Installation and Operating Manual

PiezoAmplifier PA…

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The national and regional requirements for the environment protection and the recycling of the product no longer used have to be considered. Please dispose off separately from regular household waste. For further information on waste disposal, please contact your local authorities or the dealer, from whom you have bought the product.

The information contained in this document represents the current state of knowledge. ConSenses reserves the right for technical alterations. The liability for consequential damages resulting from the application of ConSenses products is excluded.

Contents

Neglecting safety instructions can result in injury to the operating personnel or damage to the equipment. Therefore, please follow safety instructions before each use.

Should you have any questions regarding this product, please contact the manufacturer:

ConSenses GmbH, Arheilger Weg 11, 64380 Roßdorf
E-Mail: info@consenses.de

1. Scope of delivery and accessories

1.1. Scope of delivery

The scope of delivery includes a ready-to-connect PiezoAmplifier with sensor and output connectors as well as this product documentation and a calibration protocol.

Figure 1: Product image with connection description (Image indicates optional output)

Furthermore, depending on the ordered accessories, connecting cables with different cable lengths are included.

1.2. Variants

The PiezoAmplifier can be ordered in different variations. Thus, the input charge range and the optional analog output (Figure 2) are selectable. For example Q14xN means the product variant with input charge range of up to 14,000 pC without additional option.

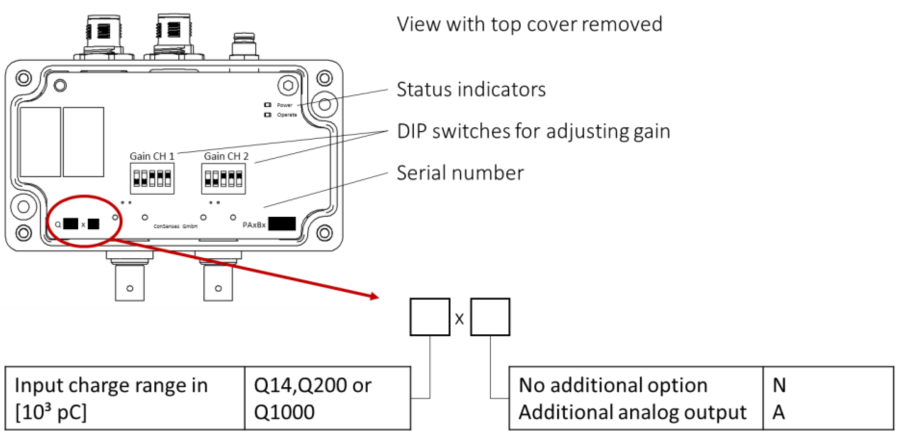


Figure 2: Product code

1.3. Accessories

The following connection cables are available for the sensor and output side connectors of the PeizoAmplifier:

Connection		Specification	Matchcode
Output side	PWR & OP	Sensor/ actuator cable with M8-socket 4-pin, unshielded, available in lengths of 5 m, 10 m, 20 m, 30 m, 50 m	LPAxPWRx 5/10/20/30/50
	Signal	Sensor/ actuator cable with M12-socket 8-pin, shielded, available in lengths of 5 m, 10 m, 20 m, 30 m, 50 m	LPAxSIGx 5/10/20/30/50
	Optional: Out	Sensor/ actuator cable with M12-socket 8-pin, shielded, available in lengths of 5 m, 10 m, 40 m	LPAxAOUTx 5/10/40
Sensor side	Extension charge signal	Ultra-low noise cable BNC to BNC plug with BNC to BNC socket adapter, available in lengths of 2 m, 5 m, 10 m	LCx 2/5/10

Table 1: Connection cables

2. Functional principle and application notes

2.1. Functionality

The first stage of the PiezoAmplifier consists of a charge amplifier. This works on the principle of an electronic integrator. Through the capacitive feedback of a high-impedance operational amplifier, positive and negative charge shifts are converted into an analog voltage signal. The operating modes "Operate" (high) and "Reset" (low) are switched by setting a measuring window in the form of a digital signal (0-2.7 V corresponds to "low", 20-24 V corresponds to "high"). The signal for specifying the measuring window is galvanically separated from the charge electronics by an optocoupler.

