

FEATURES	BENEFITS
<ul style="list-style-type: none"> <li>• Measure the Armature offset in <math>\mu\text{m}</math></li> <li>• No additional sensor required</li> <li>• Ultra-fast testing at physical limit</li> <li>• Automatic limit calculation</li> </ul>	<ul style="list-style-type: none"> <li>• Exploit maximum working range with centered armature</li> <li>• Keep distortion low</li> <li>• Control production process with offset monitoring</li> <li>• Ensure consistency of production</li> <li>• Fully ambient noise immune</li> <li>• Ready for 100% testing</li> </ul>

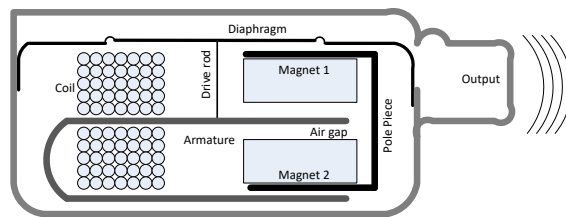
The Balanced Armature Check (BAC) is an add-on to the KLIPPEL QC system. The module measures the offset of the armature and selected linear parameters within an extremely short time (0.5 - 2 s).

A centered armature can use the full geometric moving range symmetrically providing maximal output. Also distortion is reduced with a centered armature due to low asymmetries.

The parameters are easy to interpret and give feedback for process control to avoid manufacturing bad units.

**Application:**

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



**PASS**

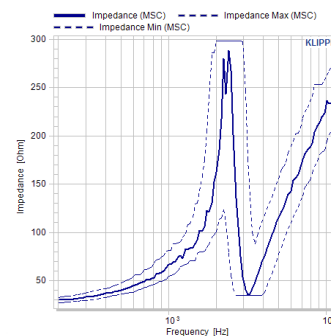
Impedance
Armature Offset
fs
Re
Qts
Le

Pass: 4 Fail: 7

[ TASK OUTPUT: BALANCED ARMATURE CHECK ]

**Armature Offset: 5.753  $\mu\text{m}$**

Name	Value	Min Limit	Max Limit	Unit	Description
Armature Offset	5.75	-20.00	20.00	$\mu\text{m}$	armature offset
fs	2341.6	2245.8	2482.2	Hz	resonance frequency (approximated from 2nd order fitting)
Re	31.43	29.83	32.97	Ohm	electrical coil resistance at DC
Qts	0.66	0.57	0.69		total Q-factor (approximated from 2nd order fitting)
Le	3.57	3.27	4.00	mH	coil inductance (approximated)



Article Number:	4000-260
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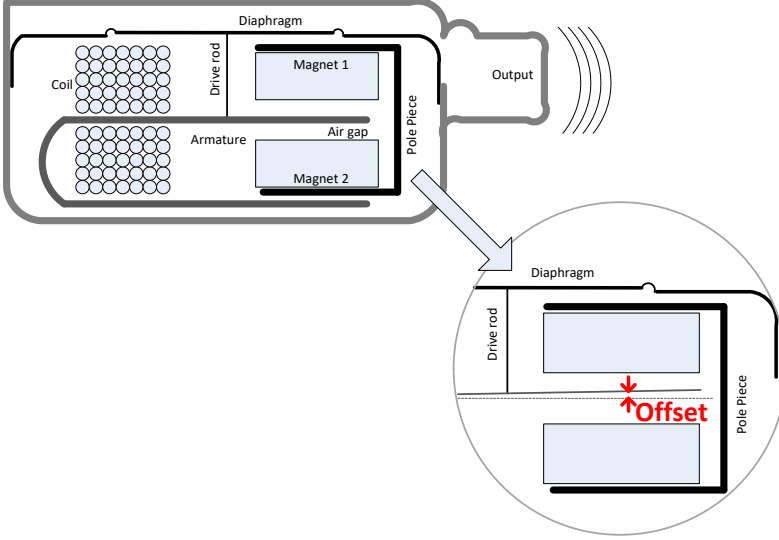
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## 1 Overview

