Balanced Armature Check (BAC) S39

Module of the KLIPPEL ANALYZER SYSTEM (QC Ver. 6, dB-Lab Ver. 210)

Document Revision 1.2

FEATURES	BENEFITS
• Measure the armature offset in µm • No additional sensor required • Ultra-fast testing at physical limit • Automatic limit calculation	• Exploit maximum working range with centered armature • Keep distortion low • Control production process with offset monitoring • Ensure consistency of production • Fully ambient noise immune • Ready for 100% testing

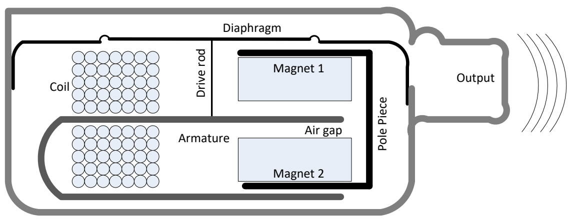
The Balanced Armature Check (BAC) is an add-on task for the QC framework of the KLIPPEL Analyzer system. The BAC measures the offset of the armature and selected linear parameters of electro-magnetic transducers within an extremely short time (0.5 - 2 s).

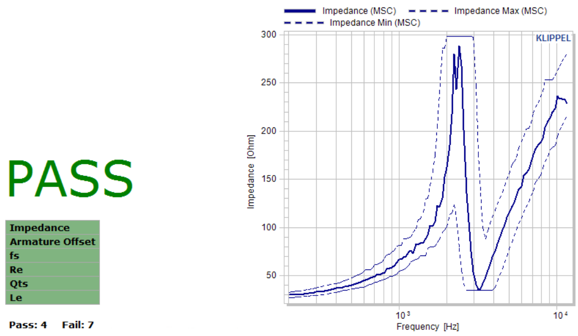
A centered armature is required to exploit the full symmetrical working range providing maximal output. Additionally, audible distortion is reduced significantly.

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

Application:

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





[TASK OUTPUT: BALANCED ARMATURE CHECK]

Armature Offset: 5.753 µm

Name	Value	Min Limit	Max Limit	Unit	Description
Armature Offset	5.75	-20.00	20.00	µm	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)

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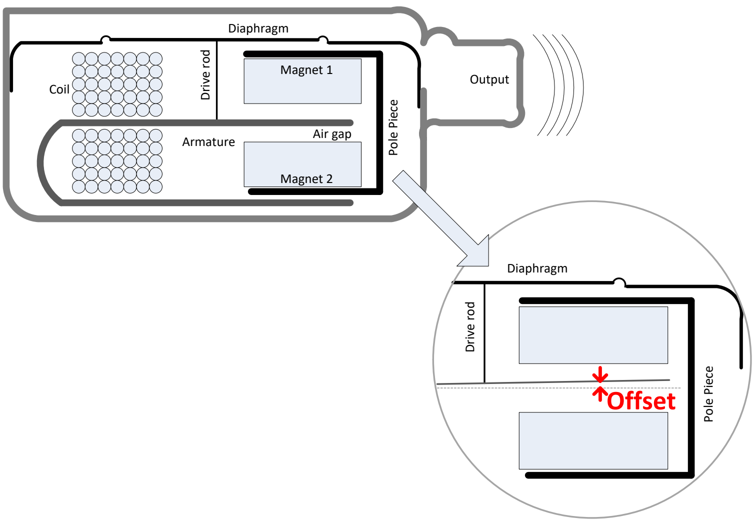
CONTENTS

