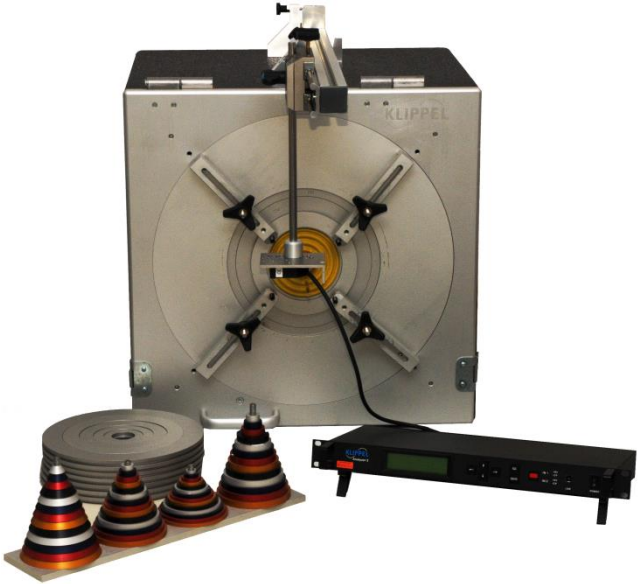


FEATURES	APPLICATION
<ul style="list-style-type: none">• Linear and nonlinear stiffness $K_{ms}(x)$• Spiders, surround, cones• Passive radiators (drones)• Size from 1 – 8 inch• Nondestructive, dynamic method• Fast, robust, simple handling	<ul style="list-style-type: none">• Specification of suspension parts• Analysis of cause of distortion• Defining mechanical limits• Quality control in manufacturing• Optimal driver design in R&D

The nonlinear stiffness $K(x)$ and the reciprocal compliance $C(x)$ of 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 set of clamping parts (rings, cones, cups) fitting to any size of circular geometries up to 222 mm 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 by the measured displacement (one-signal-method) by using modules of the KLIPPEL Analyzer System [1]. The measured parameter is required to specify the large signal properties of the suspension parts and to detect asymmetrical and symmetrical variations, which are the cause for instable vibration behavior and nonlinear distortion.



Additionally, the SPM Pro software includes the SPM Lite software, which calculates linear mechanical parameters of suspension parts and passive radiators (resonance frequency, Q-factor, stiffness, moving mass, mechanical resistance), accurately from the small signal displacement and sound pressure response.

Article Number:	2500-102 (incl. 2500-103)
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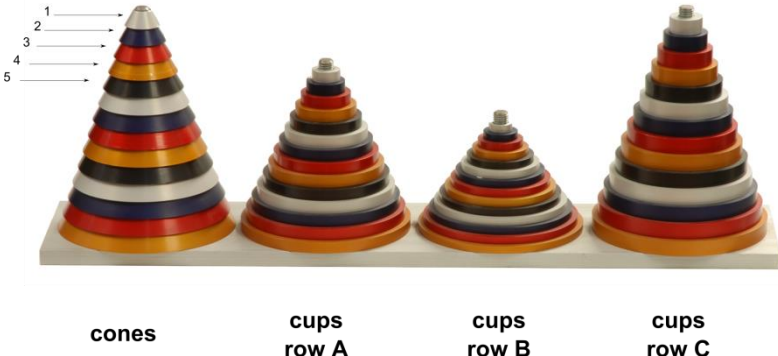
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1 Accessories for SPM Pro

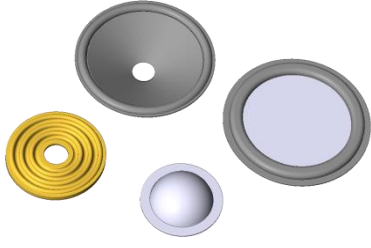
<p>SPM Pro Bench (Art. #:2500-101)</p>	<p>The measurement bench consists of the clamping platform mounted on a sealed enclosure of 95-liter volume and a linear, long throw 18” driver which excites the suspension pneumatically. The clamping platform holds the high-polished center rod for guiding the inner clamping parts (slide, cup, cone and nuts), the fixture for clamping the outer rim by using rings and the laser stand. The clamping platform can easily be folded up in a horizontal position for charging but is used in a vertical position during measurement. The set contains the cable for connecting the measurement bench to Klippel measurement hardware.</p>	
<p>SPM Pro Software incl. SPM Lite Software (Art. #: 2500-102 incl. 2500-103)</p>	<p>A special Suspension Part Measurement Software for measuring the nonlinear stiffness using the one-signal method 0</p> <p>Additionally, a special CAL Script is provided to calculate linear suspension parameters accurately from the small signal response using the two-signal method 0.</p>	
<p>Ring Set (Art. #: 2500-302)</p>	<p>Multiple sets of clamping rings allow the attachment of almost all suspension parts with a circular geometry between 2 and app. 9 inch. After measuring the outer diameter and the width of the rim, the lower ring set and the upper clamping ring can be easily identified by using a table and nomenclature. The rings are made of 10 mm aluminum. Subsets of rings (to cover only selected sizes) or special forms (elliptic sizes) are available on request.</p>	