<b>SUMMARY</b>	<p>The level of distortion generated by Balanced Armature transducers depends highly on the rest position of the armature. By shifting the armature to its optimal position, non-linear distortion can be significantly reduced. A new measurement technique is used which is capable of measuring this offset in a very short time.</p> <p>The knowledge of the offset is useful for controlling manufacturing processes and end-of-line-testing, but also for the development of new products.</p>
<b>QC REQUIREMENTS</b>	<p>The QC- Balanced Armature Check (BAC) was developed to satisfy the following requirements occurring under production conditions:</p> <ul style="list-style-type: none"> <li>• Measurement of the armature offset within the shortest possible measurement time (0.5 – 2 s).</li> <li>• The parameter supports limit setting and statistics (cpk, ppk) for assessing the process stability.</li> <li>• QC requires a robust and cost effective hardware solution. The BAC uses the Production Analyzer, which already provides current and voltage sensors. No additional sensor is required for BAC!</li> <li>• For low current BA types you may consider the special high sensitivity hardware version of the Production Analyzer.</li> <li>• The BAC dispenses with measurements of mechanical or acoustical quantities such as displacement or sound pressure. This gives high robustness of the measurement against ambient noise.</li> <li>• Extremely short training period for the BAC.</li> <li>• The armature offset measured with the BAC can be compared with harmonic and intermodulation distortion measurements using the DIS or TRF modules which are part of the KLIPPEL R&amp;D system. In the development process of new products the effect of the offset on nonlinear distortion can be measured and reasonable limits can be defined for production.</li> </ul>
<b>PRINCIPLE</b>	<p>The BAC 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 armature offset is calculated by exploiting the nonlinear information found in the current signal. For displaying the absolute value of the offset in <math>\mu m</math>, a mechanical calibration is necessary which is made by means importing the transduction coefficient <math>T_{em}</math>.</p>
<b>PARAMETERS AT X=0</b>	<p>Although the device is operated at higher amplitudes and the inherent nonlinearities produce significant distortion the parameters at the rest position <math>x=0</math> can be calculated. Those parameters are comparable with the linear parameters usually measured in the small signal domain. The electrical impedance curve <math>Z_{ei}(f)</math> is also measured at the rest position of the armature where the artifacts generated by transducer nonlinearities are suppressed.</p> <p>The BAC uses the Wright inductance model to fit those inductances reliably. If desired, the simple coil inductance <math>L_e</math> which is approximated from the Wright model can also be calculated.</p>

## 2 Definitions

<p><b>ARMATURE OFFSET</b> <math>X_{\text{OFFSET}}</math></p>	<p><b>DEFINITION:</b> The armature offset is the shift recommendation to compensate the offset relative to the magnetic field.</p> <p>The positive direction of excursion corresponds to the response of the BA excited with positive DC current.</p>
	<p>The definition is illustrated in Fig. 1.</p> <p>Note that the transduction parameter <math>T_{em}</math> defines the absolute scaling of the armature offset. See the comments on the Transduction parameter below.</p> <p>The absolute armature offset may depend also on the actual excursion used in the measurement.</p> <p>Thus it is recommended practice reporting the voice coil offset <math>X_{\text{offset}}</math> together with the transduction parameter <math>T_{em}</math> and amplitude <math>X_{\text{peak}}</math>.</p> <p>Example: <math>X_{\text{offset}} = 40 \mu\text{m}</math> (@<math>X_{\text{peak}} = 200 \mu\text{m}</math>)</p>  <p>Fig. 1: Schematic view of the armature offset.</p> <p><b>Application to end-of-line testing</b></p> <p>An armature offset generates 2nd-order harmonic and intermodulation distortion and should be close to zero. Thus the armature shall be well centered in the magnetic field.</p> <p>A permissible range defined by minimal or maximal QC limits may be applied to <math>X_{\text{offset}}</math> to check for a PASS/FAIL decision.</p>

**TRANSDUCTION  
PARAMETER  $T_{EM}$** 

The absolute armature offset in [ $\mu\text{m}$ ] is based on the impedance measurement and one absolute mechanical parameter. This parameter is needed to calibrate the mechanical system. This parameter is specific to the BA type under test.

