Motor and Suspension Check (MSC) S13

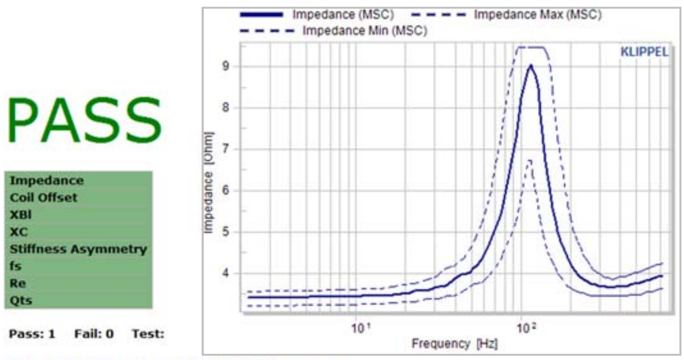
Specification to the KLIPPEL ANALYZER SYSTEM (Document Revision 1.0)

FEATURES	BENEFITS
• Large signal parameter for QC • Voice coil offset in mm • Relative to Reference DUT or • Bl Symmetry • Suspension asymmetry in % • No additional sensor required • Small signal parameter (T/S) • Ultra-fast testing at physical limit	• Simplify diagnostics of defect units • Control production process with QC results • Reduce number of defect units • Ensure consistency of production • Use the same data in QC and R&D • Exploit ambient noise immunity • Go for 100% testing

The Motor and Suspension Check (MSC) is an add-on to the QC end-of-line test system. This module measures selected large signal parameters such as voice coil offset and suspension asymmetry within an extremely short measurement time (1- 3 s). The parameters are easy to interpret and give feedback for process control to avoid manufacturing of bad units. The MSC can be applied to all kinds of transducers such as woofers, tweeters, headphones, micro-speakers and compression drivers.

Application:

- End-of-line testing
- Incoming goods inspection
- Diagnostics



Coil Offset: -0.2025 mm

Name	Value	Min Limit	Max Limit	Unit	Description
Coil Offset	-0.20	-0.35	-0.06	mm	recommended shift to compensate voice coil offset
XBl	1.86	1.69	2.06	mm	force factor limiting displacement
XC	1.61	1.45	1.77	mm	compliance limiting displacement
Stiffness Asymmetry	35.2	15.5	55.5	%	stiffness asymmetry
fs	111.4	95.2	128.8	Hz	resonance frequency
Re	3.42	3.22	3.56	Ohm	electrical voice coil resistance at DC
Qts	0.84	0.71	0.96		total Q-factor