In the "Operate" mode, a continuous integration over time of the displaced charges through the connected Piezosensor takes place. In the "Reset" mode of operation, a compensation of the displaced charged is triggered by the short-circuiting of the input capacitance. The output voltage is zero.

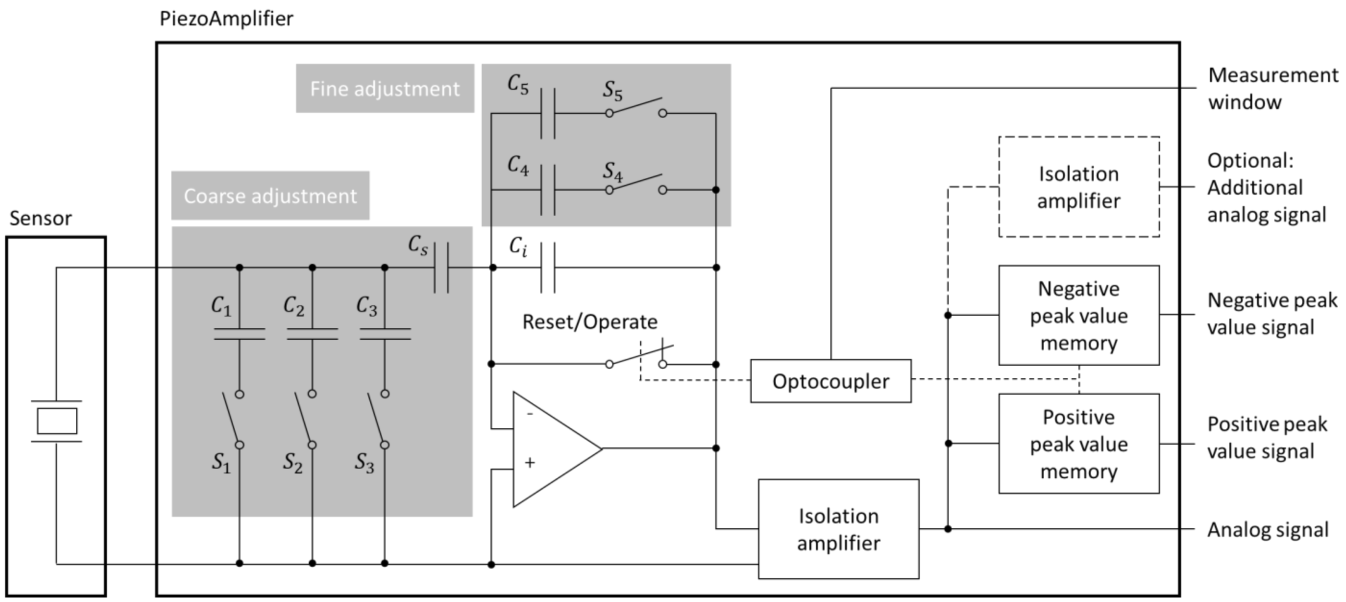


Figure 3: Block diagram of a signal processing channel

PiezoAmplifier contains two channels for signal amplification each with 16-fold adjustable gain. For each channel, an analog peak value memory is available for stabilizing the positive and negative peak values. Please note that the peak value memory works in a highly dynamic manner up to the limiting frequency of the PiezoAmplifier but it is not long-term stable (about 10s).

In order to avoid unintentional ground loops during system integration, each channel is equipped with an isolation amplifier.

Optionally, another analog output can also be ordered as a system variant. This ensures that there exists no interaction between the connected signal processor devices. If, for example, the negative peak value signal is connected to a machine control system and the additional analog signal is connected to a measurement system, the isolation amplifier integrated in the PiezoAmplifier prevents malfunctioning in one of the system from affecting the other system.

