Suspension Part Measurement Set **C2**

KLIPPEL ANALYZER SYSTEM

FEATURES	APPLICATION
• Nonlinear stiffness $K_{ms}(x)$	• Specification of suspension parts
• Spiders, surround, cones	• Analysis of cause of distortion
• Passive radiators (drones)	• Defining mechanical limits
• Size from 1 – 8 inch	• Quality control in manufacturing
• Nondestructive, dynamic method	• Optimal driver design in R&D
• Fast, robust, simple handling	

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 from the measured displacement (one-signal-method) by using modules of the KLIPPEL Analyzer System [*1*]. 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.

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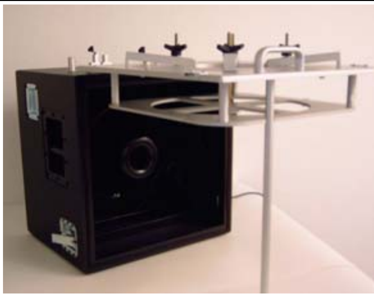
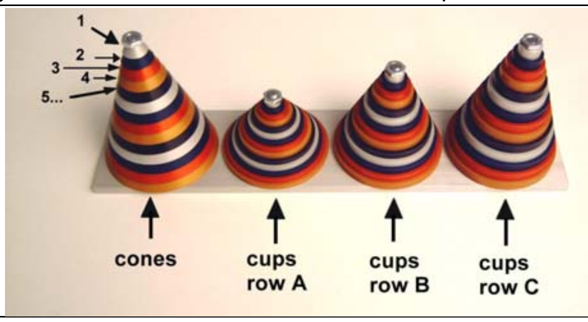
Components of SPM Set

Bench	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 centre 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 put up in a horizontal position for charging but is used in a vertical position during measurement. The set consists the cable for connecting the measurement bench to Klippel Distortion Analyzer. 
Software	A special Suspension Part Software SPM (one-signal method) [*1*] for measurement parts up to 222 mm is included in SPM Set.

Small clamping set

Small Ring Set	 Multiple sets of clamping rings allow to hold 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 easily be 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) may be provided on customer request.
Cone Set	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 of cones may be provided on customer request.
Cup Set	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 Small clamping set. Special cups may be manufactured based on customer’s specification.



additional Components required

Measurement Platform	The Distortion Analyzer 1 or 2 is used as the hardware to control the laser head and to perform the measurement. 
Sensor	 An displacement laser (e.g. ANR 1282 plus Controller ANR5132) which is usually available as standard equipment of the KLIPPEL Analyzer System measures the displacement of suspension at the required precision.

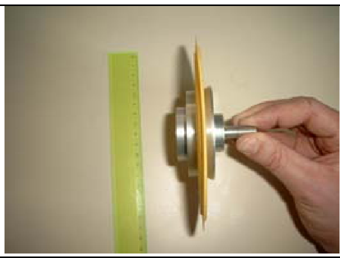
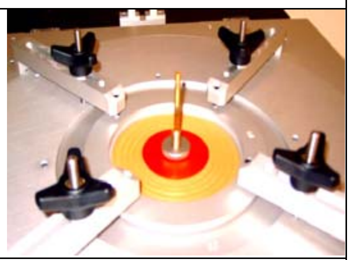
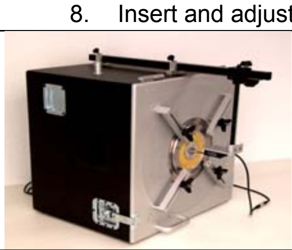
Software	The Suspension part measurement also uses software modules of the KLIPPEL Analyzer System such as the frame software dB-Lab and the Transfer Function Module TRF
Amplifier	A power amplifier is required for performing the measurement. The amplifier should provide more than 200 W output power at 4 Ohm.
Computer	A personal computer (not available at KLIPPEL) is required for performing the measurement.

Objects

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.

Although the suspension is pneumatically excited the used technique can cope with significant air porosity of the suspension.

Measurement Procedure

Centre Clamping		The measurement takes typically 5-10 minutes by performing the following steps: 1. Measure the inner and outer diameter 2. Look in 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.
Outer Clamping	4. Bring the clamping platform into horizontal position for easy handling 5. Insert the set of lower rings into the clamping platform 6. Put the slide with the clamped suspension on the guiding rod 7. Fix the upper ring to clamp the outer rim 8. Insert and adjust the laser head	
Measurement		9. Bring the clamping platform into vertical position 10. Start the measurement which takes a few seconds 11. Calculate the nonlinear stiffness 12. Print your report by using your customized template

Results

The figure shows measured stiffness curve K(x) versus displacement. For a positive displacement x=+11 mm the stiffness is approximately 30 times higher than at the rest position x=0. Please note the distinct asymmetry of the curve. The stiffness at negative displacement x=-11 mm is only 16 % of the stiffness at positive displacement x=+11 mm. Under dynamic operation an ac-signal is partially rectified and a negative dc-component is generated.

The dashed blue curve shows the mean stiffness of the suspension in the working range (-17 mm to 11 mm. This value depends on the amplitude and corresponds with the effective resonance frequency found in the large signal measurement.

Look up tables for small clamping set:

Colour	number of the cone	Cone diameter D_C (mm)	name of the cup	Cup diameter D_U (mm)
			A1	13,9
silver	1	11	B1	16,8
			C1	19,7
			A2	20,9
blue	2	18	B2	23,8
			C2	26,7
			A3	27,9
red	3	25	B3	30,8
			C3	33,7
			A4	34,9
gold	4	32	B4	37,8
			C4	40,7
			A5	41,9
black	5	39	B5	44,8
			C5	47,7
			A6	48,9
silver	6	46	B6	51,8
			C6	54,7
			A7	55,9
blue	7	53	B7	58,8
			C7	61,7
			A8	62,9
red	8	60	B8	65,8
			C8	68,7

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

			A9	69,9
gold	9	67	B9	72,8
			C9	75,7
			A10	76,9
black	10	74	B10	79,8
			C10	82,7
			A11	83,9
silver	11	81	B11	86,8
			C11	89,7
			A12	90,9
blue	12	88	B12	93,8
			C12	96,7
			A13	97,9
red	13	95	B13	100,8
			C13	103,7
			A14	104,9
gold	14	102	B14	107,8
			C14	110,7

G4	160
H4	166
A5	173
B5	180
C5	187
D5	194
E5	201
F5	208
G5	215
H5	222

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

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