The transduction parameter  $T_{em}$ , which is similar to the BI-factor of electrodynamic speakers, is used in the BAC module for this purpose. This parameter can be measured or simulated.

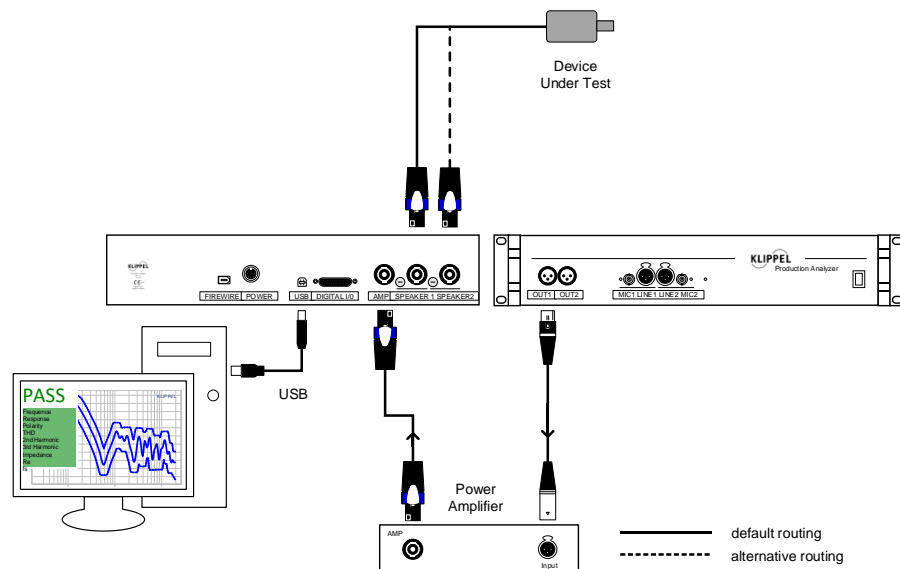
If no  $T_{em}$  is specified, the offset is presented as a relative value in [%]. It is related to the peak displacement during the test.

**Importing  $T_{em}$  from LPM:**

Using the R&D module “Linear Parameter Measurement LPM” this parameter can be measured using a displacement laser sensor.

For an accurate absolute armature offset the laser should access the excursion of the armature within the magnetic gap. In most cases this is not possible. It is common practice to use a certain point on the membrane, which is excited by a drive rod. This is not the offset of the armature inside the magnetic gap due to the leveler effect. If the mechanical details are known, the leveler effect can be compensated by a simple factor.

$T_{em}$  strongly depends on the position of the laser target point on the membrane even for very low frequencies. The Scanner module SCN (Klippel R&D System) can be used, to assess the vibration behavior at around the resonance frequency.

**3 Hardware****MINIMAL  
SETUP**

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

- QC Production Analyzer
- PC
- Power amplifier and cables

The BAC 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

<b>PRODUCTION ANALYZER</b>	<p>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 can be connected to connector SPEAKER 2.</p> <p>To guarantee an optimal signal-to-noise ratio for balanced armature measurements, the standard current sensors may be non-ideal. The High Sensitivity version of the Production Analyzer is recommended.</p> <p>Please find more information in <i>H4 – Production Analyzer Hardware</i> for detailed specification.</p>
<b>POWER AMPLIFIER</b>	Any standard audio amplifier meeting the power and bandwidth requirements of the tests shall be used.
<b>FIXTURE</b>	The transducer may be measured in free air or with a closed port to achieve a better linear fitting due to the absence of acoustic resonances.
<b>ACOUSTICAL ENVIRONMENT</b>	There are no specific requirements, the BAC is very insensitive to ambient noise.