2.2. Setting options

For gain adjustment power off the device an open the top cover as explained in Section 4.2.

Figure 4 shows the arrangement of the switches. The switch position shown is the status of these switches at the time of delivery and corresponds to the lowest amplifier setting: 0 0 1 1 1.

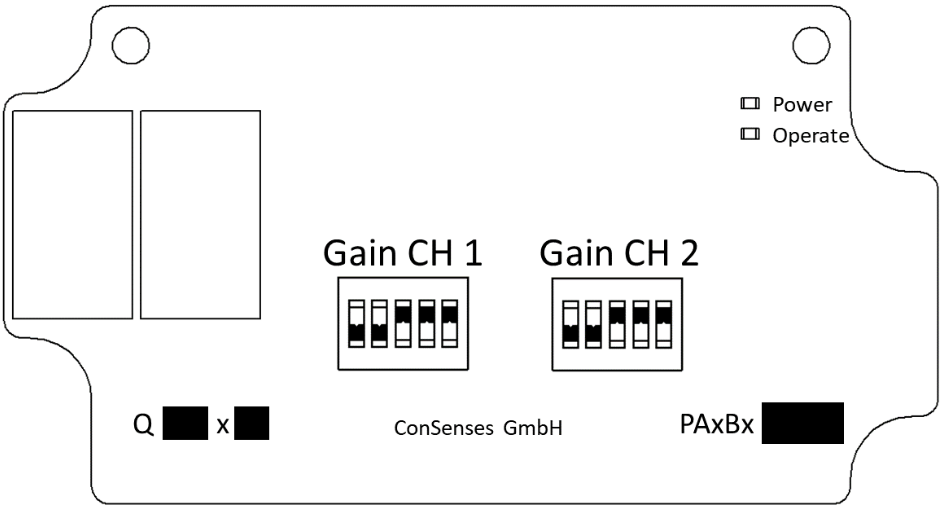


Figure 4: Arrangement of the DIP switches

Each channel has a fivefold DIP switch. The lower switch position means "0" and the higher "1". The desired gain can be selected by coarse and fine adjustment.

Please note:

- The gain adjustment is performed for each channel separately.
- Before changing the gain, make sure that the permissible range for the input charge is not exceeded.
- When changing the gain, first set the required switches to 1, then change the switch to 0 if necessary. Otherwise there exists a theoretical risk of damage! (see Figure 5)

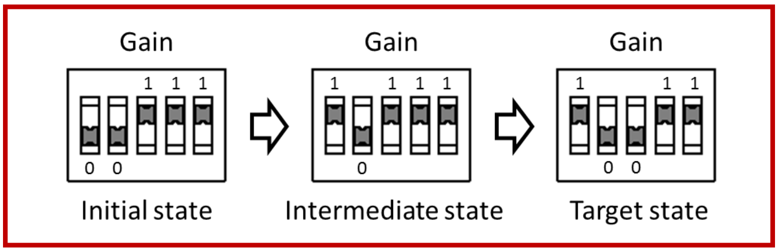


Figure 5: Example gain selection

For each amplifier setting, the corresponding charge ranges for all 3 variants Q14, Q200 and Q1000 are listed in Table 2. Due to the component tolerances the actual ranges can deviate by up to ± 5%.

