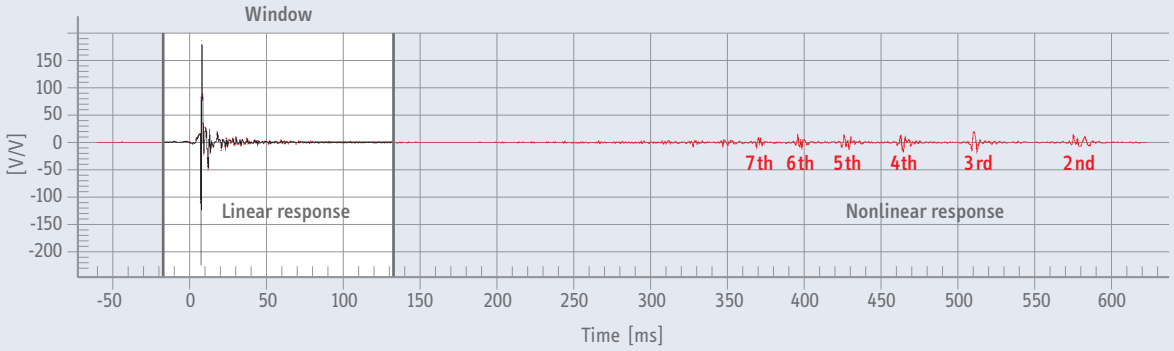
Variation of E modulus and loss factor for common loudspeaker materials

TRANSFER FUNCTION MEASUREMENT

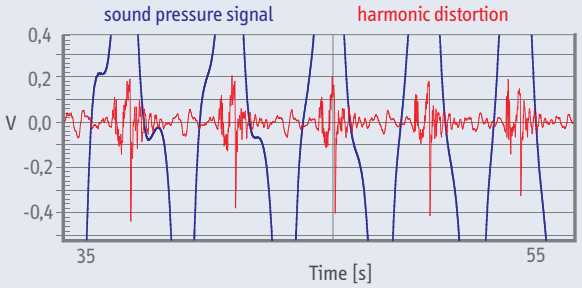
The fastest tool for frequency response and more

- Investigate transient behavior
- Check for distortion and noise
- Shape stimulus to get high SNR
- Find rub & buzz and other failure

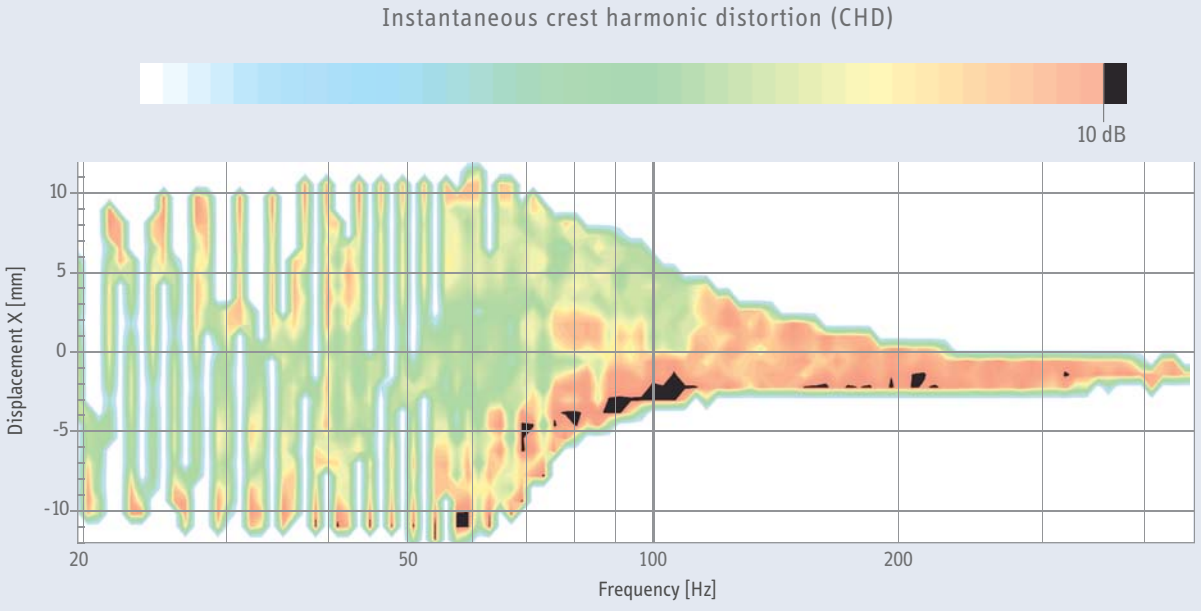
The TRF module measures two signals simultaneously, and determines the linear transfer function (<43 kHz) and the harmonic distortion in the output signals. The stimulus is a logarithmic sweep with adjustable spectrum making fast measurements at high SNR possible. Window techniques applied to impulse response allows separation of the direct sound from early reflections, diffuse field and nonlinear distortion. Finally, post-processing provides the minimal phase, group delay and other transformations in the frequency-time domain.



