Measurement Service M1

KLIPPEL R&D SYSTEM (Document Revision 1.4)

KLIPPEL is not liable for any damage or destruction of loudspeaker samples during measurement or transportation. The customer takes the risk.

HOW IT WORKS

WHAT WE NEED	• Choose from the tasks offered the measurements you need for your transducers or ask us what measurements are recommended to fulfill your requirements. • Please instruct us about the time and way of shipping the devices for testing and returning them to you. • Let us know whether we have to handle the data confidential. • Send the devices for testing via parcel service to KLIPPEL's address in Dresden. • For devices with OEM connectors please send counterparts or adapters to 4mm lab connectors or open wire ends. • Specifications or any information about the desired application of the device are welcome to define test levels and signals. • For laser measurements the diaphragm cover must be accessible. In some cases the cover has to be removed. • For 1. T/S Parameter and 2. Nonlinear Parameter we need direct connection to the voice coil without filter / capacitor. Make sure that a capacitor can be bridged or add a sample without capacitor. For all other measurements you can choose if we should measure with or without filtering.
WHAT YOU GET FROM US	• We will send you the results of the measurements as a written report in pdf-format. • You will also receive the whole measurement database for your own analysis. We will provide you with dB-Lab viewer software so that you can visualize the results and export the data in many formats to other applications. This also applies to the result of the cone vibration and geometry measurement. You may download the cone vibration analysis software from our website and may analyze the vibration and the radiation into the 3D space at any frequency you like. You are allowed to distribute the data and viewer software to any third person such as subcontractor, customer or supplier.

CONTENT

1 T/S Parameter Measurement

	Article: 3000- 010
Modules used	Linear Parameter Measurement (LPM)
Method	The software module Linear Parameter Measurement (LPM) measures the linear parameters at low signal amplitudes. A one-step measurement is performed by fitting both in electrical impedance and displacement response. Problems associated with the adjustment of a mass and leakage in diaphragm or test enclosure are avoided. Operation of the driver in the small-signal domain is ensured by measuring the distortion and the noise floor in displacement, current and radiated sound pressure.
Results	A report on the measurement will be generated containing an introduction to the measurement, measurement conditions used and the following parameters • Linear parameters in the small signal domain • Creep parameter describing loss of stiffness of suspension at low frequencies
Target	This measurement provides you with the small signal parameters that are the basis for the specification of the driver.

2 Nonlinear Measurement

2a Nonlinear Parameter Measurement	**Article: 3000- 020**
Modules used	Large Signal Identification (LSI)
Method	The software Large Signal Identification (LSI) measures the parameters and state variables at high amplitudes up to the limits of the driver. Full protection is provided by calculating accessible voice coil peak displacement Xmax automatically.
Results	A report on the measurement will be generated containing an introduction to the measurement, measurement conditions used and the following parameters • Nonlinear parameters versus displacement such as Bl(x), Cms(x), Le(x) • Parameters at the rest position when driver operated in large signal domain • Parameter variations versus time • Maximal output (maximal displacement) • Symmetry point of nonlinear Bl(x) and Cms(x) curve and state variables monitored during measurement: • Peak and bottom value of voice coil displacement • Instantaneous voice coil temperature • Electrical input signals (voltage, current, real power) • Voice coil temperature • Thermal power compression • Nonlinear distortion in audio-signal • Contribution from each nonlinearity (distortion analysis)
Target	This measurement provides the large signal parameters that are the basis for understanding the physical causes of distortion and for performing a detailed diagnostic of the driver.