Coarse	Fine	Charge Ranges [pC] for 0...10V				
				Q14	Q200	Q1000
0 0 1	1 1	0	-	13,970	219,170	1,069,547
	0 1	0	-	11,990	171,700	817,015
	1 0	0	-	9,680	118,170	512,491
	0 0	0	-	7,700	70,700	259,959
0 1 0	1 1	0	-	6,004	48,529	130,880
	0 1	0	-	5,153	38,018	99,978
	1 0	0	-	4,160	26,165	62,713
	0 0	0	-	3,309	15,655	31,811
1 0 0	1 1	0	-	2,829	8,877	18,880
	0 1	0	-	2,428	6,955	14,422
	1 0	0	-	1,960	4,786	9,047
	0 0	0	-	1,559	2,864	4,589
0 0 0	1 1	0	-	1,270	2,170	2,880
	0 1	0	-	1,090	1,700	2,200
	1 0	0	-	880	1,170	1,380
	0 0	0	-	700	700	700

Table 2: Charge ranges

2.3. Exemplary measurement result

Figure 6 shows a typical measurement result. Measurement window is periodically opened (by applying 24 V at the measurement window connection) and closed (0 V), so that time-continuous charge signals can be read at the analog output. The positive and negative peak value memory persists with the respective maximum or minimum values during the opened measuring window.

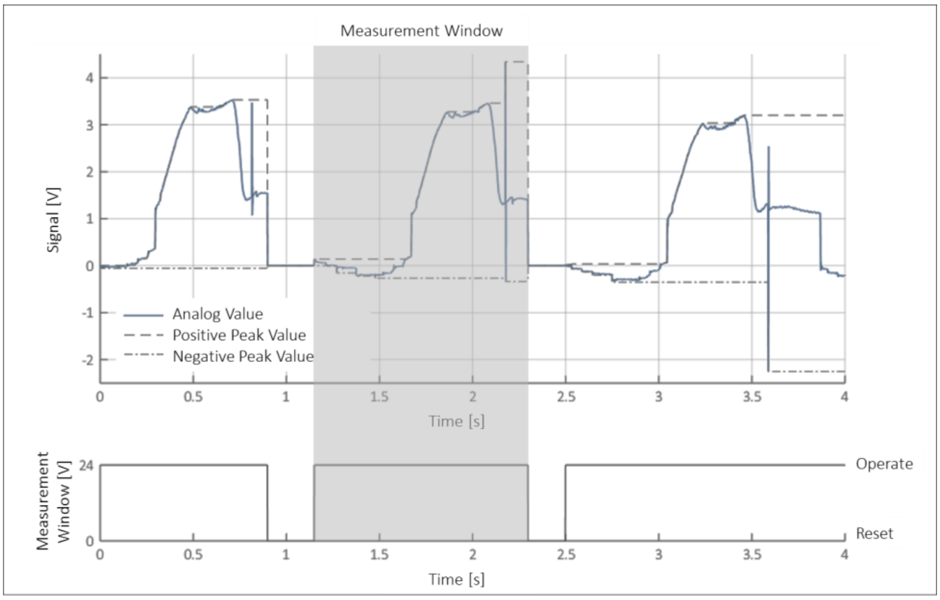


Figure 6: Exemplary measurement result

The output voltage is dependent on the coarse and fine adjustment made (see Figure 3):

$$U = \frac{x}{C} \cdot Q$$

U: Output Voltage [V] x: Attenuation ratio C: Input capacity [pF] Q: Input charge [pC]

Depending on the product variant, the following values apply (Deviations of ± 5% possible due to component tolerances):

Coarse	x		
	Q14	Q200	Q1000
0 0 1	0.1	0.01	0.003
0 1 0	0.2	0.04	0.02
1 0 0	0.45	0.24	0.15
0 0 0	1	1	1

Fine	C [pF]		
	Q14	Q200	Q1000
1 1	127	217	288
0 1	109	170	220
1 0	88	117	138
0 0	70	70	70

Table 3: Gain values

If the measurement shall be based on a corresponding channel setting, the following calculations can be made:

1. Conversion of the voltage value into a charge value or rather into a force or acceleration signal as the case may be (see chapter 2.3.1)
2. Achieve a higher output signal at the same input charge by selecting another gain value (see chapter 2.3.2)

2.3.1. Conversion into a measurement variable

Compatible force or acceleration sensors with a piezoelectric operating principle generally have the specification of sensor sensitivity S. For force sensors, this specification is in the unit $[S_{Force}]$ = pC/N and for acceleration sensors in the unit $[S_{Acc}]$ = pC/g (g: multiple of acceleration due to gravity).