1 Overview

Summary	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, nonlinear distortion can be significantly reduced. A new measurement technique is used which is capable of measuring this offset in a very short time. The knowledge of the offset is useful for controlling manufacturing processes and end-of-line-testing, but also for the development of new products.
Targets	The QC- Balanced Armature Check (BAC) was developed to satisfy the following requirements occurring under production conditions: • Measurement of the armature offset within the shortest possible measurement time (0.5 – 2 s). • The parameter supports limit setting and statistics (e.g. C_{pk}, P_{pk}) for assessing the process stability. • QC requires a robust and cost-effective hardware solution. The BAC can be operated with the Production Analyzer or KLIPPEL Analyzer 3, which provide current and voltage sensors. No additional sensor is required for BAC. • The purely electrical measurement principle provides high robustness against ambient noise. • Extremely short training period for the BAC. • The armature offset measured with the BAC can be compared with harmonic and intermodulation distortion measurements using the DIS or TRF modules which are modules of the R&D framework of KLIPPEL Analyzer 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.
Principle	The BAC is based on a patent protected identification technique. 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 *μm*, a mechanical calibration is necessary which is made by means importing the transduction coefficient T_{em}.

Parameters at x=0	Although the device is operated at higher amplitudes and the inherent nonlinearities produce significant distortion, the parameters at the rest position x=0 can be calculated. Those parameters are comparable with the linear parameters usually measured in the small signal domain. The electrical impedance curve $Z_{el}(f)$ is also measured at the rest position of the armature where the artifacts generated by transducer nonlinearities are suppressed. The BAC uses the *Wright* inductance model to model inductance behavior reliably. If desired, the simple coil inductance L_e which is approximated from the *Wright* model inductance is provided as well.

2 Definitions

Armature Offset X_{offset}	**DEFINITION:** The armature offset is the shift recommendation to compensate the offset relative to the magnetic field. The positive direction of excursion corresponds to the response of the BA excited with positive DC current. The definition is illustrated in the figure below. Note that the transduction parameter T_{em} defines the absolute scaling of the armature offset. See the comments on the Transduction parameter below. The absolute armature offset may depend also on the actual excursion used in the measurement. Thus, it is recommended practice reporting the voice coil offset X_{offset} together with the transduction parameter T_{em} and amplitude X_{peak}. **Example**: X_{offset}= 40 µm (@X_{peak}= 200 µm)  Fig. 1: Schematic view of the armature offset. **Application to end-of-line testing** 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. A permissible range defined by minimal or maximal QC limits may be applied to X_{offset} to check for a PASS/FAIL decision.
Transduction Parameter T_{em}	The absolute armature offset in [µm] 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 Bl-factor of electro-dynamic 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.

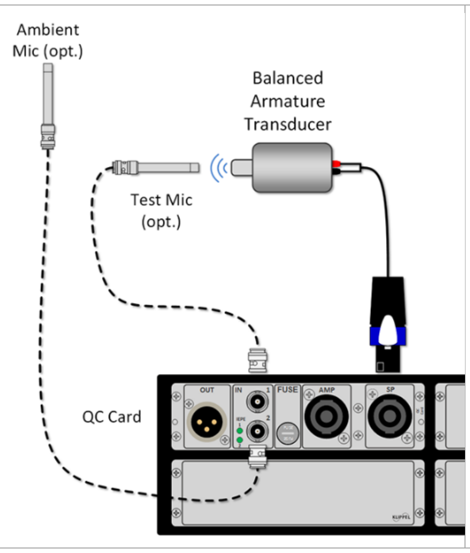
For an accurate absolute armature offset the laser should access the excursion of the armature within the magnetic gap. In most cases this is not possible. It is common practice to use a certain point on the membrane, which is excited by a drive rod. This is not the offset of the armature inside the 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 Requirements

3.1 Hardware

Minimal Setup



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

- KLIPPEL Analyzer 3 (KA3) QC configuration (alt: *ALS* configuration)
- PC
- USB license dongle

Alternatively, the *KLIPPEL Production Analyzer* (PA) High Sensitivity version can be used together with an external power amplifier.

The BAC can be combined with traditional tests such as SPL, THD, Rub&Buzz, polarity using optional microphones.

