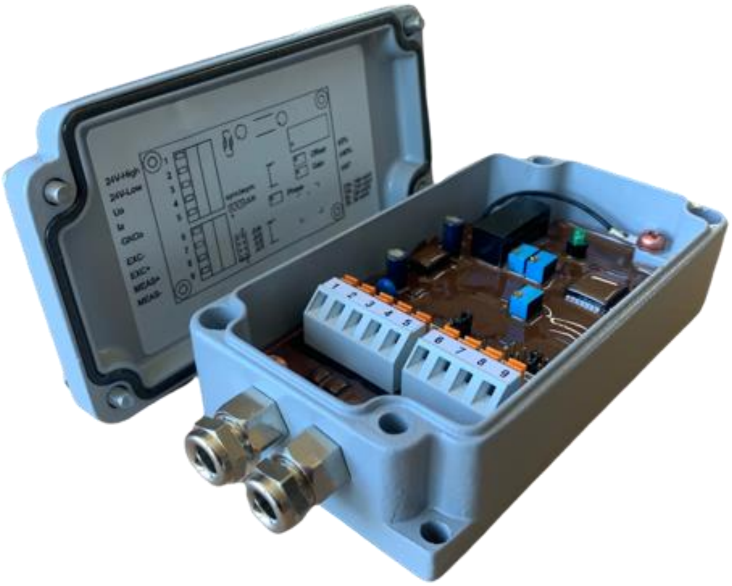

Operating instructions for

Carrier Frequency Amplifier

Series MBI 46.51.39

Table of contents

1 General

Please read and follow these operating instructions carefully.

1.1 Warranty and liability

Any warranty and liability claim against MESSOTRON shall be lost if

- damage occurs due to non-observance of the operating instructions
- modifications have been made that are not documented in this manual
- nameplate has been removed from the device

1.2 Importance of Nameplate

The specification of the model type and the manufacturing number is required for repair and for the procurement of subsequent deliveries and spare parts. Both information is given on the nameplate.

Do not remove the nameplate from the device and handle with care.

1.3 Technical support and contact details

If you have any questions, please do not hesitate to contact us.

MESSOTRON GmbH & Co KG
Friedrich-Ebert-Str. 37
D-64342 Seeheim-Jugenheim
Germany

Phone:+49 (0) 6257 999 730
Email: info@messotron.com

Further information can also be found on the website www.messotron.com

2 Safety

2.1 Intended use

Use the **MBI 46.51.39 carrier frequency amplifier** exclusively for the operation of differential transformers (LVDT) and inductive half-bridge displacement transducers (LVIT). The amplifier may only be operated with passive transducers without built-in electronics. Any further use shall be deemed not to be in accordance with its intended purpose.

In order to ensure proper and safe operation, the device must only be operated in accordance with this instruction. Make sure to follow any applicable legal / safety regulation for the respective use of application. This also applies to the use of accessories.

2.2 Site Conditions

Be sure that the site conditions for the intended installation are within the technical specifications of the device e.g., in terms of temperature and IP protection etc.

Do not use the device near other machinery or devices such like large electrical machines, high voltage cables and facilities that generate strong electric or magnetic fields.

2.3 General hazards

The device complies with the latest state-of-the-art technology and regulations and is safe when used as intended. Residual hazards may emanate from the device if it is improperly used and operated e.g., by insufficiently qualified personnel.

2.4 Qualified personnel

Both the commissioning and operation of the device may only be carried out by trained professionals who are aware of the dangers at hand. Professionals must be familiar with national health and safety regulations, accident prevention regulations and general industrial standards for installation of electronic equipment.

2.5 Transport damages

Before unpacking, check the packaging of the device for any damages. If the packaging has been damaged during transport and if there is a suspicion of damage to the device, it may not be put into operation. Have MESSOTRON check the device before using it.

3 Warnings and markings

3.1 Use of warnings

For warnings, the following hazard classes are specified according to ANSI. Z 535 used:

Warning sign, signal word	Meaning
DANGER	Indicates a dangerous situation in which death or serious bodily injury occurs if it is not avoided.
WARNING	Indicates a dangerous situation in which death or serious bodily injury can occur if not avoided.
CAUTION	Characterizes a dangerous situation in which mild to moderate bodily injuries can occur if not avoided.
HINT	Indicates possible property damage: The product or environment can be harmed.

3.2 Other markings

TIP	Tips contain important information on how to get the most out of your device. Disregarding a tip can result in incorrect measurement results.

4 Product

4.1 Terms and definitions

Term	**Definition**
Carrier frequency measuring amplifier	Carrier frequency measuring amplifiers are used for LVDT/LVIT: • to provide the inductive sensor with the excitation voltage • to amplify the sensor output signal • to convert the sensor output into a normalized signal
Displacement sensor	In these instructions the term displacement transducer may also be mentioned: sensor, transducers, or position sensors.
Differential transformer (LVDT)	Differential transformers consist of a primary coil and two secondary coils placed around a movable magnetic core. The coils are coupled based on the transformer principle. LVDT stands for "Linear Variable Differential Transformer".
Inductive half-bridge transducer (LVIT)	Differential inductors represent a Wheatstone half-bridge with two measuring coils. The impedance of the two measuring coils is influenced in opposite directions by a movable magnetic core. They are also referred to as LVIT (Linear Variable Inductance Transducer).
Long-stroke sensors based on the eddy current principle	Long-stroke sensors are inductive displacement sensors using a half-bridge circuit, where only one coil is used for measuring. The second coil is designed as a space-saving equivalent circuit. A movable tube made of a conductive material changes the impedance of the measuring coil based on the eddy current principle.
Symmetric sensor	The measuring coils of differential transformers and inductors are built in a symmetrically (mirrored) design. The electrical zero is at the center of the nominal stroke.
Asymmetric sensor	The space-saving equivalent circuit of the 2^{nd} coil of the long-stroke sensors results in an asymmetric design enabling a more favorable stroke-to-length ratio. The electrical zero is at the start of the nominal stroke, where the tube completely covers the measuring coil.
Core rod	The core rod is a cylindrical part consisting of • a magnetic core • a core extension
Measuring tube	The measuring tube is made of aluminum. In asymmetric displacement sensors it is moved over the measuring coil drawing energy from the coil field proportional to the tube's position (eddy current effect).
Excitation voltage	AC voltage (typically 1...5 Vpp), supplying the inductive sensor.
Carrier frequency	Excitation frequency, usually 5 or 10 kHz, to drive the inductive displacement sensor.