Therefore it is first necessary to convert output voltage into charge:

$$Q = \frac{C}{x} \cdot U$$

Subsequently, the measurement variable can then be calculated through the quotient of charge and sensor sensitivity:

For force sensors: $F = {}^{Q}/_{S_{Force}}$; $[F] = N$; For acceleration sensors: $a = {}^{Q}/_{S_{Acc}}$; $[a] = g$

2.3.2. Setting the range of the output voltage

The following table gives the overall gain factor $V_{overall}$ based on the input charge range for the mentioned product variant.

Coarse	Fine	$V_{overall}$		
		Q14	Q200	Q1000
0 0 1	1 1	1.00	1.00	1.00
	0 1	1.17	1.28	1.31
	1 0	1.44	1.85	2.09
	0 0	1.81	3.10	4.11
0 1 0	1 1	1.91	4.52	8.17
	0 1	2.22	5.76	10.70
	1 0	2.75	8.38	17.05
	0 0	3.46	14.00	33.62
1 0 0	1 1	4.24	24.69	56.65
	0 1	4.94	31.51	74.16
	1 0	6.12	45.79	118.23
	0 0	7.70	76.54	233.07
0 0 0	1 1	9.39	101.00	371.37
	0 1	10.94	128.92	486.16
	1 0	13.56	187.32	775.03
	0 0	17.04	313.10	1527.92

Table 4: Variants depending on overall gain

If a need exists for a higher output signal for the same input charge, the following course of action is proposed:

First determine the output value for the channel settings made (for example 01011 with $V_{overall,Q14,before}$ = 1.91; U_{before} = 5 V. Set the desired output signal fixed (for example U_{after} =7 V).

$$V_{overall,after} = \frac{U_{after}}{U_{before}} \cdot V_{overall,Q14,before} = 2.67$$

3. Safety instructions

3.1. Intended use

The PiezoAmplifier is designed to be used as a signal converter in the measurement chain for the measurement of quasi-static and dynamic forces within the range specified by the technical data of the respective nominal load capacity. The use as a machine element also requires compliance with safety factors.

Any other use is not intended.

In order to mandate a safe operation, the product may only be used in accordance with the assembly instructions and in compliance with the following safety regulations along with the provided technical data. When in use for a particular application, the legal and safety regulations must also be observed. This applies similarly when the using accessories.

The use of charge amplifier as a safety component is not intended.

Proper transport, appropriate storage and professional installation along with careful operation and maintenance are absolutely essential for correct and safe operation of charge amplifier.

3.2. Operating staff

This product is to be mounted and operated exclusively by the qualified personnel in accordance with the technical data in context with the undermentioned safety rules and regulations.

Qualified personnel are considered those who have been trained as operators of the facility and instructed with the safety concept and are familiar with the operation of product as described in the documentation. The operator must have carefully read and understood the installation instructions and safety precautions.

When using PiezoAmplifier for the specific application, safety regulations for that particular application must also be observed. The same applies as well when using accessories.

Pay attention to safety conscious work and compliance of relevant accident prevention regulations.

3.3. Safety regulations and load capacity

For a safe operation of the PiezoAmplifier, instructions regarding installation and load capacity are to be absolutely observed. Maximum load specified in the technical datasheets must not be exceeded. This concerns:

- Maximum charge transfer at the measurement input with the corresponding gain setting.
- Procedure for the adjustment of amplification factors.
- Temperature limits

Signal cables of the sensors must be installed so that the electromagnetic emissions do not cause interference to the sensor functionality.

Before each application, project planning and risk analysis should be carried out that takes into consideration all safety aspects of the surrounding technology. This applies particularly to the protection of personnel and equipment. In order to avoid defects or errors in systems that have a personnel, equipment damage or loss of data, additional safety precautions must be taken into consideration.