2b Nonlinear + Thermal Parameter Measurement		Article: 3000- 021
Modules used	Large Signal Identification (LSI) Simulation (SIM)	
Method	The software Large Signal Identification (LSI) measures the nonlinear and thermal parameters and state variables at high amplitudes. The protection parameter (maximal input power, temperature, nonlinearities) provide mechanical and thermal protection of the device under test. The nonlinear and thermal parameters are exported to the Large Signal Simulation Module (SIM) and the thermal performance is calculated for a single tone stimulus.	
Results	A first report on the LSI measurement will be generated containing an introduction to the measurement, measurement conditions used and the following parameters All nonlinear parameters and state information as listed in 2a Nonlinear Parameter Measurement (Article 3000-020) • Thermal resistance Rtv between voice coil and magnet system • Thermal resistance Rtm between magnet system and ambience • Thermal capacity Ctv of the voice coil • Thermal capacity Ctm of the magnetic system • Thermal time constant TAUtv of the voice coil • Thermal time constant TAUtm of the magnetic system • Air convection parameter rv A second report on the SIM simulation shows • Voice coil temperature in thermal steady state • Magnet temperature in thermal steady state • Bypass factor describing the fraction of power which will bypass the voice coil due to convection cooling and eddy current heating in the pole tips which will not increase the voice coil temperature	
Target	This measurement provides you with the large signal parameters that are the basis for understanding the nonlinear and thermal causes, which limit the maximal output and generate signal distortion. This information has high diagnostic value and is the basis for developing design choices.	

3 Displacement vs. voltage + frequency

	Article 3000 - 030
Modules used	3D Distortion Measurement (DIS)
Method	The behavior of the speaker (driver or system) is evaluated in the full working range by using a single tone versus frequency measured at four amplitude linearly spaced. The speaker is protected against thermal and mechanical overload by the increase of the voice coil temperature compared with user-defined limits. Analysis of the measured displacement shows the amplitude of the fundamental, and DC part of the displacement versus frequency and amplitude.

Results	A report on the measurement will be generated containing an introduction to the measurement, measurement conditions used and the following results • Fundamental component versus both frequency and amplitude • Peak and bottom displacement • Compression of the fundamental component • DC-component in displacement
Target	Objective assessment of the speaker with emphasis on symptoms and effects in the large signal domain such as • Maximal output of fundamental component • Amplitude Compression of the fundamental due to driver nonlinearities • Stability of the speaker impaired by speaker nonlinearities • Dominant causes of 2^{nd}-order distortion

4 Distortions

	Article 3000 - 040
Modules used	3D Distortion Measurement (DIS) Transfer Function module (TRF) Linear Parameter Measurement (LPM)
Method	The behavior of the speaker (driver or system) is evaluated in the full working range by using a single tone sweep, two-tone complex (bass tone sweep + constant voice tone and voice tone sweep + constant bas tone) and multi-tone stimulus. The speaker is protected against thermal and mechanical overload by monitoring the harmonic distortion in the sound pressure and the increased voice coil temperature compared with user-defined limits. The radiated sound pressure in the near field of the speaker. Analysis reveals harmonic and intermodulation distortions which represent most critical test stimuli having a sparse or complex spectrum such as music.
Results	Three reports are generated which contain the measured data and a short introduction to the measurement, measurement conditions. a) Results of the TRF measurement using the single tone sweep • Fundamental SPL component versus frequency • Harmonic Distortion in radiated sound pressure versus frequency and amplitude • Equivalent input distortion, transformed from the sound pressure to the input voltage b) Results of the DIS measurement using the two tone complex • Total intermodulation distortion to assess the motor and radiation distortion • Difference and summed-tone distortion versus frequency c) Results of the LPM measurement using the multi-tone stimulus • Distortion pattern in sound pressure representing the effect of all nonlinearities • Distortion pattern in electrical input current representing the effect of nonlinear inductance
Target	• Comprehensive assessment of the loudspeaker performance in the large signal domain • Relationship between nonlinear symptoms (distortion) and physical causes (regular nonlinearities) related to design of the motor and suspension system • Verification of the nonlinear parameters

5 Rub & Buzz Analysis

	Article 3000 - 050
Modules used	Transfer Function module (TRF-Pro)
Method	A single tone sweep is used to measure complex harmonic distortion (magnitude + phase) and to derive the impulsive components in the time domain by considering higher-order component (n>20). The crest factor of the higher-order harmonics is calculated and plotted versus frequency and instantaneous voice coil displacement. A crest factor exceeding a limit of 10 - 12 dB indicates impulsive distortion which is a reliable indicator for rub and buzz, loose particles, air leakage and other defects. A series of measurements starting at very small amplitudes (20 dB below the maximal voltage) and increased by 1 dB is performed to determine the voltage when the first impulsive distortions are detected.
Results	• Crest factor versus voice frequency and displacement • Time signal of the sound pressure signal and impulsive distortion
Target	This measurement reveals • Maximal input voltage and the maximal SPL output • Causes of impulsive distortion (rubbing coil, limiting, air leaks give a typical pattern) • Conditions generating impulsive distortion (position of the coil, voltage, frequency)