Term	Definition
Measuring voltage	Output signal proportional to the displacement (AC voltage in the mV range) provided by the inductive displacement sensor.
Zero-point	At the electrical zero-point, the output signal of the displacement sensor is zero. Refer to the data sheet of the displacement sensor for physical position of the zero-point, see “measurement A”.
Rated output (FSO)	The rated output of the sensor is defined as the ratio of the sensor output voltage (measurement voltage) to the sensor input voltage (excitation voltage) at the end of the nominal stroke. For calibrated displacement sensors the rated output is e.g. 80 mV/V, independent of the nominal stroke of the displacement sensor. In older data sheets, the term “nominal output” may be used as well as full scale output (FSO).
Sensitivity	The sensitivity is defined as the ratio of the measurement voltage to the excitation voltage per mm of displacement (e.g. 10 mV/V/mm). For standardization purposes information on sensitivity and rated output for MESSOTRON displacement sensors is determined and provided independent of phase (i.e. without consideration of a phase shift).
Phase (phase shift)	With inductive sensors and/or long connecting cables, there will be a noticeable phase shift between the excitation voltage and the measurement voltage. This phase shift lowers the (effective) sensitivity of the sensor in the measuring chain. All MESSOTRON series MBI 46.13 measuring amplifiers can compensate a phase shift.
Linearity error	The linearity error of measuring devices is the maximum deviation between the nominal characteristic (straight line) and the real characteristic of the measuring device. The error information is referenced to the total measuring range (FSO / Full Scale Output).
Nominal output range	The nominal output range of the measuring amplifier indicates the range covered by the output signal, if the displacement sensor operates in the (nominal) measuring range.
Voltage output	Analog voltage output of the measuring amplifier: • typically ±10 V for symmetric displacement sensors • typically 0-10V for asymmetric displacement sensors

4.2 Function and design

The **MBI 46.51.39 carrier frequency amplifier** generates an alternating excitation voltage required for the operation of inductive displacement transducers. The carrier frequency is typically 5 kHz, unless otherwise specified.

The output signal from the displacement transducer is pre-amplified by the measuring amplifier and evaluated ratiometrically, i.e. in relation to the supply voltage. This avoids measurement errors due to fluctuations in the supply voltage e.g., due to impedance change of the displacement transducer or cables.

In the following stages, the measurement signal is filtered and scaled to the desired output range for further processing.

4.3 Suitable displacement transducers

The device series can be used with a variety of inductive transducers. Further details may be found in chapter 11 or in the respective datasheet.

TIP	For selection of suitable sensor / amplifier combination • Type of displacement sensor (LVDT, LVIT, others) • Wiring details of the sensor • Required carrier frequency • Excitation voltage • Rated output / sensitivity

The electrical design of the three displacement transducer types offered by MESSOTRON is described below.

4.3.1 Linear Variable Inductive Transducers (LVIT)

Electrically, a displacement transducer based on the differential inductor principle represents a Wheatstone half-bridge consisting of two measuring coils. The core, which moves inside the coils, causes in its middle position (electrical zero point) that both measuring coils have the same impedance. The bridge circuit is thus balanced, the measuring voltage is zero.

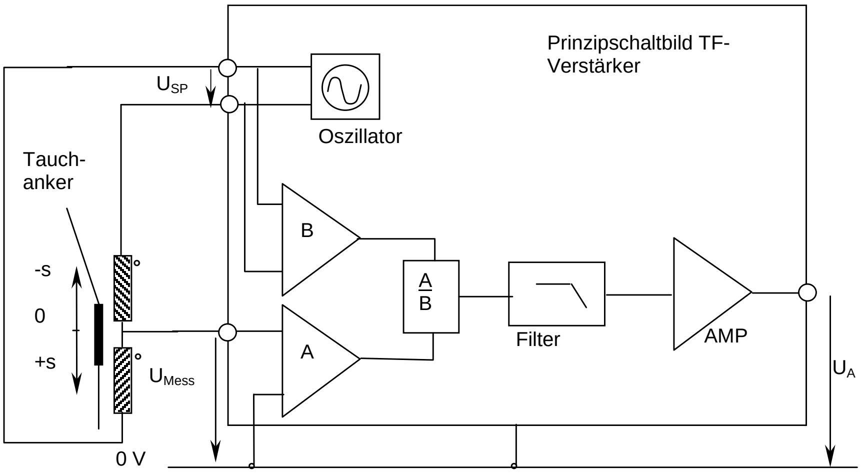

Figure 1 Amplifier with Differential Choke

If the core is moved out of its middle position, the impedances of the two measuring coils change and the measuring voltage grows proportionally within the measuring range proportionally with the displacement of the core.

4.3.2 Linear Variable Differential Transformers (LVDT)

Differential transformers consist of one primary and two secondary coils, which are coupled via a magnetic core according to the transformer principle.

The primary coil being fed with an AC voltage induces a voltage in the secondary coils. The output is zero due to the counter-connection of these coils, when the core is in the middle position.

If the core is moved out of its middle position, the impedances of the two secondary coils change and the measuring voltage grows proportionally within the measuring range proportionally with the displacement of the core.

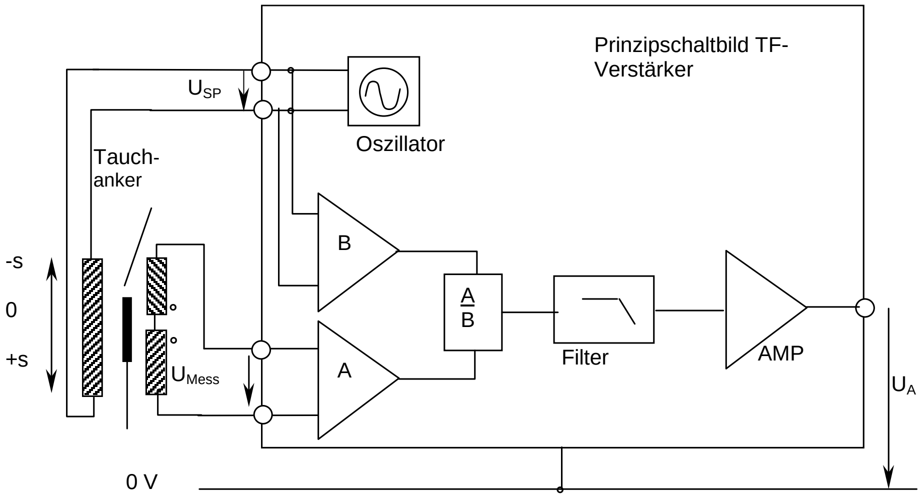

Figure 2 amplifier with differential transformer

4.3.3 Long-stroke sensors (eddy current principle)

Long-stroke displacement transducers are sensor using a half-bridge circuit in which only one coil is used as a measuring coil and the second coil is designed in a space-saving replacement circuit. A movable measuring tube changes the impedance of the measuring coil according to the eddy current principle. In contrast to the symmetrical displacement transducers, the electric zero point is located at the beginning of the nominal measuring range where the tube is placed all the way onto/across the measuring coil.