The harmonic distortion is also analyzed in the time domain to assess the crest factor of the harmonic distortion which is a sensitive indicator for transient distortion caused by rub & buzz and other defects.



The diagram shows the instantaneous crest factor of harmonic distortion (coded as color) versus frequency and voice coil displacement. At low frequencies the crest factor is below 10 dB which is characteristic for motor and suspension nonlinearities. Voice coil rubbing generates transient distortion which leads to much higher crest factors (black spots) at the resonance frequency at the negative maximum of the displacement.



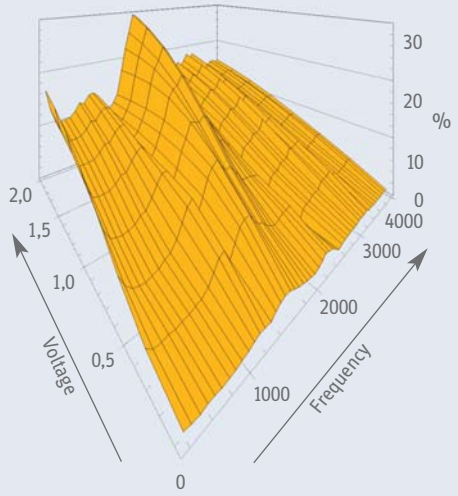
DIS

3D-DISTORTION MEASUREMENT

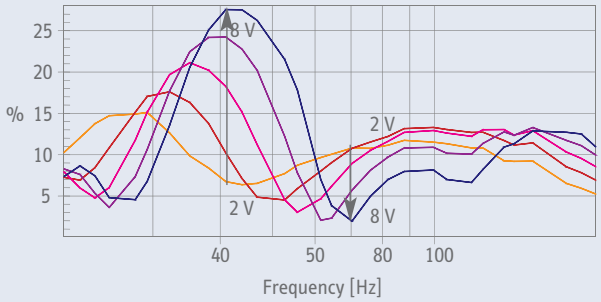
Measure transfer behavior versus frequency and amplitude

- Optimize speakers in small and large signal domain
- Measure signal distortion and amplitude compression
- Ensure stable behavior and maximal output
- Measure speaker at the limits safely

Third-order intermodulation distortion in percent



DIS module performs a series of measurements using a single or two-tone stimulus varied in amplitude and frequency. The FFT is synchronous to the stimulus length giving maximal spectral resolution and dispensing with windowing. The results are the steady-state amplitude responses of the DC-component, fundamentals, harmonic and intermodulation components. The voltage at the transducer terminals may be adjusted automatically and the voice coil temperature is monitored by impedance measurements. The measurement is interrupted if excessive mechanical and thermal overload will damage the transducer.



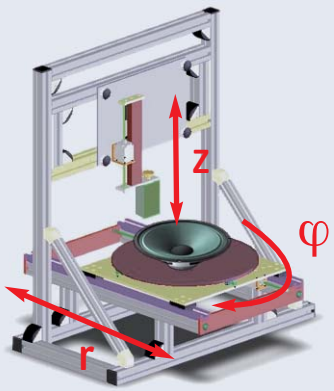
The behavior of loudspeakers varies significantly with the amplitude of the input signal. For example 2nd order harmonic distortion rise and fall with the terminal voltage at different frequencies.