6 Measurement of Cone Vibration + Geometry

	Article 3000 - 060
DUT	Drive units and loudspeaker systems (woofers, tweeters, headphones, microspeakers) according specification of C5- Scanning Vibrometer, Note: Cones made of porous and transparent material require coating of the scanned surface
Modules used	SCN Cone Scanning hardware and SCN Vibration Analysis Software
Method	The **SCN Scanning Hardware** uses a turntable with two additional linear actuators and an control hardware to scan the target surface in polar coordinates and to measure the vibration (displacement) and geometry of the scanned surface (3000 points). The **SCN Analysis Software** is supplied with the measured vibration data and the cone geometry to perform visualization, animation of the mechanical vibration and the prediction of the sound pressure output at any point in half-space sound field. Novel decomposition techniques show radial and circular modes and vibrations components related with the SPL output. It is the target of the analysis to provide a better understanding of the interaction between vibration and radiation.
Input Information	The customer has to provide some input information on the target application: • frequency range band (upper frequency limit) • flatness of the on-axis response

Results	The customer receives a database and the SCN Analysis Software to view the measured vibration data, analyze the modes of vibration and to see the impact on the sound pressure output. The following data are presented: • Amplitude displacement transfer function • 3D Vibration Animation (Cone Surface) • 2D Vibration Animation (Cone Profile at φ) • Geometry of target surface • SPL response of total component • Directivity plot • SPL response of in-phase component (producing sound) • SPL response of anti-phase component (reducing sound output) • SPL response of radial mode (crucial for sound pressure output) • SPL response of circular mode (indicates rocking modes) In addition to that he receives a report showing • List of critical frequencies (failing the target application and causing irregular behavior) • Comments to the physical mechanisms at the critical frequency • Recommendations for improvements (if possible)
Target	The measurement and analysis gives essential clues about the interaction between mechanical vibration and acoustical radiation. For example, it shows the physical cause (a mechanical or acoustical problem) for irregularities (dips and peaks) in the sound pressure response at a point in the 3D sound field. Most of the regular behavior can also be predicted by using Finite Element Analysis and material parameters. The analysis also shows irregular vibration behavior (rocking modes, circular or partial break up modes) which are caused by irregularities in the cone (thickness, density), the effect of wires and suspension and acoustical environment (air flow in a small enclosure). The irregular behavior may cause Rub & Buzz defects and excessive distortion at particular frequencies where the mechanical vibration is high but the acoustical output is low. • Fast access the critical frequencies • Better understanding the physical mechanisms • Indications for practical improvements • Support and training in using the SCN Analysis software

7 Prediction of System Behavior

	Article 3000 - 070
Modules used	Simulation (SIM)
Requirement	• Large Signal Parameters provided by customer or available from Driver Parameter Measurement (Art. 3000 – 001) • enclosure parameters (port resonance, size, volume, loss factor describing leakage and nonlinear flow resistance of port if available)
Method	Using the Simulation module a prediction of the large signal behavior of the complete system (driver mounted in enclosure) is performed using the large signal parameters. The simulation uses the same single-tone and two-tone stimulus as the 3D distortion measurement and provides comparable results. The results are interpreted with respect to dominant cause of distortion, limiting factors of output amplitude and compression effects.

	The performance of the final loudspeaker system may be predicted up to very high amplitudes even before the first prototype is finished. The prediction is based on the large signal parameters of the driver and may consider additional specification of the final loudspeaker system provided by you: • Standard enclosures such as closed-box, vented-box and band pass system or driver mounted in free air or baffle • Considering the driver nonlinearities (Bl(x)-product, Cms(x), L(x)) • Acoustical nonlinearities (port turbulences, adiabatic compression and radiation) • Heating of the driver (cold, short-term coil equilibrium, steady-state coil/magnet/frame) • Initial conditions (Temperature, displacement) • Two-tone signal varied versus amplitude and frequency
Results	The measurement report provided comprises the following results • Amplitude of the Spectral Component versus both frequency and amplitude • Representation of the results as a 3D- or 2D plot with multiple curves • Harmonic Distortion in radiated sound pressure versus frequency • Intermodulation distortion to assess the motor and radiation distortion • Amplitude of fundamental component in sound pressure and voice coil displacement to assess the maximal output • Stability of the system expressed by DC-component due to motor asymmetry or port geometry
Target	Selection of the optimal driver for the particular application. Optimization of the size of enclosure and ports considering the generation of air turbulence and jet stream.