<p>Cup & Cone Set (metal) (Art. #: 2500-111)</p>	<p>The cone is used for clamping the inner rim of the suspension part nondestructively. Multiple cones are organized in a set with a simple nomenclature to cover from 14 - 111 mm diameters. Single cones are available on request.</p> <p>The counterpart of the cone is the cup which clamps the inner rim. The cups are manufactured in multiple sets to give the user full flexibility over all sizes of suspension parts. Cup Set row A, row B and row C are included in the set. Special cups can be manufactured based on customer's specification.</p> 
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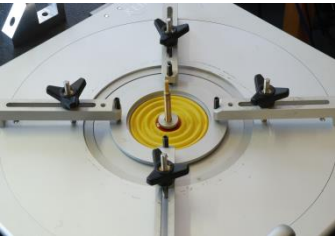

2 Additional Components required

<p>Measurement Platform</p>	<p>The Distortion Analyzer 1 or 2, or the Klippel Analyzer 3 may be used as the hardware to control the laser head and to perform the measurement.</p> <p>Note: If you are using a Klippel Analyzer 3, an additional license dongle will be provided.</p>	
<p>Sensor</p>	<p>A displacement laser, which is usually available as standard equipment of the KLIPPEL R&D System measures the displacement of suspension at the required precision. Due to high displacements, the sensors have to have a large linear working range. Recommended types are:</p> <ul style="list-style-type: none"> • ANR 1282 plus Controller ANR5132 (discontinued) • LK-H082 plus Controller LK-G5001P 	
<p>Software</p>	<p>The Suspension part measurement also uses software modules of the KLIPPEL R&D System such as the frame software <i>dB-Lab</i> and the Transfer Function Module <i>TRF</i></p>	
<p>Amplifier</p>	<p>A power amplifier is required for performing the measurement. The amplifier should provide more than 200 W output power at 4 Ohm.</p>	
<p>Microphone (opt.)</p>	<p>A quarter inch microphone is required for the linear suspension parameter measurement (SPM Lite) only to measure the sound pressure in the test bench.</p>	
<p>Computer</p>	<p>A personal computer (not available from KLIPPEL) is required for performing the measurement.</p>	