KLIPPEL Analyzer 3

In order to use the BAC with the KLIPPEL R&D System (from version 210), the KA3 hardware is required. The analyzer is also supported from QC Version 6.

It is recommended to use a KA3 with QC Card or in A(L)S configuration

- Amplifier Card
- (Laser Card)
- Speaker Card

No external amplifier is required in this case.
The required minimal card configuration for use with external amplifier is:

- XLR Card
- Speaker Card

	Please refer to the specifications of the KA3 and the extension cards for more information.
Production Analyzer (alt.)	As an alternative to the KA3 hardware, the *Production Analyzer* also provides current and voltage sensors for two channels. 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. Please find more information in *H4 – Production Analyzer Hardware* for detailed specification.
Power Amplifier (opt.)	Any professional audio amplifier meeting the power and bandwidth requirements of the tests may be used. An additional power amplifier is not required in case a KA3 equipped with a QC Card or an Amplifier Card. Find more details in *KLIPPEL Amplifier Requirements* or specifications *H6 Amplifier Card* and *H11 QC Card*.
PC	Please refer to the general recommendations in *KLIPPEL QC SYSTEM PC Requirements*. The signal processing algorithms of the MSC may affect the total test time, therefore a fast CPU is recommended.

3.2 Software

QC Framework	The BAC requires QC Standard software. BAC is installed with the QC software; no additional setup is required. A dedicated license is required to operate the module.
R&D Framework	From release version 210, the BAC may be operated within the KLIPPEL RnD software release. No additional setup, only a BAC license is required for operation. **Note**: KLIPPEL Analyzer 3 (KA3) hardware is required to operate the BAC in the RnD software framework.

3.3 Further Requirements

Test Fixture	The transducer may be measured in free air or with a closed port to achieve a better linear fitting due to the absence of potential acoustic resonances.
Acoustical Environment	There are no specific requirements, the BAC is very insensitive to ambient noise.

4 Limits

4.1 Transducer

Parameter	Symbol	Min	Typ.	Max	Unit
Coil resistance [1]	R_e	0.1	20 - 250		Ω
Resonance frequency	f_s	15		6000	Hz
Total loss factor	Q_{ts}	0.3		6	
Principle	Balanced Armature transducer				

[1] Maximal resistance depends on the current sensor used in the Production Analyzer

4.2 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)

4.3 Input Parameters (Setup)					
Parameter	Symbol	Min	Typ.	Max	Unit
rms voltage	U_{rms}	0.1	4	200	V
Driver Type	*Type*	• small BA (fs>1kHz) • large BA (fs<1kHz) • general (advanced mode)			
Calibration of mechanical units [2]	*Calibration*	• Relative (no import required) • T_{em}(x=0) import			
Transduction coefficient (if T_{em}(x=0) import selected)	$T_{em}(x=0)$	0.01			N/A
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
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	T_{pre}	0	0.5	20	

5 Measurement Results

	Measured Quantity	Symbol	Unit	QC limits applicable
LARGE SIGNAL PARAMETERS (ABSOLUTE) [1]				
	Armature offset	X_{offset}	µm	x
RELATIVE LARGE SIGNAL PARAMETERS (RELATIVE)				
	Relative armature offset	$X_{offset}/\max(X_{peak}, X_{bottom})$	%	x
PARAMETERS AT THE REST POSITION (X=0)				
	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[3]	L_e	mH	x
STATE INFORMATION				
	Peak Current	I_{peak}	A	
	Peak Voltage	u_{peak}	V	
	Positive Peak Displacement[1]	X_{peak}	µm	
	Negative Peak Displacement[1]	X_{bottom}	µm	
	Headroom Current	H_i	dB	
	Distortion Current	D_i	dB	

[1] Additional information about the mechanical system is required (import T_{em} at x=0)

[2] Absolute identification of the mechanical parameters without laser sensor requires import of $T_{em}(x=0)$

[3] 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

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