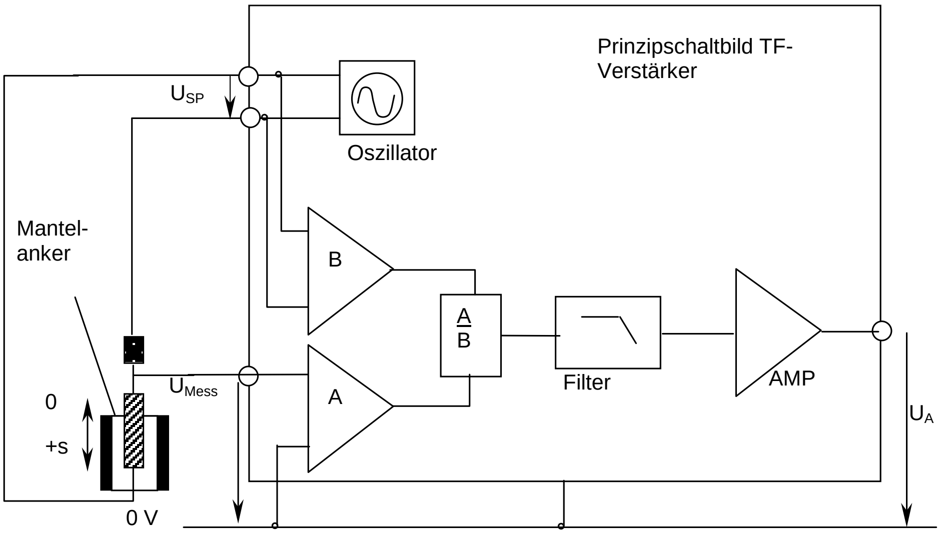

Figure 33 Measure amplifier with long-stroke displacement transducer

4.4 Types and options

The amplifier is available in the following versions:

MBI 46.51.39 Standard

5 kHz carrier frequency

24 VDC supply

voltage (0...10 V)

current output (4... 20 mA)

field housing

terminal block

Options: other carrier frequency in the range (1...20 kHz)

4.4.1 Layout / Drawing

The device comes in a rugged aluminum field housing of industrial standard. It is dustproof and protected against water jets in accordance with protection class IP 66 (DIN EN 60529).

For mounting of the field housing there are two M4.4 bolt holes at opposite corners. The cover may only be opened and removed to connect the device electronically and to perform the setting and adjustments.

To insert the connection cables for power supply, signal output and transducer, there are two M8 cable glands (IP68, maximum cable diameter 3.5... 5.5 mm) both at one side.

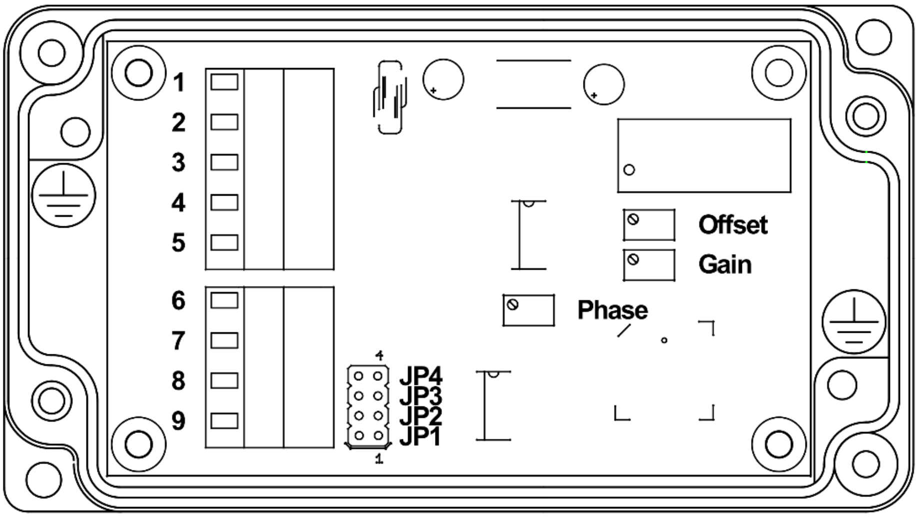

Figure 4 Layout of electronic board

Cable feedthroughs that are not used shall be closed with a suitable plug for protection against moisture and dirt from outside.

The individual strands of the connection cables are placed in the protected interior of the housing. The cable shield is connected to the housing with a grounding screw (M4).

HINT
To avoid humming loops, the cable shield should be connected on one side only. If possible, connect it to the source of the signal / voltage.

4.4.2 Dimensional Drawing of the housing

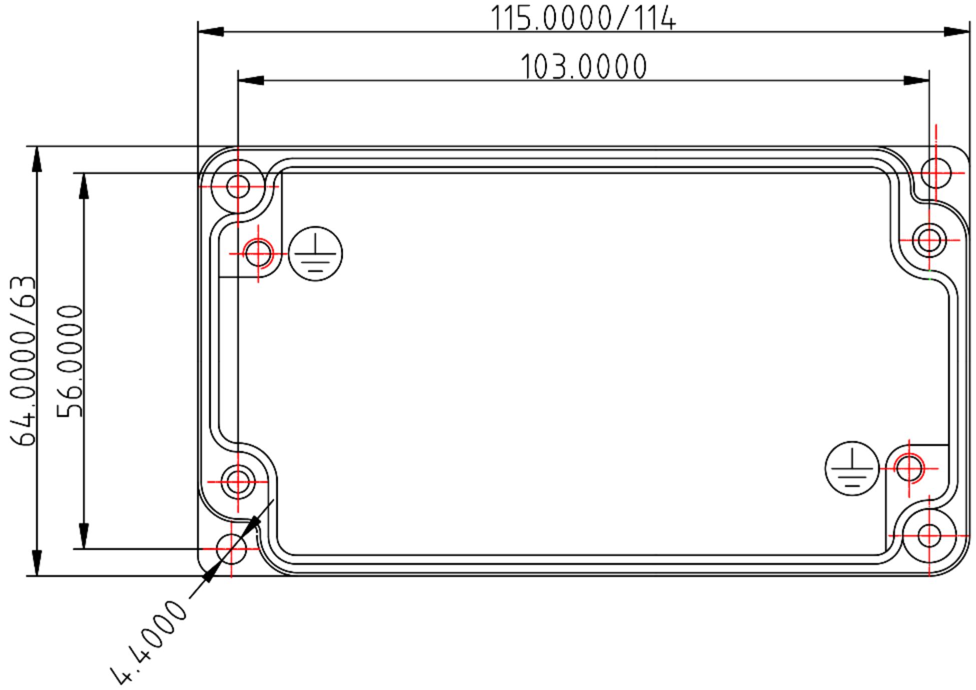

Figure 5 Layout of electronic board

5 Commissioning

WARNING
The amplifier may only be put into operation by qualified personnel.
Electrostatic discharges on electronic assemblies can lead to damage or direct failure of components. Therefore, take all necessary measures to avoid electrostatic charging (ESD protective measures).
Swapped or faulty connection, in particular external voltages connected to the signal output or sensor input / output can destroy the device.

If the connection cable is laid properly, the distance between the displacement transducer and the measuring amplifier can be up to 100 m and more.

TIP	Connect the inductive displacement transducer to the amplifier via a shielded, low-capacitance cable.
TIP	Do not route the cable parallel to power lines and at a sufficient distance from electric drives, transformers, and frequency converters that may create electromagnetic fields.

5.1 Wiring Details / Pin Assignment

The connection of the device / amplifier is carried out according to the assignment in the following table using spring-loaded terminals. There is no soldering work required.