## 4 Limits

Transducer					
Parameter	Symbol	Min	Typ.	Max	Unit
Coil resistance <sup>1</sup>	$R_e$	0.1	20 - 250		$\Omega$
Resonance frequency	$f_s$	15		6000	Hz
Total loss factor	$Q_{ts}$	0.3		6	
Principle	Balanced Armature transducer				

<sup>1</sup> Maximal resistance depends on the current sensor used in the Production Analyzer

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)

Input Parameters (Setup)					
Parameter	Symbol	Min	Typ.	Max	Unit
rms voltage	$U_{rms}$	0.1	4	200	V

Driver Type	Type	<ul style="list-style-type: none"> <li>• small BA (<math>f_s &gt; 1\text{kHz}</math>)</li> <li>• large BA (<math>f_s &lt; 1\text{kHz}</math>)</li> <li>• general (advanced mode)</li> </ul>			
Calibration of mechanical units <sup>2</sup>	Calibration	<ul style="list-style-type: none"> <li>• Relative (no import required)</li> <li>• <math>T_{em}(x=0)</math> import</li> </ul>			
Transduction coefficient (if $T_{em}(x=0)$ import selected)	$T_{em}(x=0)$	0.01			N/A
<b>Optional Input Parameters (if advanced mode selected)</b>					
lowest frequency of multi-tone complex	$f_{start}$	2	2	20	Hz
highest frequency of multi-tone complex	$f_{stop}$	375		12000	Hz
Excitation Density (number of tones in multi-tone complex)	Resolution	1	20	200	tones/octave
Duration of stimulus	$T$	0.17	0.68	5.46	s
Number of loops repeated the stimulus before measurement to get steady-state	Pre-loop	0	0.5	20	

## 5 Measurement Results

	Measured Quantity	Symbol	Unit	QC limits can applied
<b>LARGE SIGNAL PARAMETERS (ABSOLUTE) <sup>1</sup></b>				
	Armature offset	$X_{offset}$	$\mu\text{m}$	x
<b>RELATIVE LARGE SIGNAL PARAMETERS (RELATIVE)</b>				
	Relative armature offset	$X_{offset}/\max(X_{peak}, X_{bottom})$	%	x
<b>PARAMETERS AT THE REST POSITION (<math>X=0</math>)</b>				
	Voice coil resistance	$R_e$	Ohm	x
	Resonance frequency	$f_s$	Hz	x
	Total loss factor	$Q_{ts}$		x
	Impedance curve	$Z_{el}(f)$	Ohm	x
	Inductance of the LR2 Model <sup>3</sup>	$L_e$	mH	x
<b>STATE INFORMATION</b>				
	Peak Current	$I_{peak}$	A	
	Peak Voltage	$U_{peak}$	V	
	Positive Peak Displacement <sup>1</sup>	$X_{peak}$	$\mu\text{m}$	
	Negative Peak Displacement <sup>1</sup>	$X_{bottom}$	$\mu\text{m}$	
	Headroom Current	$H_i$	dB	
	Distortion Current	$D_i$	dB	

<sup>1</sup> Additional information about the mechanical system is required (import  $T_{em}$  at  $x=0$ )

<sup>2</sup> Absolute identification of the mechanical parameters without laser sensor requires import of  $T_{em}(x=0)$

<sup>3</sup> The coil inductance is only approximated from the Wright model to deliver an easy interpretable parameter. Balanced Armature inductances cannot be described by the simple  $L_e$  inductance model in general.

## 6 Patents

Germany	102013012811
USA	14/499,379
China	2014103769646
Korea	1020140095591

Find explanations for symbols at:

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

Last updated: July 28, 2017