SCN

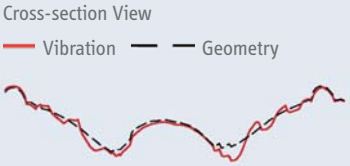
SCANNING VIBROMETER

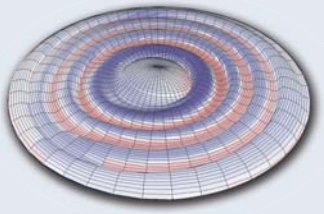
Measure mechanical vibration of the transducer

- Make vibration visible
- Predict directivity pattern
- Show contribution to sound pressure output
- Separate radial and circular modes
- Detect loudspeaker defects



The Scanning Vibrometer (SCN) performs a non-contact measurement of the mechanical vibration and the geometry data of cones, diaphragms, panels and enclosures over the whole audio band (< 25 kHz). One rotational and two linear actuators (φ, r, z) scan a laser displacement sensor on a user-defined grid. The collected geometry data can be exported to other FEA/BEA applications while the vibration data can be analyzed within the SCN software. Modern techniques of image processing are used for enhancing relevant information, suppressing noise and animating the vibration as a stroboscopic video. The sound pressure output in the far field and the directivity pattern are calculated and the contribution of each vibrating point is visualized.





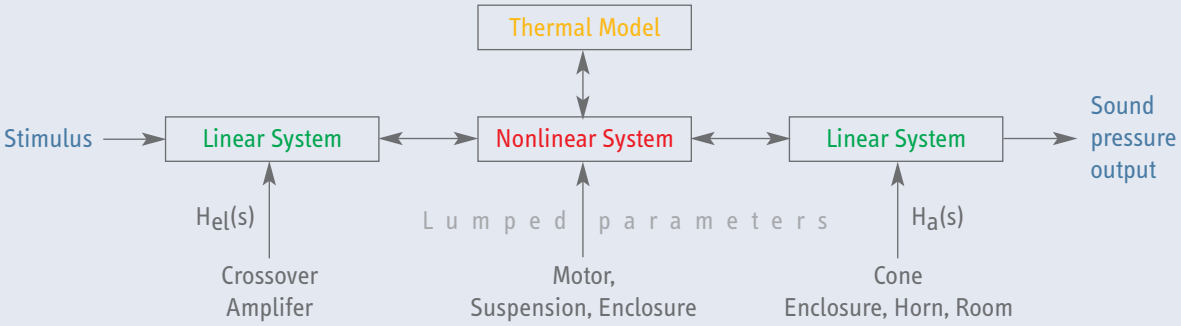
3D-Animation

SIMULATION

Analyze and synthesize transducers and complete systems

- Assess large signal performance objectively
- Investigate design choices
- Compare FEA, BEA with measurements
- Save cost in prototyping

The SIM module performs a lumped parameter analysis (LPA) of transducers and complete electro-acoustical systems based on linear, nonlinear and thermal parameters and transfer functions $H_{el}(s)$ and $H_a(s)$ describing the linear relationship in the electrical and acoustical domain, respectively. The nonlinearities in driver, enclosure and radiation may be switched off or edited by hand to see the impact on the large signal performance. The numerical integration provides all mechanical, electrical and acoustical state variables and their spectral components for a single-tone and two-tone signal. The SIM module provides results in the same format as the 3D Distortion Measurement module (DIS) to support a direct comparison between prediction and measurement.

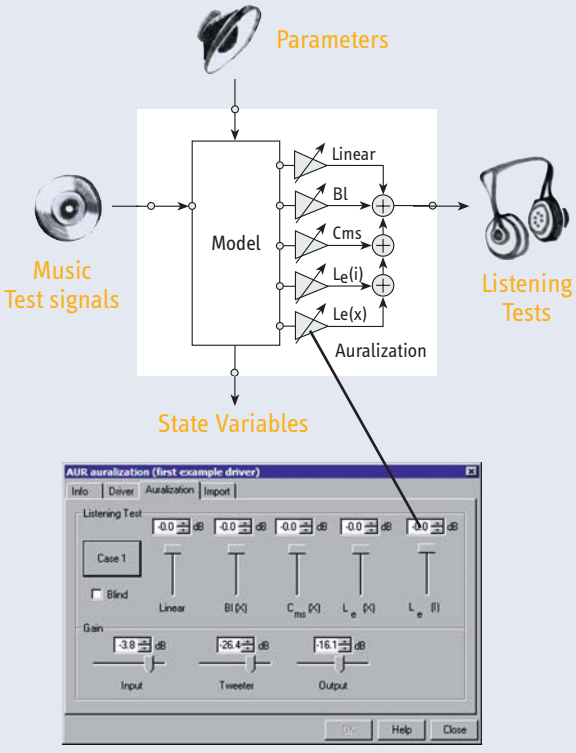


AURALIZATION

Investigate impact on sound quality

- Combine objective and subjective evaluation
- Analyze loudspeakers with music
- Listen to separated distortion components
- Match targets in marketing and engineering