Pin / Clamp	Type	Assignment
1	Supply	Supply voltage 24V-High
2	Supply	Supply voltage 24V-Low
3	Signal	Voltage output U_A
4	Signal	Current output I_A
5	Signal	Ground GND_A
6	Sensor	Excitation voltage EXC-
7	Sensor	Excitation voltage EXC+
8	Sensor	Signal MEAS+
9	Sensor	Signal MEAS-

Figure 55 Connection assignment

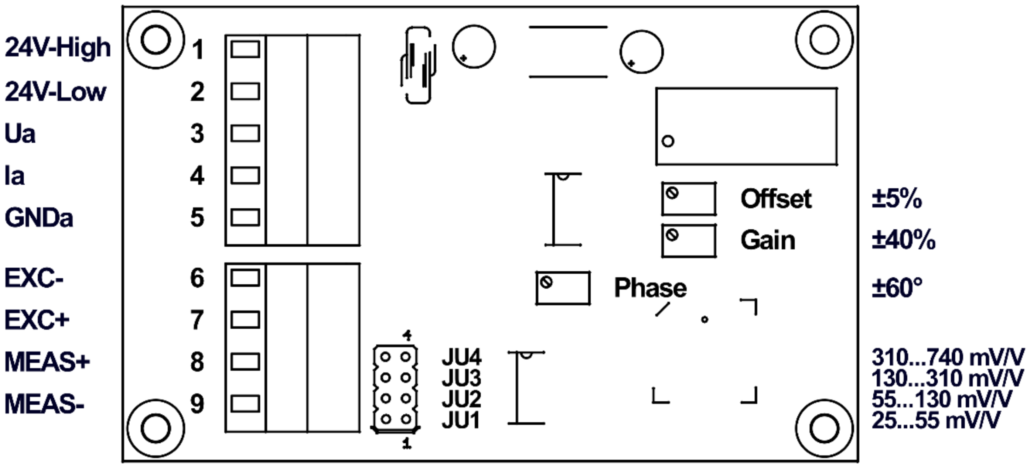

Figure 6 Layout of electronic board

5.2 Use with MESSOTRON transducers

When connecting a MESSOTRON displacement transducer according to the following table, a positive (growing) output signal results when the core is moved out of the displacement transducer, or the measuring tube is moved down / away from the transducer coil.

If an inverted negative (decreasing) signal is desired one of the terminals 8 and 9 or alternatively terminals 6 and 7 may simply be swapped.

MBI 46.51.39		Differential Transformer Transducer (LVDT) Dxx...			Differential Half-Bridge Transducer (LVIT) Wxx...			Long-Stroke Transducer WP…	
Clamp	Signal	Strand	Cable	Plug	Strand	Cable	Plug	Cable	Plug
6	EXC-	WH (BN)	WH	2 (B)	THIS	THIS	3 (C)	THIS	C
7	EXC+	THIS	THIS	3 (C)	RD	RD	2 (B)	RD	B
8	MEAS+	RD	RD	1 (A)	WH+YE	WH	1 (A)	WH	A
9	MEAS-	BK	BK	4 (D)	-	-	-	-	-

Figure 76 Connection of MESSOTRON displacement transducers

5.3 Setting and adjustment options

The measuring amplifier must be adapted to the displacement transducer used. The parameters to be set are:

- Type of transducer (symmetrical/unbalanced)
- Position of the electric zero point
- Compensation of the phase position
- Gain / Sensitivity

5.3.1 Position of the electric zero point

The electrical output signal of a real inductive displacement transducer is not always exactly zero at mechanical zero point (with MESSOTRON displacement transducers according to dimension A). Material and manufacturing tolerances can lead to deviations, which can be corrected with the zero point potentiometer. Low tolerances in the mechanical adjustment of the displacement transducer can also be compensated.

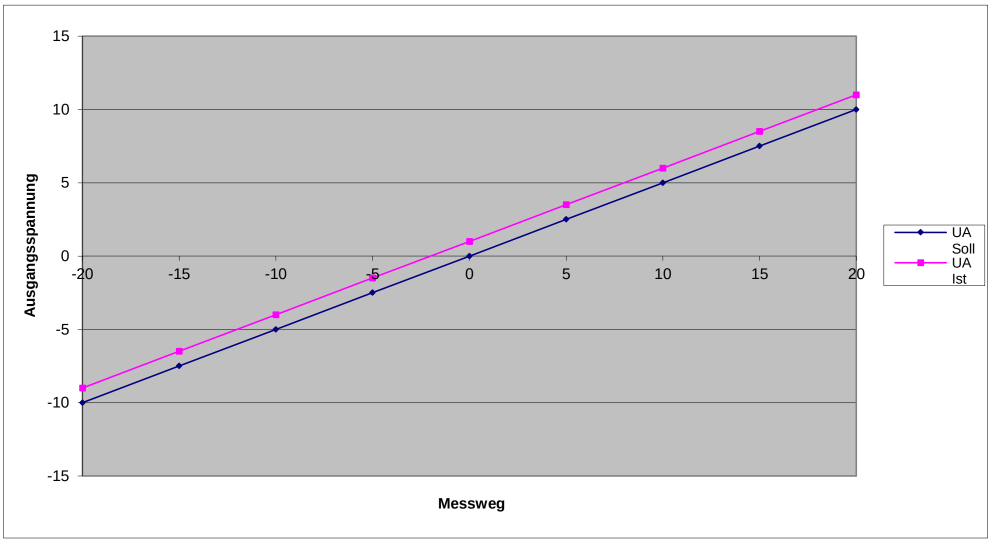

Figure 8 7Correcting the Zero Point

The adjustment of the zero point potentiometer causes a vertical shift of the measuring path-output signal characteristic curve. A larger shift of the electrical zero point, e.B. to the beginning or to the end of the measuring range, requires a change of the basic setting and cannot be carried out retrospectively.

5.3.2 Phasenkompensation

In the case of inductive displacement transducers, a phase shift between the supply and the measuring voltage can occur due to the principle.

The measuring amplifier evaluates the ratio between supply and measuring voltage in order to suppress measurement errors due to fluctuations in the supply voltage. If the phase shift is not compensated, this can lead to a deviation in the sensitivity of the displacement transducer.