3.4. Supplementary notes on safety instructions

The PiezoAmplifier as a transducer cannot assume any safety related feature by itself. For this reason additional components and equipment required for the safety of the installer and operator should be equally taken care of. Electronics handle the measurement signal such that in case of a failure of measurement signal, no subsequent damages can occur.

In the event of a failure through breakage or malfunctioning of charge amplifier that can cause harm to persons or equipment, the user must arrange to reach a securer operating state. Such measures can, for example, be achieved by joining or disjoining the safety devices or something similar and must at least satisfy the applicable accident prevention regulations.

3.5. General dangers of neglecting safety instructions

The PiezoAmplifier conforms to the state of the art technology and are reliable to operate. However, an element of risk exists when operated improperly. For this reason, any person entrusted with installing, operating and dismantling of the device should read and understand the operating manual, especially the safety instructions.

Due to the improper use of PiezoAmplifier or by the nonobservance of safety instructions, damage, malfunction, failure or breakage of PiezoAmplifier can occur. Especially by the failure of force sensors, equipment or persons in the vicinity can be harmed. A malfunction or failure of the PiezoAmplifier can have the consequence that the items or personnel in the vicinity of the PiezoAmplifier can be brought into danger.

The services and items delivered as the product covers a signal converter and is only a part of the measuring chain. Additional safety related checks of the measurement chain are to be planned, realized and implemented by the equipment designer/installer/operator to minimize residual hazards. Existing regulations are to be observed.

3.6. Alterations and modifications

The product is not allowed to be modified without the explicit consent of the manufacturer. Any modification shall exclude any liability of the manufacturer for resulting damage.

4. Mechanical installation

4.1. General installation guidelines

Handle the device carefully. This is to prevent any damage that may cause distortion in measurement signal. Make sure that the PiezoAmplifier is protected from harsh conditions like salt water, oil, cooling lubricant, snow, rain or ice.

Protect the contact points against any contamination and do not touch the terminals. False signals occur if there is a decrease in the insulation resistance of the electrical measurement system consisting of piezo sensor, signal cable and signal converter. Symptom of such a decrease in insulation resistance is positive or negative signal drift of the nominal output span without any force applied.

The use of PiezoAmplifier in extremely humid conditions (>80% rel. humidity) should be avoided. PiezoAmplifier with the attached signal cable possess the protection class IP67 in accordance with DIN EN 60529. This protection is ensured as long as the cable connection is properly installed.

Please make sure that the force sensor is not overloaded (see Section **3.3**). In case of an overload there exists a danger of failure, which poses a risk to the safety of the operating staff and the resulting system. Take measures to protect against overload or take appropriate measures to handle the consequences of such a failure.

4.2. Mechanical Installation

Unscrew the four countersunk screws (see Figure 7 left) with a cross tip screw driver and remove the top cover.