8 Power Test

	Article 3000 - 080
Modules used	Power Test (PWT)
Requirement	Customer must specify signal type, signal settings, duration, On/Off-cycles, voltage stepping…
Method	The power test module PWT is used to generate a stimulus such as noise, sweeps, tones according to various standards and to realize a desired voltage profile (stepping in dB steps) and ON/OFF cycling at the speaker terminals. Using voltage and current monitoring at the speaker terminals the instantaneous state of the loudspeaker (voice coil temperature, power, voltage, displacement) and important loudspeaker parameters (resistance, loss factors, resonance frequency, nonlinear parameters) are measured and recorded over time.
Results	A report on the measurement will be generated containing an introduction to the measurement, measurement conditions used and the following parameters • Nonlinear parameters versus displacement such as Bl(x), Cms(x), Le(x) • Parameters at the rest position when driver operated in large signal domain • Parameter variations versus time • Maximal output (maximal displacement) • Symmetry point of nonlinear Bl(x) and Cms(x) curve and state variables monitored during measurement: • Peak and bottom value of voice coil displacement • Instantaneous voice coil temperature

	• Electrical input signals (voltage, current, real power) • Voice coil temperature • Thermal power compression • Nonlinear distortion in audio-signal Contribution from each nonlinearity (distortion analysis)
Target	Long-term monitoring of the loudspeaker performance while using a stimulus which is typical for the final application.

9 Measurement of Suspension Parts

	Article 3000 – 007
DUT	**Standard Suspension Parts:** The measurement can be performed at suspension parts such as spiders, cones with surrounds and passive radiators with a Diameter < 9 inch **Micro Suspension Parts:** Measurement can be performed on small (<45mm) non-porous diaphragms such as micro-speaker diaphragms, Headphone diaphragms, Tweeter diaphragms or Microphone diaphragms. Diaphragms must be glued into a stiff panel as described in Specification MSPM Bench A12.
Modules used	Transfer Function Module (TRF) SPM Bench + Software (SPM) Optional: MSPM Bench + Software (MSPM)
Method	The nonlinear stiffness K(x) and the reciprocal compliance C(x) of any suspension parts (spider, surrounds, cones) and passive radiators (drones) are measured versus displacement x over the full range of operation. A dynamic, nondestructive technique is developed which measures the parts under similar condition as operated in the loudspeaker. This guarantees highest precision of the results as well as simple handling and short measurement time. Suspension parts are fixed in the measurement bench by using a universal set of clamping parts (rings, cones, cups) fitting to any size of circular geometries between 1.5 - 9 inch diameter. The working bench excites pneumatically the suspension to vibration at the resonance frequency related to the stiffness and the mass of the suspension and inner clamping parts. The nonlinear stiffness is calculated from the measured displacement (ONE-SIGNAL-METHOD) by using modules of the KLIPPEL Analyzer System. The measured parameter is required for specifying the large signal properties of the suspension parts and to detect asymmetrical and symmetrical variation which are the cause for instable vibration behavior and nonlinear distortion.
Results	A report on the measurement will be generated containing an introduction to the measurement, measurement conditions used and the following results • effective Stiffness K_{eff} and Compliance C_{eff} measured at small amplitudes (< 1mm) • nonlinear Stiffness K(x) and nonlinear compliance C(x) measured in the medium working range $-x_{peak}/2 < x < x_{peak}/2$ • nonlinear Stiffness K(x) and nonlinear compliance C(x) measured over the full working range $-x_{peak} < x < x_{peak}$
Target	Objective assessment of the suspension part with emphasis on symptoms and effects in the large signal domain such as • variation of stiffness versus displacement • dependency of stiffness on peak displacement X_{peak}