The software module AUR simulates large signal behavior of a transducer for any input signal (music, test signal) in real time. The sound pressure output signal is decomposed into the linear part and nonlinear distortion components generated by motor, suspension and inductance nonlinearity. The user may scale each part separately and compose an output signal which is subject to listening tests. They may be performed as blind AB-comparisons while the amplitude of the distortion components and the state variables (temperature, displacement) are measured objectively.



SIM

AUR

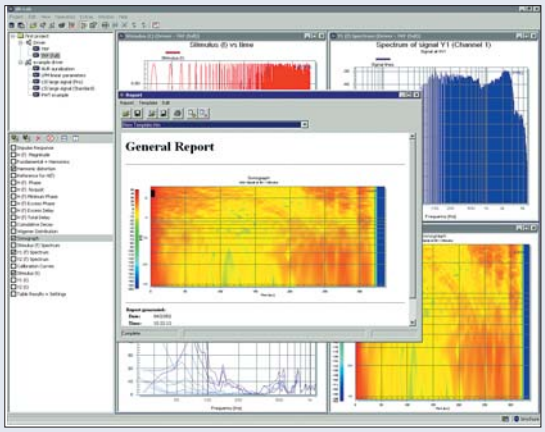
dB-LAB

PROJECT MANAGEMENT SOFTWARE

Manage complex tasks

- Customize all analyzer modules
- Work with the same tool in office, lab, production
- Communicate beyond borders
- Simplify archiving of data

dB Lab provides a common environment used for all modules of the KLIPPEL R&D System. It is the basis for combining measurements, numerical simulations and any kind of post-processing to complex projects which are processed as a batch automatically. The setup parameters and the graphical display of the results can easily be customized and stored as templates for future work. dB Lab provides different ways for visualizing and comparing data and to generate automatic reports based on HTML format customized according to the corporate identity (logo, comments, and additional illustrations). Since dB Lab is also provided as free visualization software, primary data can be easily exchanged between coworkers, suppliers and customers.



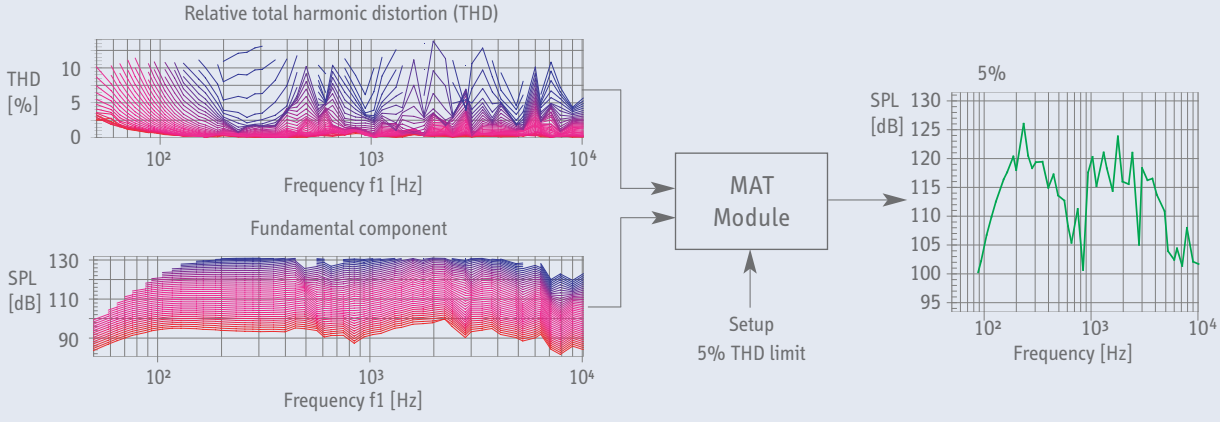
MATLAB

MATH PROCESSING SOFTWARE

Exploit the power of MATLAB and SCILAB

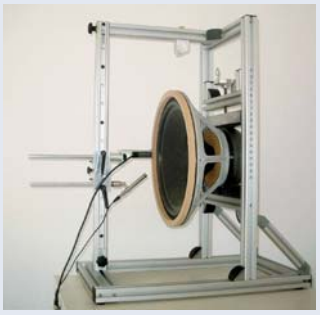
- Write flexible, powerful scripts
- Implement your own ideas
- Hide math in a container
- Create new tools for your team