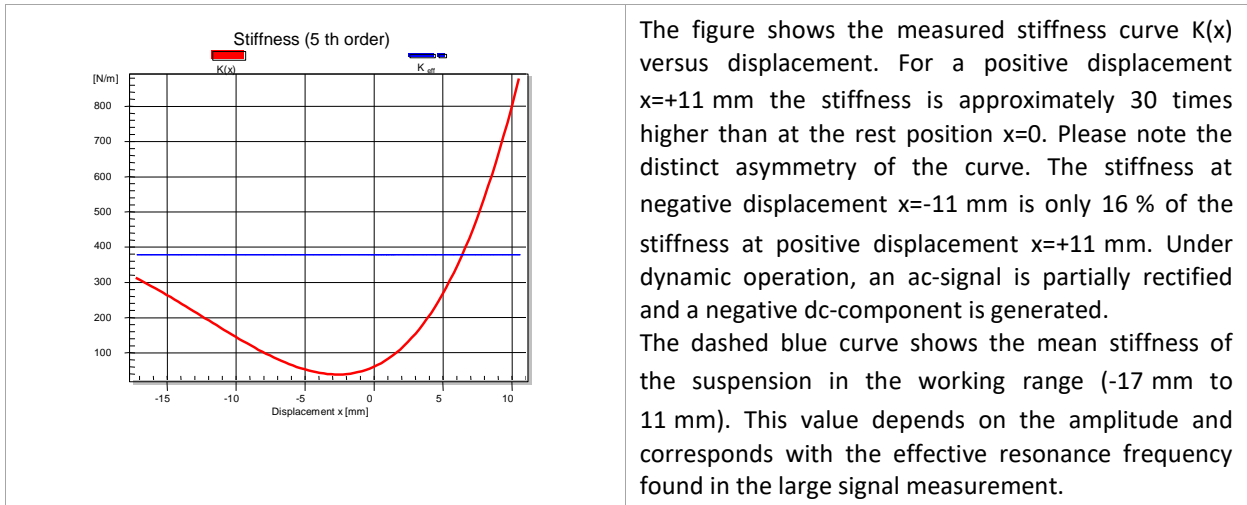
3 Objects

	<p>Suspension parts (spiders, suspensions, cone with suspensions) and passive radiators of circular geometries with a diameter up to 222 mm can be measured by using the small clamping set (rings, cups, cones). For particular objects with more complicated curvatures, unusual sizes or extremely small rims special clamping parts can be manufactured on customer's request. KLIPPEL may provide service based on detailed drawings.</p> <p>Although the suspension is pneumatically excited, the technique used can cope with significant air porosity of the suspension.</p>
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4 Measurement Procedure

<p>Centre Clamping</p>	<p>The measurement usually takes 5-10 minutes by performing the following steps:</p> 	<ol style="list-style-type: none"> 1) Measure the inner and outer diameter 2) Look at the tables to find the optimal clamping parts using the nomenclature 3) Clamp the inner rim by using the slide, cone, cup and two nuts.
<p>Outer Clamping</p>		<ol style="list-style-type: none"> 1) Bring the clamping platform into horizontal position for easy handling 2) Insert the set of lower rings into the clamping platform 3) Put the slide with the clamped suspension on the guiding rod 4) Fix the upper ring to clamp the outer rim 5) Bring the clamping platform into vertical position
<p>Measurement</p>		<ol style="list-style-type: none"> 1) Fold down the laser rack and adjust the laser head 2) Start the measurement which takes a few seconds 3) Calculate the nonlinear stiffness 4) Print your report by using your customized template

5 Results



6 Look up tables for small clamping set:

Color	Number of the cone	Cone diameter D_c (mm)	Name of the cup	Cup diameter D_u (mm)
silver	1	11	A1	13,9
			B1	16,8
			C1	19,7
blue	2	18	A2	20,9
			B2	23,8
			C2	26,7
red	3	25	A3	27,9
			B3	30,8
			C3	33,7
gold	4	32	A4	34,9
			B4	37,8
			C4	40,7
black	5	39	A5	41,9
			B5	44,8
			C5	47,7
silver	6	46	A6	48,9
			B6	51,8
			C6	54,7
blue	7	53	A7	55,9
			B7	58,8
			C7	61,7
red	8	60	A8	62,9
			B8	65,8
			C8	68,7
gold	9	67	A9	69,9
			B9	72,8
			C9	75,7
black	10	74	A10	76,9
			B10	79,8
			C10	82,7
silver	11	81	A11	83,9
			B11	86,8
			C11	89,7
blue	12	88	A12	90,9
			B12	93,8
			C12	96,7

Name of the ring	D_R (mm)
A1	30
B1	33
C1	36
D1	39
E1	42
F1	45
G1	48
H1	51
A2	54
B2	57
C2	61
D2	65
E2	69
F2	73
G2	77
H2	81
A3	85
B3	89
C3	93
D3	98
E3	103
F3	108
G3	113
H3	118
A4	124
B4	130
C4	136
D4	142
E4	148
F4	154
G4	160
H4	166
A5	173
B5	180
C5	187
D5	194

Suspension Part Measurement Pro

C2

red	13	95	A13	97,9
			B13	100,8
			C13	103,7
gold	14	102	A14	104,9
			B14	107,8
			C14	110,7

E5	201
F5	208
G5	215
H5	222

7 SPM Pro Bench Specification

7.1 Specification for revision 1.4 and below

Physical Dimensions (LxWxH)		
Dimensions of Bench only in mm	470x570x570	
Maximum Dimensions of Bench with attachments in mm	790x720x690	
Maximum/Minimum Ratings		
Parameter	Minimum	Maximum
Driver Nominal Impedance in Ω	4	
Driver Excursion (peak-to-peak) in mm		75
Driver Voltage in V rms (Sinusoidal Stimulus, Long Term)		60
Driver Voltage in V rms (Sinusoidal Stimulus, Short Term)		120
Driver Voltage in V rms (Multitone Stimulus)		35

Driver used: AuraSound NS18-992-4A

Possible replacement driver: FaitalPro 18XL1800 (04604223)