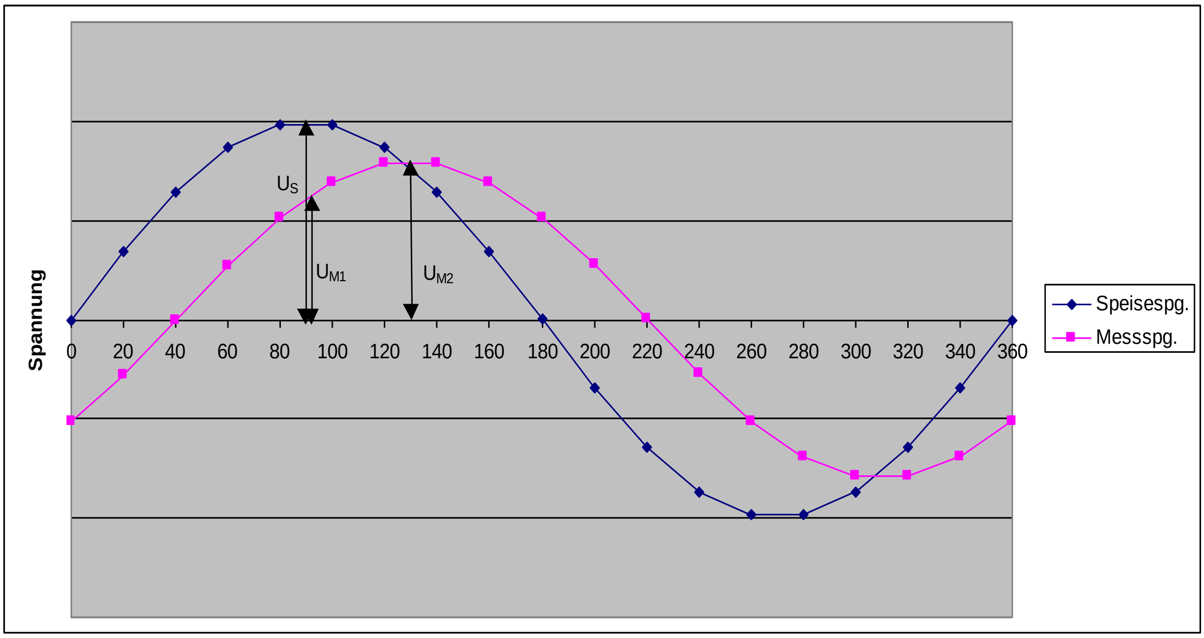

Figure 9 Shift

Figure 9 shows that without phase compensation, a reduced voltage ratio of U_{M1}/U_S results. Phase compensation results in an optimized voltage ratio U_{M2}/U_S.

Phase compensation shifts the evaluation of the measuring voltage in such a way that the phase position caused by the displacement transducer is compensated and the full sensitivity of the displacement transducer can be used.

5.3.3 Reinforcement

The gain of the amplifier must be adjusted depending on the nominal characteristic value of the displacement transducer used in order to obtain the desired output signal. If the output signal does not reach the desired value, e.B. at the end of the nominal measuring range, the gain must be increased.

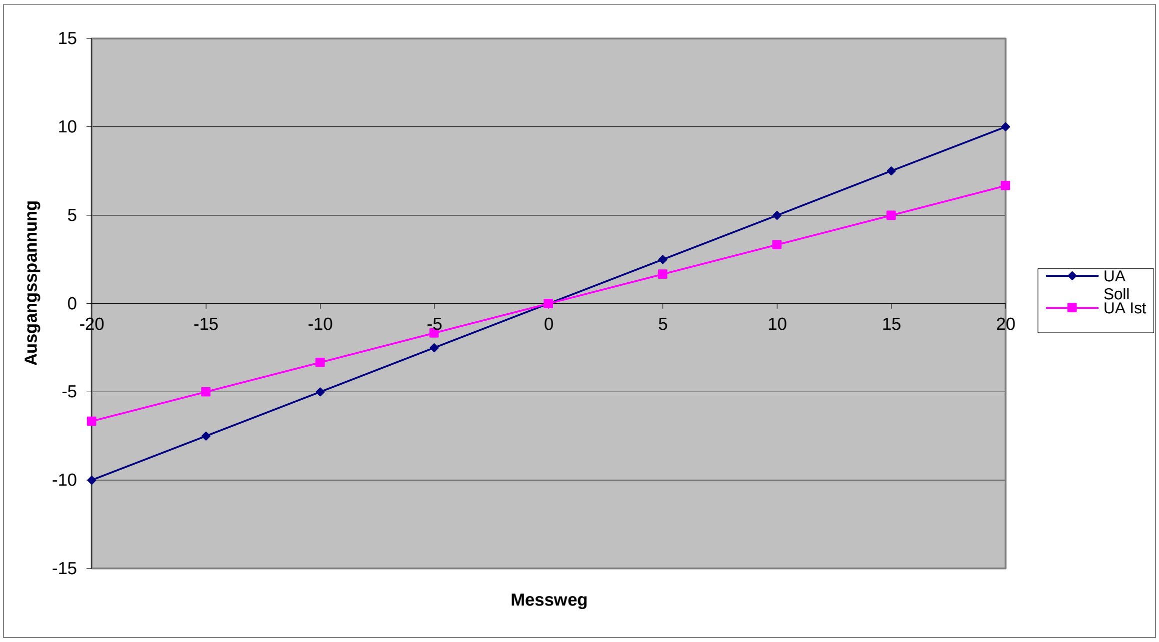

Figure 10 9Correct the gain

A higher gain causes a greater slope of the measuring path-output signal characteristic curve (or rotation of the characteristic curve counterclockwise).

5.4 Setting of transducer type

Before starting the adjustment, the measuring amplifier must be set whether an inductive displacement transducer with symmetrical or with asymmetrical coil mount is to be used. In the standard configuration, the amplifier is set for symmetrical displacement transducers. If an asymmetrical displacement transducer is used, the JP2 jumper must be plugged into the righthand position.

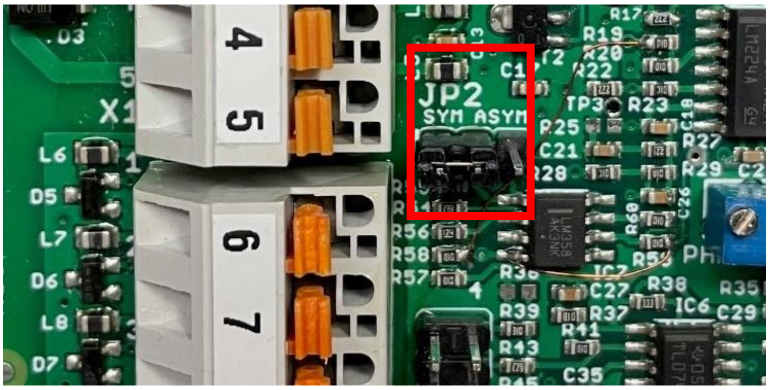

Figure 7 Selection of Transducer Type (Symmetric/Unbalanced)

5.5 Adjustment of gain range

To match the measuring amplifier with the sensitivity of the sensor, the gain range be selected by use of JP1 jumper. Depending on the nominal output signal of the transducer used, the plug-in bridge is plugged into one of the 4 gain ranges.

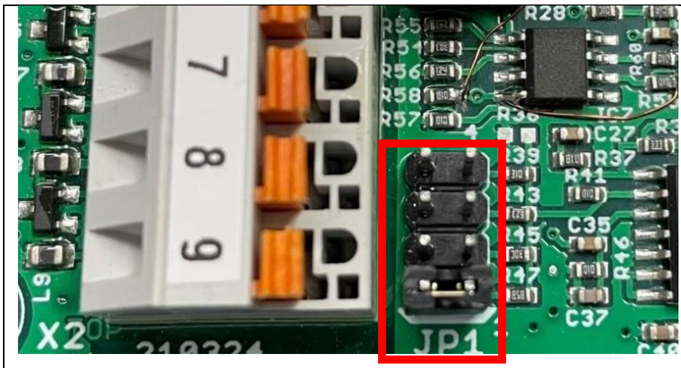	**Gain Range:** JP1-4: 310 ... 740 mV/V JP1-3: 130 ... 310 mV/V JP1-2: 55 ... 130 mV/V JP1-1: 25 ... 55 mV/V

Figure 118 Setting of Gain Range

5.6 Adjustment of offset, gain and phase-shift

Subsequently, the measuring amplifier can be adapted to the displacement transducer and the desired output signal by means of trimming potentiometers for fine adjustment. Small tolerances in the mechanical installation of the transducer can also be compensated.