Article Number:	4000-230

CONTENT

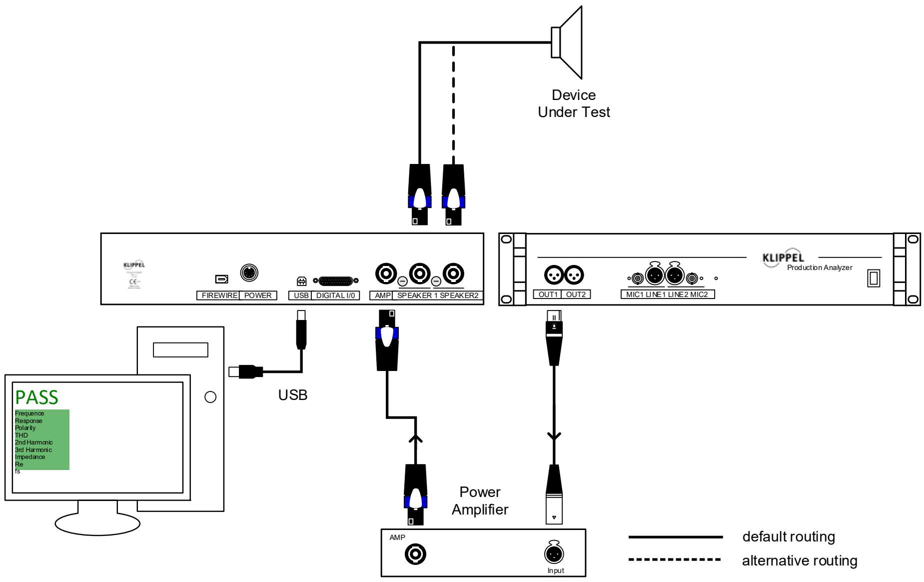
1 Overview

Summary	The maximal output, distortion and motor stability of a transducer highly depend on the suspension properties which vary significantly from batch to batch due to material uncertainties, climate and storage conditions. A new measurement technique is presented which makes it possible to measure voice coil offset in mm, suspension asymmetries in percent and other large signal parameters useful for quality control during end-of-line testing. This data is easy to interpret and directly indicates defects of motor and suspension. Exploiting this information in process control reduces the number of failed units and ensures consistent properties of the manufactured drive units and loudspeaker systems.
QC requirements	The QC- Motor and Suspension Check (MSC) was developed to satisfy the following requirements occurring under production conditions: • Objective and reliable detection of defects in motor and suspension within the shortest possible measurement time (1 – 3 s). • Although performing the measurement up to high amplitudes the MSC shall also provide the parameters at the rest position, such as Kms(x=0), which correspond to the small signal parameters (T/S). • Large signal parameters information is reduced to single values to support limit setting and statistics (cpk, ppk) for assessing the process stability. • The interpretation of the large signal parameters is simple and supports loudspeaker diagnostics. For example using a new batch of spiders may cause an offset of the voice coil position. Since the MSC measures this offset in mm this information can directly be used as a feedback to process control to correct the coil position. • QC requires a robust and cost effective hardware solution. The MSC uses the Production Analyzer, which already provides current and voltage sensors for small and high amplitudes. No additional sensor is required for MSC! • The MSC dispenses with measurements of mechanical or acoustical quantities such as displacement or sound pressure. This gives high robustness of the measurement against ambient noise. • Extremely short training period for the MSC. • The large signal parameters (coil offset, suspension asymmetry,…) measured with the MSC can directly be compared with the data measured by the Large Signal Identification (LSI) which is a module of the KLIPPEL R&D system.
Principle	The MSC is based on a new identification technique, which is patent protected. The loudspeaker is excited by a multi-tone signal of sufficient bandwidth and amplitude. Only electrical signals (voltage and current) are measured at the terminals of the transducer. The output parameters of the MSC are calculated by exploiting the nonlinear information found in the current signal. The MSC can identify 2^{nd}-order mechanical systems comprising stiffness, moving mass and losses and also 4^{th}-order systems with additional acoustical resonances as caused by a vented enclosure.

Parameters at x=0	Although the loudspeaker is operated at higher amplitudes and the loudspeaker nonlinearities produce significant distortion the parameters (fs, Q_{ts}, K_{ms}, ...) at the rest position x=0 can be calculated. Those parameters are comparable with the linear Thiele-Small parameters usually measured in the small signal domain. The electrical impedance curve $Z_{el}(f)$ is also measured at the rest position of the coil and the artifacts generated by loudspeaker nonlinearities are suppressed. Note that the stiffness K_{ms} of the suspension at x=0 depends highly depends on the peak displacement (also in the small signal domain where the nonlinearities are not active). This can be explained by visco-elastic effects caused by temporal deformation of the fibre structure of the suspension material.