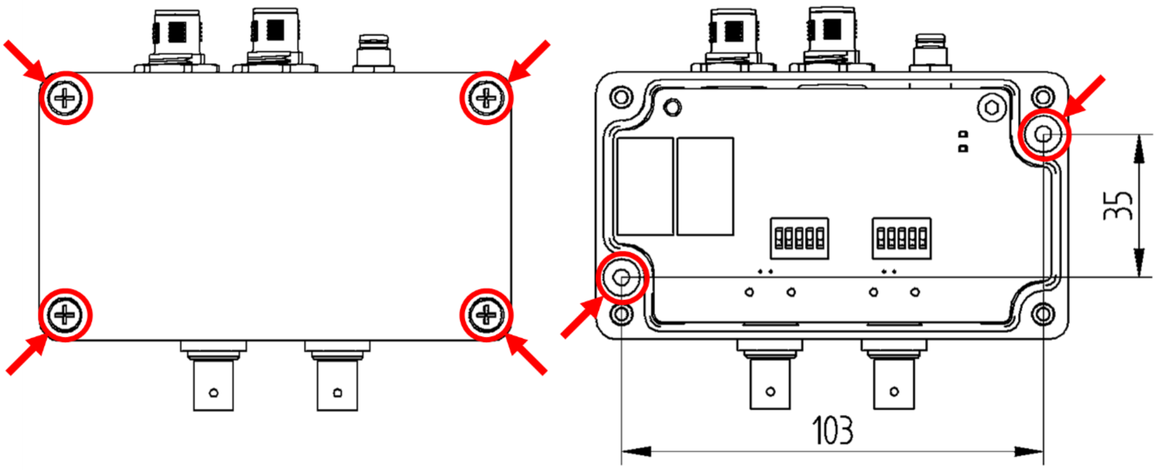


Figure 7: Mounting

The charge amplifier body is fixed with 2 cylindrical screws (M4x16 till M4x20). The holes provided for this purpose are shown in the Figure 7 on the right, encircled in red. During assembly, the correct tightening torque (2.9 Nm for strength class 8.8) as well as a screw securing must be observed.

It is also important to ensure that a sufficient distance to the next wall or neighbouring equipment is maintained, so that the cables can be routed correctly without the need for minimum bending steps (see Dimensions in Section 6.1). After the installation and adjustments, the cover has to be screwed again. The tightening torque of the countersunk screws is 0.50 - 0.75 Nm.

5. Connection

5.1. Sensor side

Appropriate connecting cables for piezo-based force sensors are typically characterized by a very high Internal resistance (>10 TΩ) and a special construction of cable to minimize triboelectric effects. Furthermore, the capacitance of the cable must be low. The ConSenses signal cable LC... meets these requirements and also features appropriate terminals at the receiver as well as the amplifier side. Handle the signal cable carefully, as any damage can directly deteriorate the signal quality. It is strongly recommended to immediately replace damaged cables.

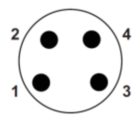
In order to prevent signal interference due to triboelectric effects, care should be taken when laying the signal cable that the cable is moved as little as possible and at best remains in rest. The minimum cable bending radius of 26 mm must not be underrun, so that any damage to the cable construction is avoided. Avoid stray field of motors, transformers and switches. Also avoid immediate vicinity of power supply lines or hot parts for laying signal cables.

When connecting the signal line to the charge amplifier, make sure that the measuring amplifier is in the "Reset" mode during the connection in order to avoid damage to the amplifier (for example by detaching the PWR&OP connections).

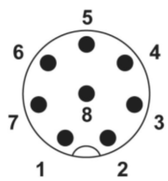
5.2. Output side

The plug connections or rather the available connection cables (see Section 1.2) are as follows

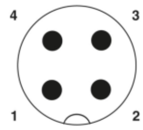
Power / Measurement window (4-pin M8-plug):

Contact Nr.	Wire colour	Function	Plug diagram
1	bn	Measurement window	
2	wh	-	
3	bu	+ 24 VDC	
4	bk	GND	

Analog signals (8-pin M12-plug), shielded:

Contact Nr.	Wire colour	Function	Plug diagram
1	wh	CH1 analog value	
2	bn	CH1 pos. peak value	
3	gn	CH1 neg. peak value	
4	ye	CH2 analog value	
5	gy	CH2 pos. peak value	
6	pk	CH2 neg. peak value	
7	bu	GND	
8	rd	-	