TIP	The precise nominal properties of the measuring amplifier are only achieved after about 15 minutes of warm-up time.

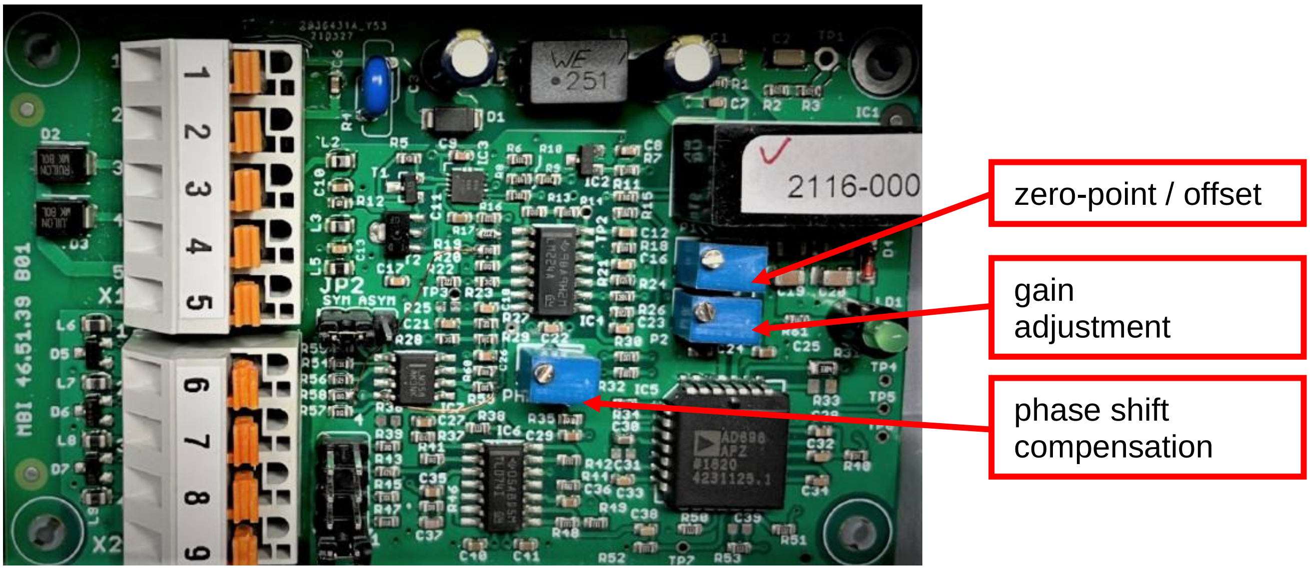

Figure 12 Position of the trim potentiometers

5.6.1 Adjustment process for symmetrical transducers

With symmetrical displacement transducers, the electrical zero point is in the middle of the nominal measuring stroke. Typically, the voltage output of the amplifier also provides a symmetrical output signal for a symmetrical displacement transducer.

- For **zero-point adjustment**, remove the core from the transducer and set the output signal of the amplifier to 0 V with the zero-point potentiometer. Then insert the core rod back into the displacement transducer and fix it in the center position so that the output signal is again zero. Small corrections with the zero-point potentiometer after mechanical adjustment are permissible.

  If the zero-point setting is not possible in the manner described, then you can alternatively bring the core into a position in which the displacement transducer delivers the same minimum value both with the usual connection and with swapped signal connection pin 6 and 7.
- Perform the **phase-shift adjustment** by moving the core to approx. 75% of the stroke and now set the output signal to its highest possible value / maximum by means of the phase potentiometer.
- For **gain adjustment**, move the core to the end of the nominal range and set the voltage to the desired output signal with the gain potentiometer. Then check the setting at the beginning of the nominal range and correct it slightly if necessary. If adjusting the output signal via the potentiometer setting range is not sufficient, switch the JP2 jumper to a different sensitivity range.

5.6.2 Adjustment process for asymmetrical transducers (WP series)

The zero point of an unbalanced displacement transducer is typically at the beginning of the nominal measuring range. As a rule, the measuring amplifiers for unbalanced displacement transducers are set in such a way that they have an output signal of 0...10 V or 4... 20mA .

- For **zero point adjustment**, bring the sheath anchor of the displacement transducer to the mechanical zero position (measure A) according to the data sheet and set the output signal of the measuring amplifier to 0 V with the zero point potentiometer.
- You perform **the phase adjustment** by moving the sheath anchor shortly before the end of the (nominal) measuring range and setting the maximum of the output signal with the phase potentiometer. If necessary, the gain setting must be adjusted. Then check the zero point setting and correct it if necessary.
- For **gain adjustment,** move the sheath anchor to the end of the (nominal) measuring range and then set the output signal to the setpoint with the gain potentiometer. If adjusting the output signal via the potentiometer's adjustment range is not sufficient for gain, change the JP2 jumper to a different sensitivity range (see 5.4.1).

5.7 Optimization of the linearity behavior

The procedure for the basic settings and the adjustments described in the previous chapters apply to a measuring with an "ideal displacement transducer" without linearity deviation.

However, real displacement transducers have a linearity deviation. In these cases, the linearity behavior of the transducer can be further optimized taking into account the respective measuring task.

Figure 13 shows the typical linearity curve of a symmetrical displacement transducer, as determined after setting the amplifier according to the steps described above. The maximum linearity error in the measuring range under consideration is 0.5%. It is zero in the middle and at the end of the measuring range.