2 Hardware

2.1 Minimal Setup



The figure above shows the minimal equipment required to run the MSC:

- QC Production Analyzer
- PC
- Power amplifier and cables

Of course the MSC can be combined with traditional tests such as SPL, THD, Rub&Buzz, polarity using optional equipment

- microphones,
- barcode reader, switches, assembly line control via digital I/O connector

→ more information in the KLIPPEL specification “C3 - QC End of Line Test System

2.2 Production Analyzer	The production analyzer hardware provides current and voltage sensors for two speaker channels. This allows performing an alternative testing of drive units. While a first drive unit is measured on connector SPEAKER 1 a second drive unit will be connected to connector SPEAKER 2. The current sensors can be customized to the transducer type to handle the maximal peak current (100 mA for a microspeaker or 60 A for a subwoofer). Please find more information in *H4 – Production Analyzer Hardware* for detailed specification.
2.3 Power Amplifier	Any standard audio amplifier meeting the power and bandwidth requirements of the tests may be used. Find more details in *KLIPPEL_Amplifier_Requirements*
2.4 PC	Please refer to the general recommendations in : *KLIPPEL QC SYSTEM PC Requirements* The extensive signal processing of the MSC may affect the total test time, therefore a fast CPU is recommended.
2.5 Fixture	The transducer may be measured in free air or connected to a sealed enclosure. Additional resonances close to the fundamental resonance frequency should be avoided.

3 Limits

3.1 Transducer

Parameter	Symbol	Min	Typ.	Max	Unit
Voice coil resistance [1]	R_e	0.1	4 - 120		Ω
Resonance frequency	f_s	20		3000	Hz
Total loss factor	Q_t	0.3		6	
Voice coil inductance	L_e	0.05		5	mH
Principle	electro-dynamical transducer with a 2nd-order mechanical system, also in vented enclosure (4th-order system)				
Types	subwoofer, woofer, midrange, tweeter, micro-speaker, headphones, compression driver				

[1] Maximal resistance depends on the current sensor used in the Production Analyzer (customization is possible)

3.2 Requirements for Power Amplifier

Maximal input level				15	dBu
Frequency response ref. 1 KHz @ 5Hz ... 20 kHz				1	dB
Input sensitivity at rated output power			0 (775)		dBu (mV)

3.3 Input Parameters (Setup)

Parameter	Symbol	Min	Typ.	Max	Unit
rms voltage	U_{rms}	0.1	4	200	V
Driver Type	*Type*	• subwoofer • woofer • midrange driver • micro-speaker • headphone • tweeter • subwoofer in vented box • woofer in vented box • general (advanced mode)			
Calibration of mechanical units [2]	*Calibration*	• Relative (no import required) • Bl(x=0) imported • Mass M_{ms} imported,			
Force factor (if Bl(x=0) import selected)	*Bl(x=0)*	0.01			N/A
Moving mass (if Mms import selected)	M_{ms}	0.01			gram
Optional Input Parameters (if advanced mode selected)					
lowest frequency of multi-tone complex	f_{start}	2	2	20	Hz
highest frequency of multi-tone complex	f_{stop}	375		12000	Hz
test frequency for Re measurement (pilot tone)	f_{Re}	375		12000	Hz
Excitation Density (number of tones in multi-tone complex)	*Resolution*	1	20	200	tones/ octave
Duration of stimulus	*T*	0.17	0.7	5.46	s
Number of loops repeated the stimulus before measurement to get steady-state	*Pre-loop*	0	0.5	20	
Compensation of power amplifier high-pass behavior	*Compensate Amplifier*	on /off			
Inductance Model used to consider Para-inductance	*Inductance Model*	• Leach Model (2 parameters) • LR-2 Model (3 parameters) • Wright Model (4 parameters)			

[2] Absolute identification of the mechanical parameters without laser sensor requires import of *Bl(x=0)* and/or M_{MS}