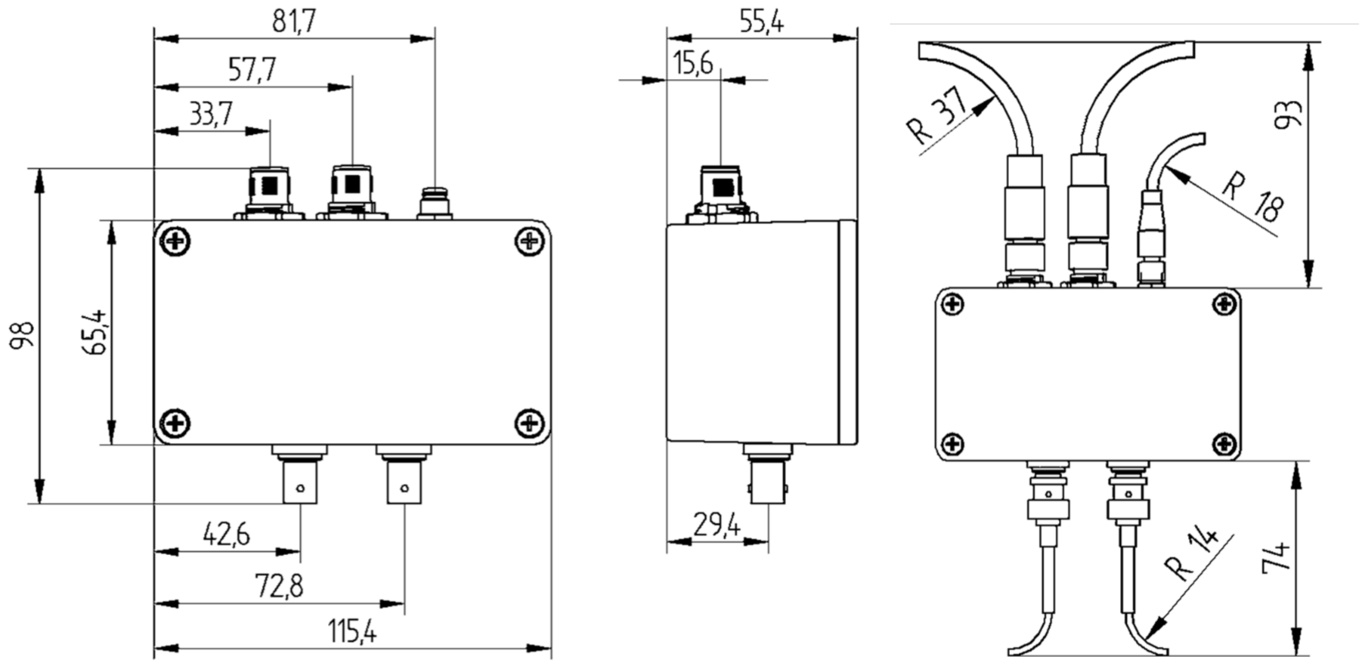
Additional output (4-pol M12-Stecker), shielded:

Contact Nr.	Wire colour	Function	Plug diagram
1	bn	CH1	
2	wh	CH2	
3	bu	-	
4	bk	GND	

6. Datasheet

6.1. Dimensions

Top view   Side view   Cable connections



6.2. Technical data

Operating temperature	°C	-20 … 70
Protection class according to DIN EN 60529 (with connected cable)		IP67
Input charge ranges	pC	Q14: 0…13,970 Q200: 0…219,170 Q1000: 0…1,069,547
Measurement window	V	Reset: 0… 1 Operate: 20 … 26 (Typically 24)
Output signal	V	± 10
Power supply	VDC	18 … 36
Maximum current consumption	A	0.2 (at 24 VDC)
Frequency limit	Hz	50,000

7. Declaration of conformity

CE

We,

ConSenses GmbH, Arheilger Weg 11, D-64380 Roßdorf, Germany

Declare under our sole responsibility that the product

PiezoAmplifier

In the design

PAxB…

Meets the following regulations of the European Union:

Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility

Consequently, the underlying relevant standards or normative documents are listed herein:

EN 61326-1: 2013 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements

EN 61326-2-3:2013 Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-3 Particular requirements – Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning

Signed for and on behalf of:

ConSenses GmbH

Roßdorf, 14.07.2017

Dr. Matthias Brenneis, Director