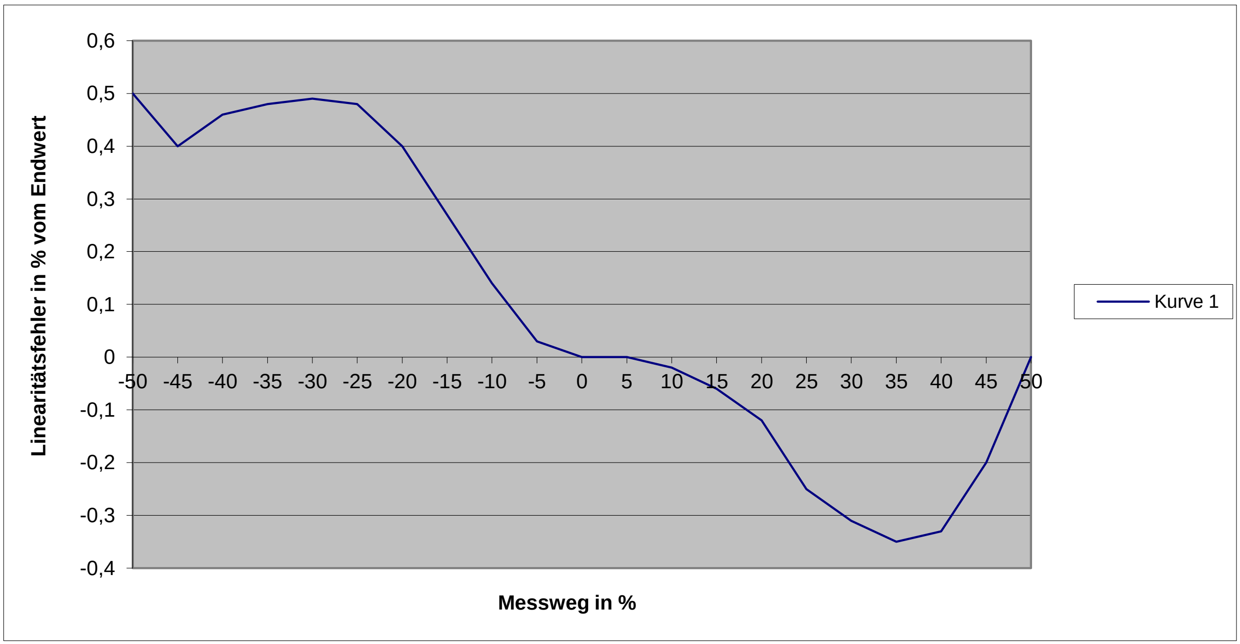

Figure 13 Typical error curve of a displacement transducer, without optimization

5.7.1 Optimization with the lowest error at zero point

If the measuring task mainly requires the lowest possible error in the zero point of the displacement transducer, the maximum deviation in the measuring range can also be reduced.

- To do this, adjust the gain in small steps. This causes a "rotation" of the illustrated linearity curve around the zero point; the zero-defect setting at the end of the measuring range is displayed.

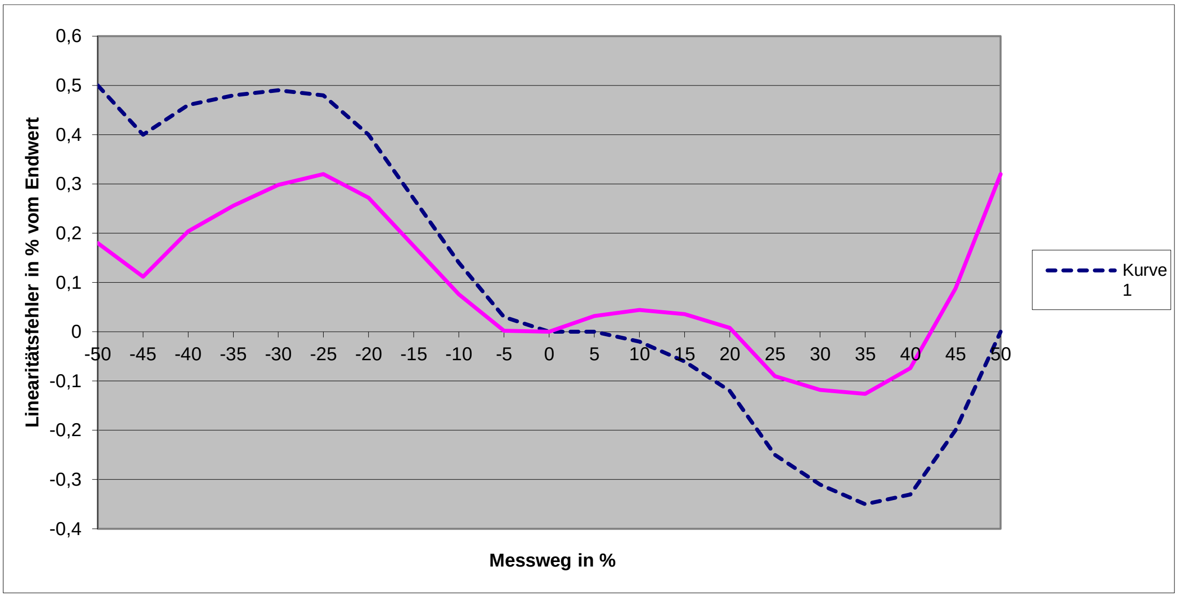

Figure 14 Ideal zero-point linearity, max linearity error reduced to 0.32%

5.7.2 Optimization with minimal absolute error

If the linearity curve shall be optimized for minimal overall absolute error diregarding the zero-point accuracy, then you can further improve the curve omitting the setting at zero point.

Slightly adjust the zero point by the potentiometer and thus move the linearity curve until the maximum positive and negative error are equal in amount.