4 Measurement Results*

Measured Quantity	Symbol	Unit	QC limits can applied
LARGE SIGNAL PARAMETERS (ABSOLUTE) [1]			
(Negative) Voice coil offset*	X_{offset}	mm	x
Force factor limited displacement*	X_{Bl}	mm	x
Compliance limited displacement*	X_C	mm	x
RELATIVE LARGE SIGNAL PARAMETERS (RELATIVE)			
Relative voice coil offset	X_{offset}/X_{peak}	%	x
Force factor limited displacement (relative)	X_{Bl}/X_{peak}	%	x
Compliance limited displacement (relative)	X_C/X_{peak}	%	x
Stiffness Asymmetry*	A_{SYM},	%	x
PARAMETERS AT THE REST POSITION (X=0)			
Voice coil resistance	R_e	Ohm	x
Moving mass[1]	M_{ms}	grams	
Stiffness[1]	K_{ms}	N/mm	
Force Factor[1]	Bl	N/A	
Resonance frequency	f_s	Hz	x
Total loss factor	Q_{ts}		x
Electrical loss factor	Q_{es}		
Mechanical loss factor	Q_{ms}		
Impedance curve	$Z_{el}(f)$	Ohm	x
Port resonance frequency[2]	f_b	Hz	x
Port loss factor[2]	Q_b		x
Mechanical resistance[1]	R_{ms}	Ns/m	
Inductance of the LR2 Model	L_e	mH	
Electrical capacitance representing moving mass	C_{mes}	µF	
Electrical inductance representing driver compliance	L_{ces}	mH	
Electrical resistance representing mechanical losses	R_{es}	Ohm	
STATE INFORMATION			
Peak displacement[1]	X_{peak}	mm	
Bottom displacement[1]	X_{bottom}	mm	
Absolute peak displacement of Reference DUT during limit setting[1]	X_{prot}	mm	
Symmetrical AC displacement at Bl(x) max[1]	X_{ac}	mm	

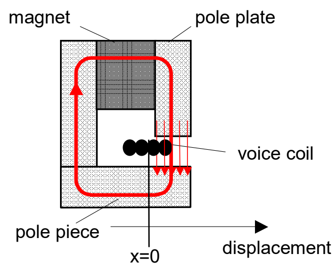
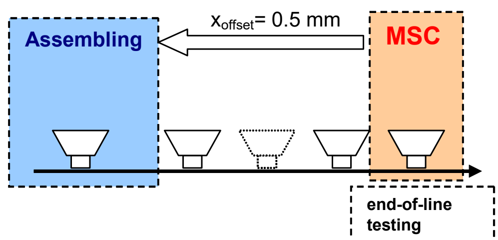
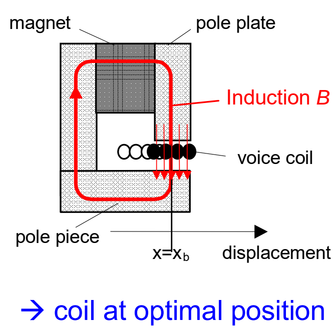
DC displacement (average and peak-to-peak)	X_{dc}, $X_{dc,max}$	mm	
Lowest ratio of nonlinear force factor during measurement related to rest position	Bl_{min}	%	
Lowest ratio of nonlinear compliance during measurement related to rest position	$C_{ms,min}$	%	

* This parameter is defined in MSC Manual.

[1] Additional information about the mechanical system is required (import Bl or Mms value at x=0)

[2] only for Driver Types in vented box

5 Example: Voice coil position under process control

Problem:	An offset in the voice coil position may be caused by using a new batch of spiders. This offset generates excessive harmonic distortion. However, the harmonic distortion does not show the physical cause.	
Solution:	As soon as the first device using the new spider part arrives at the end of line the voice coil offset is detected by MSC. The parameter X_{offset} expressed in mm is transmitted to the assembling station and used as a shift recommendation to correct the voice coil rest position.	
Result:	100 % -testing of the voice coil position can be realized by MSC within a few seconds. MSC combined with process control makes it possible to produce transducers at high quality even if the properties of the parts and the production condition vary.	

ACKNOWLEDGEMENT:

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6 Patents

Germany	102007005070 1020120202717 19714199 43340407 4332804.0
USA	8,078,433 14/436,222 6,058,195 5815585
China	ZL200810092055.4 201380054458.9 981052849
Japan	5364271 2972708
Europe	13786635.6
Taiwan	102137485
India	844/MUMNP/2015
Great Britain	2324888

Find explanations for symbols at:
http://www.klippel.de/know-how/literature.html
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