	• revealing effects of visco-elasticity

10 Measurement of Material Parameters

	Article 3000-008
Samples	Any material (paper, rubber, fabric, plastic, other composite materials) should be provided as thin foils of homogenous material (10 mm wide and 60 mm long). Exact density and thickness must be provided for the material
Additional Input Information	It is recommended to provide the data about density and thickness of the samples. Those parameters should be determined by measuring a larger piece of the sample.
Modules used	Material Parameter Measurement Module (MAT) Transfer Function Module (TRF)
Method	A sample of the material is clamped as a beam in vertical direction (hanging) and excited pneumatically to the fundamental resonance. The transfer function between sound pressure inside the test enclosure (proportional to the driving force) and the displacement is measured by using a laser sensor and a microphone. The resonance frequency and the Q factor is derived from the transfer function and is the calculation for Young's E modulus and the loss factor.
Results	• Young's E-modulus • loss factor η under the following conditions • resonance frequency f_s • relative humidity • ambient temperature T_a
Target	The material parameters are the basis for numerical prediction of mechanical vibrations using finite element analysis (FEA). The parameters simplify the communication between driver and cone manufacturer and may be used to assess the consistency of the material parameters (Quality Control).

11 Near Field Scanning

	Article 3000-090
Samples	Any Loudspeaker systems. For handling reasons, systems may not exceed the physical dimensions of 40cm (length, height or width) and weight of 25kg.
Additional Input Information	It is recommended to provide information about the desired • Measurement bandwidth • Frequency resolution of the result data.
Modules used	Near Field Scanner 3D (NFS) Transfer Function Module (TRF)
Method	The Near-Field Scanner 3D (NFS) uses a moving microphone to scan the sound pressure in the near field of a compact sound source such as a loudspeaker. The device under test does not move during the scanning process. The reflections in the non-anechoic environment are then consistent and can be monitored with our novel analysis software, which uses acoustical holography and field separation techniques to

	extract the direct sound and to reduce room reflections.
Results	• Directivity in near / far field • Frequency Response at any point in 3D space • Balloon / Polar plot • Contour Plot • Power response • Near Field SPL distribution • Near Field Wave Propagation
Target	The objective of this measurement is the easy and reliable measurement of directivity and sound pressure in any distance. Traditionally such measurements are done in far field under anechoic conditions. The new method of holographic sound field expansion characterizes the complete sound field (near and far field) with a simple set of parameters. This set of parameters can be identified by a measurement in near field.

12 B-Field Scanning

	Article 3000-009
Samples	Any loudspeaker magnet system with round coil shape and following size limitations: Min. voice coil gap width depends on diameter of the coil, due to the rectangle shape of the B-Field sensor, which has to be moved thru the gap. • Min. voice coil gap width = 0.65 mm (sensor thickness) • Min. voice coil gap width at 40mm coil diameter = 0.75 mm • Min. voice coil gap width at 20mm coil diameter = 0.8 mm • Min. voice coil gap width at 10mm coil diameter = 0.9 mm • Max. voice coil height = 80mm For more information see BFS-Sensor specification A11.
Additional Input Information	It is recommended to provide information about the related voice coil, for the Bl calculation. Voice coil parameters could be modified afterwards as post-processing. • r = radius of the voice coil • d = diameter of the voice coil wire (not needed if W is defined) • h = height of the voice coil • N = number of voice coil layers • W = number of voice coil turns • coil_restposition = defines the rest position of the voice coil when mounted in the magnetic gap relative to the origin of BFS measurement (defines the zero position of the Bl(x) curve)
Modules used	B-Field Scanner (BFS) Scanning Vibrometer (SCN) Transfer Function Module (TRF)
Method	The B-Field Scanner (BFS) uses a turn table to rotate the DUT (magnet system) and measures the B-Field strength at specified grid positions with variable angle (phi) and

	height (z).
Results	• measured magnetic flux density over height B(z) • measured variation of flux density over the angle ΔB(phi) • calculated force factor over coil displacement Bl(x) • calculated variation of force factor over angle ΔBl(x, phi) • 3D-plot of flux density over height and angle B(phi, z) •
Target	Measuring the magnet system itself without mounted soft parts allow to find inhomogeneous field distribution, which could cause undesired behavior at the final speaker. It allows to verify the simulated and desired material properties. Results can be compared to the dynamically measured Bl(x) at the final speaker.

Find explanations for symbols at:

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

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