7.2 Specification for revision 1.5

Physical Dimensions (LxWxH)		
Dimensions of Bench only in mm	500x570x570	
Maximum Dimensions of Bench with attachments in mm	940x720x790	
Maximum/Minimum Ratings		
Parameter	Minimum	Maximum
Driver Nominal Impedance in Ω	4	
Driver Excursion (peak-to-peak) in mm		75
Driver Voltage in V rms (Sinusoidal Stimulus, Long Term)		60
Driver Voltage in V rms (Sinusoidal Stimulus, Short Term)		120
Driver Voltage in V rms (Multitone Stimulus)		35

Driver used: AuraSound NS18-992-4A

Possible replacement driver: FaitalPro 18XL1800 (04604223)

7.3 Specification for revision 1.6 and above

Physical Dimensions (LxWxH)		
Dimensions of Bench only in mm	500x570x570	
Maximum Dimensions of Bench with attachments in mm	940x720x790	
Maximum/Minimum Ratings		
Parameter	Minimum	Maximum
Driver Nominal Impedance in Ω	8	
Driver Excursion (peak-to-peak) in mm		72
Driver Voltage in V rms (Sinusoidal Stimulus, Long Term)		100
Driver Voltage in V rms (Sinusoidal Stimulus, Short Term)		140
Driver Voltage in V rms (Multitone Stimulus)		40

Driver used: FaitalPro 18XL1800 (04604223)

8 References

W. Klippel, "Dynamical Measurement of Loudspeaker Suspension Parts", Convention Paper, 117th AES Convention, October 2004, San Francisco

C7 – Suspension Part Measurement Lite, product specification

9 Patents

GERMANY	102007005070
USA	8,078,433
CHINA	ZL200810092055.4
JAPAN	5364271

Find explanations for symbols at:

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

Last updated: May 02, 2018



KLIPPEL MODULE OVERVIEW FOR MOVING PARTS MEASUREMENT



	SPM Lite	SPM Pro	MSPM Lite	MSPM Pro	QC LST Lite	QC LST Pro
R&D System	✓		✓		✓ ⁵⁾	
QC System	-		-		QC Basic or Standard	
Base Module	TRF		TRF	LPM	-	
Analyzer Hardware	Distortion Analyzer 2 Klippel Analyzer 3 ⁵⁾		Distortion Analyzer 2 Klippel Analyzer 3 ⁵⁾		QC Production Analyzer Klippel Analyzer 3 ⁵⁾	
Test Bench	SPM or LST	SPM	MSPM ⁶⁾		LST or SPM ⁷⁾	
Laser Sensor (Default) (Measurement Range)	IL-030 (+/- 12.5 mm)	LK-H082 (+/- 18 mm)	LK-H052 (+/- 10 mm)		IL-030 or IL-065 (+/- 10 mm or +/- 20 mm)	
Laser Sensors (Alternative) (Measurement Range)	LK-H022 LK-H052 LK-H082 LK-H152 LK-G32	LK-H052 (+/- 10 mm) LK-H152 (+/- 40 mm)	LK-H022 (+/- 3 mm) LK-H082 (+/- 18 mm) LK-G32 (+/- 5 mm)		LK-H022 LK-H052 LK-H082 LK-H152 LK-G32	
Microphone	✓	-	✓		Opt.	✓
Linear Parameters f_0, Q, k, c, m, r	✓	- (only k_{eff})	✓ (only effective)		✓ (m import, no r)	✓ (m & k relative, no r)
Nonlinear Parameters $K(x), C(x)$	-	✓	-	✓	-	
Mass Import	✓	-	✓		✓	
Added Mass	✓	-	✓	-	-	
DUT \varnothing in mm	30 – 222 ¹⁾ (490 ²⁾)	30 – 222 ¹⁾	< 70		30 – 222 ¹⁾ (490 ²⁾)	
Frequency Range in Hz	1 – 100 ⁴⁾ (200 ³⁾)	1 – 100	100 - 2500		1 – 100 ⁴⁾ (200 ³⁾)	

1) Standard Ring Set

2) SPM Bench (with custom ring)

3) LST Bench

4) SPM Bench

5) Min. dB-Lab Release 210

6) MSPM Bench requires additional equipment for laser positioning (SCN Vibrometer, LST-Bench or Pro-Stand)

7) For DUTs with $\varnothing \geq 222$ mm / ≤ 490 mm, customized clamping rings required