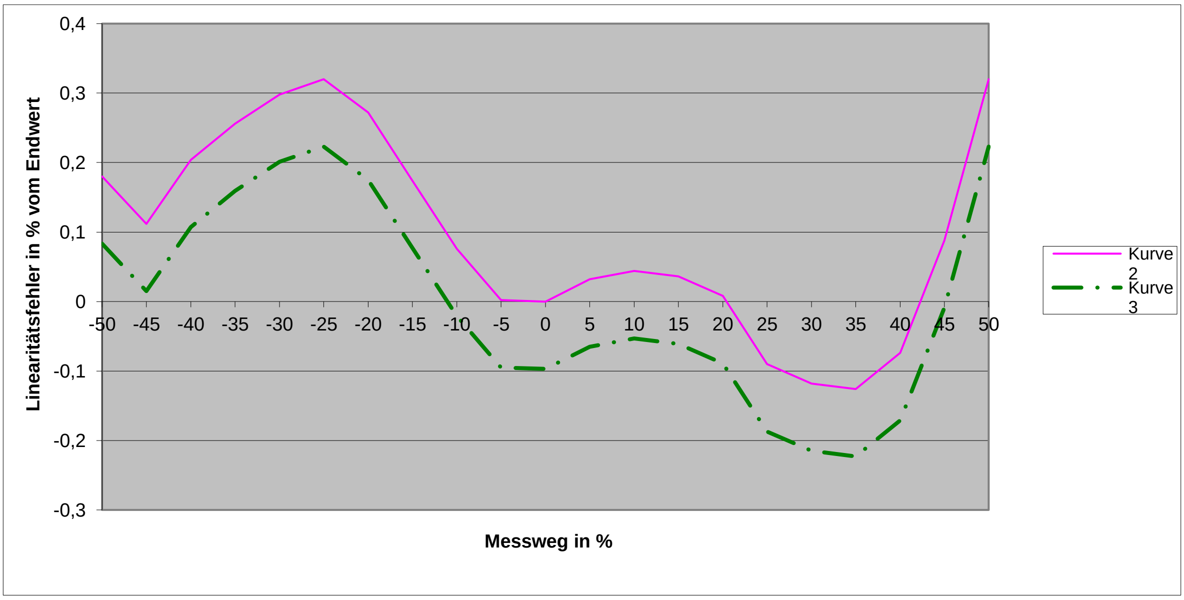

Figure 15 Lowest deviation (max. 0.22 %) in the entire measuring range

5.7.3 Other linearity optimizations

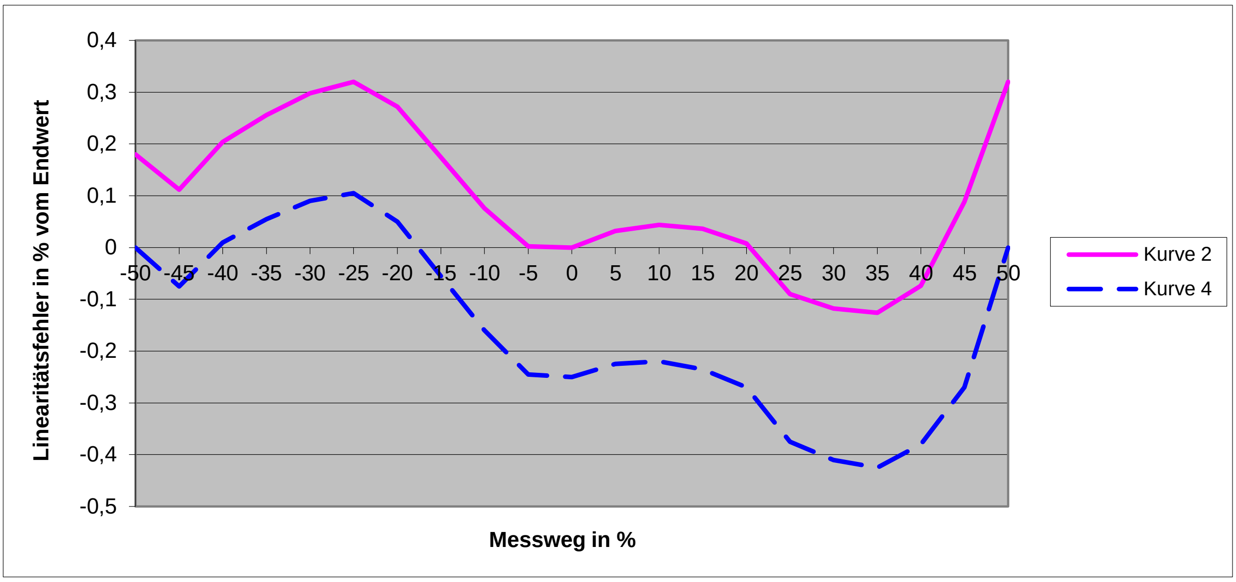

Figure 1613 Null error setting at the beginning and end of the measuring range

6 Operation

The device is intended for unattended continuous operation.

WARNING
For decommissioning, it must be disconnected from the power supply.
If foreign objects or liquids enter the device, have the device checked by MESSOTRON before using it again.

7 Repair

HINT
Do not try to repair a defective amplifier independently. Repair attempts of any kind lead to the loss of the warranty and liability claim.

MESSOTRON devices are intended for use in harsh industrial environments. They are designed for long-term, trouble-free operation. In case of a failure or damage, please contact us by phone or email: Phone: +49 (0) 6257 999 730; Email: info@messotron.com

If necessary, send the product for inspection to:

MESSOTRON GmbH & Co KG
Friedrich-Ebert-Str. 37
D-64342 Seeheim-Jugenheim

Germany

Please enclose a delivery note and a detailed description of the error.

8 Maintenance

8.1 Maintenance

The device does not contain any parts to be maintained.

8.2 Cleaning

HINT
Electrostatic discharges on electronic assemblies can lead to pre-damage or direct failure of components. Therefore, take all necessary measures to avoid electrostatic charging (ESD protective measures).

When cleaning, pay attention to the following points:

- Clean the case or front panel only with a soft, slightly damp cloth.
- Carefully remove dry dirt on the boards with a dust cleaner or brush.
- If liquid gets into the device, have the device checked by MESSOTRON before using it again.

9 Disposal

The device, any accessories and packaging must be disposed of in accordance with the respective national guidelines. Please note the national and local regulations for environmental protection and raw material recovery.

10 EU Declaration of Conformity

EU – Konformitätserklärung
Declaration of EU - Conformity / Déclaration de EU - Conformité

Hiermit erklären wir, dass die Produkte
Herewith we declare that the products / Nous déclarons que les produits

MBI 46.1x
MBI 46.31.1x, 46.31.3x
MBI 46.32.1x, 46.32.3x, 46.32.4x
MBI 46.33.1x, 46,33.3x
MBI 46.41.3x
MBI 46.50.xx
MBI 50.25.x
MBI 50.33.x
MNHCON, MNHµCON

die grundlegenden Anforderungen folgender Europäischen Richtlinien erfüllt
is in conformity with the following European Directives / est conforme à la dispositions de la Directive

☒ **EMV-Richtlinie** EMC Directive / Directive CEM — **2014/30/EU**

nachgewiesen durch die Einhaltung der aufgeführten harmonisierten Normen
verified by the compliance with the harmonised standards listed below /
et justifié par le respect des normes harmonisées mentionnées ci-dessous

EMV EMC / CEM — **DIN EN 61326-1 (2013)**

Jahr der Anbringung der CE-Kennzeichnung year of declaration / année de déclaration du marquage — **2016**

MESSOTRON
Hennig GmbH & Co KG

Seeheim-Jugenheim, den 14.02.2018

Stephan Hotz, Konformitätsbeauftragter

11 Specifications

MBI 46.51.39
Measuring amplifier for operation of inductive displacement sensors

Linearity error	< 0,1 % FSO
Carrier frequency	5 kHz ±5 % optional 1...20 kHz
Dynamic bandwidth	500 Hz (3 dB, at 5 kHz)
Excitation voltage (primary EXC+, EXC-)	approx. 2 V_{rms}, sinusoidal max. 12 mA_{rms}
Input resistance (secondary MEAS+, MEAS-)	approx. 100 kΩ
Output signal	4...20 mA impedance < 500 Ω, 0…10 VDC, load resistance > 10 kΩ
Noise level and residual carrier voltage	< 5 mV_{rms}
Temperature coefficient of zero point	< 0,10 % / 10 K @ 100 mV/V < 0,15 % / 10 K @ 20 mV/V
Temperature coefficient of gain	< 0,05 % / 10 K @ 100 mV/V < 0,15 % / 10 K @ 20 mV/V
Operating temperature	-30...+70°C
Storage temperature	-30...+85°C
Protection rating	IP66
Electromagnetic compatibility	DIN EN 61326-1
Supply voltage	10...36 VDC
Current consumption (@ 24 VDC)	max. 60 mA
Electrical connection	2 cable glands IP68 (power supply/output signal and sensor), spring-loaded terminals inside
Dimensional data	approx. 115 x 64 x 34,5 mm
Weight	approx. 0,3 kg

Suitable sensors

Inductive differential transformers (LVDTs)	with 4-wire technology
Differential inductors (LVITs) and Long-stroke sensors (eddy current design)	inductive half bridges with 3-wire technology
Rated output	25...740 mV/V
Input impedance	100...1000 Ω

Changes and errors excepted.

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