The MAT module is a programmable tool for realizing mathematical analysis, statistics, graphical display, formatting, exporting and any other kind of post and pre processing. A basic tool box is already provided by KLIPPEL but can easily be extended by using the power of MatLab® or SciLab (available as shareware). After encapsulating the code in the script container, coworkers who are not familiar with the high-level languages may operate the MAT module via a simple-to-use interface.



ACCESSORIES
To complete your system

Driver Stands



Parameter identification and other mechanical or acoustical measurements in the near field require rigid mounting of the transducer in vertical position. The non-magnetic driver stands hold all kinds of transducers and allow easy adjustment of sensors (laser, microphone) in vertical and horizontal position and rotation on two axes.

Microphones

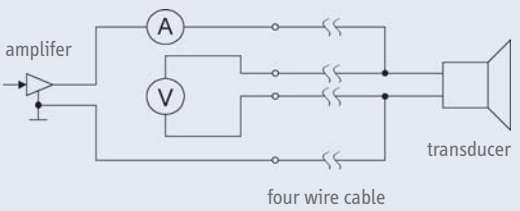
Condenser and electret microphones are provided which are optimal for transducer measurements in research, development and manufacturing. No external power supply is required because ICP or phantom power is provided by Distortion Analyzer DA2.

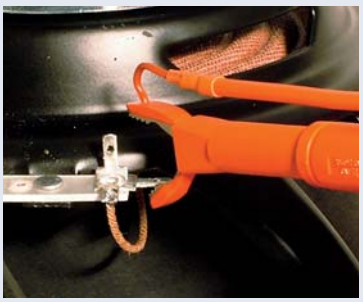
Laser Displacement Sensors

Direct measurement of the mechanical vibration becomes almost as important as acoustical measurements. A variety of sensors based on the laser triangulation principle measure displacement (< 100 mm) from dc to 25 kHz at sufficient signal to noise ratio to calculate linear and nonlinear parameters, measure cone-breakups and check the stability of the transducer. A translation stage supports the fine adjustment of the laser to micro speakers and tweeters.

Cables

The speaker cables and connector clips provide a 4 wire force-sense configuration for voltage pickup directly at the speaker terminal to maintain high precision at high currents in long cables.





KLIPPEL® R&D SYSTEM

Application	Modules	Parts	Driver	System
linear lumped parameters (e.g. T/S Parameters)	LPM, LSI, PWT, SPM	•	•	•
nonlinear lumped parameters (e.g. Bl(x))	LSI, PWT, SPM		•	•
voice coil offset (Bl-symmetry)	LSI		•	•
maximal peak displacement X_{max}	LSI, DIS		•	
thermal parameters	LSI, PWT		•	•
visco-elastic behavior (creep)	LPM, LSI, SPM	•	•	•
material parameters (E modulus, loss factor)	MPM, TRF	•		
electrical impedance	LPM, TRF		•	•
amplitude and phase response (e.g. sensitivity)	TRF, DIS, LPM		•	•
transient analysis (impulse response, decay spectrum)	TRF		•	•
harmonic distortion (n^{th}-order, THD, THDN)	TRF, DIS, SIM		•	•
intermodulation distortion	DIS, SIM		•	•
AM distortion	DIS-PRO, SIM		•	•
multi-tone distortion	LPM		•	•
distortion analysis (contribution from Bl(x), Cms(x), Le(x), Le(i))	LSI, AUR		•	•
rub & buzz (crest factor of harmonic distortion)	TRF		•	•
HI-2 (weighted harmonics)	DIS		•	•
instability (e.g. dynamic dc displacement)	DIS, SIM, TRF, LSI, AUR		•	•
listening test	AUR			
amplitude compression (thermal & nonlinear)	DIS, LSI, PWT, SIM		•	•
vibration of cone, diaphragm, enclosure	SCA, TRF		•	•
temperature of coil and magnet	LSI, PWT, SIM		•	•
accelerated life test, environmental test (power test)	PWT		•	•

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