CONMONSense sensor: application note

Preamble

Welcome to our comprehensive guide on our sensor technology called "CONMONSense." In this document, we will provide you with an in-depth overview of our new product range, highlighting its features, applications, and the benefits it offers to various industries. CONMONSense sensors represent a leap forward in sensor technology, combining advanced capabilities with simplicity and affordability.

The CONMONSense sensors utilize advanced technology and features that enable to deliver ultrasound measurements consistently.

With their robust design, they can be installed in the most challenging environments to increase reliability, while reducing downtime and maintenance costs.

The new sensor range offers a wide spectrum of features and options that can enhance the functionality of your existing monitoring system to help you achieve better results and improve asset performance.

1. Definitions

The SDT CONMONSense range introduces several heterodyned ultrasound sensors that are sensitive to vibroacoustic phenomenon propagated in the air or through a solid medium. Unlike the SDT sensors of the SDT handheld devices, the SDT CONMONSense sensors directly provide audible signals that can be acquired and stored by your existing systems. This eliminates the need for dedicated SDT handheld devices requiring higher sampling rates, making the monitoring process more efficient and easier to implement in your organization.

The CONMONSense sensors are equipped with embedded analog electronics that heterodyne and condition the signals using analog filters. This helps focus on the useful response of the sensor, making it easier to connect to your existing acquisition systems.

The sensors have a typical band-pass frequency range of 4 kHz, image of ultrasound signals, enabling any compatible acquisition system to acquire audible signals at moderate sampling rates. The recorded signal is directly available in the optimum sensitivity range of human hearing.

The analog outputs are standardized to be easilly interfaced with any acquisition systems, including SDT VIGILANT. The CONMONSense sensors are available in mode AC (signal) and DC (RMS only), making them adaptable to a wide range of applications.

Source: https://blog.veris.com/choosing-analog-signal-types-for-industrial-sensors-0-10v-or-4-20ma

a. What are the different designs for?

In compliance with ISO 29821:2018, 2 designs are available, namely:

1. structure borne or contact resonant sensor.
2. airborne sensors, having different IP ratings (IP65 and IP40) to best suit the constraints of your environment.

The CONMONSense sensors, available in both contact and airborne designs, share similarities with the sensors compatible with SDT handheld devices. However, they have some distinctions, in terms of their signal measurement capabilities. The CONMONSense range employs an embedded electronics system that performs the heterodyne process within the sensor itself. While the CONMONSense sensors offer advanced compatibility, their electronics result in a minimum measurement capacity close to 15-20 dB[µV] (depending on the mode) which means that, in this case, sensors dedicated to the SDT hand-held instruments should be preferred. This means that CONMONSense may have limitations when it comes to measuring weak signals. In summary, the typical background noise, and the capability to acquire weak signals remains typically x 2.5 times better for the combination of the SDT instruments sensors compared to CONMONSense.

b. Typical applications

In short, any application covered by our handheld devices can be permanently monitored with CONMONSense. Below, a generic guideline to help decision-making based on the 8 ultrasound application pillars:

Ultrasound pillar	**Main ultrasound source/ CONMONSense recommendation**	**Dedicated SDT solutions**
	Structure borne	RS2T RS2NL100-300-500
	Structure borne	LUBESense1
	Airborne	Flex ID2 AIRSense ULTRASense
	Airborne	Flex ID2 AIRSense RS2A ParaDish2
	Structure borne	RS2T RS2NL100-300-500
	Structure borne	RS2T RS2NL100-300-500
	Both	RS2T RS2NL100-300-500

	Airborne + liquid Not covered by CONMONSense	TTS2

c. Benefits of the CONMONSense sensors:

- Step into the world of ultrasound: experience the easiest way to measure ultrasound signals already transformed into audible signals, while using conventional acquisition systems that are often limited by their sampling frequency.
- Enhanced Efficiency: by providing real-time and accurate data, the CONMONSense sensors enable businesses to optimize their processes, reduce waste, and improve productivity.
- Cost Savings: with their affordability and extended compatibilities, the CONMONSense sensors help organizations reduce operational costs and increase profitability.
- Data-Driven Decision Making: the sensors provide valuable insights, enabling informed decision making and proactive maintenance strategies.
- Scalability: with a complete range, the CONMONSense sensors can be easily integrated into existing systems, allowing for scalable deployment across different industries and applications.
- Simplified Implementation: sensors come with user-friendly interfaces and comprehensive documentation, ensuring straightforward installation and configuration, to give a sixth sense to your installations.

d. What are the different output types?

In industrial applications, analog sensors play a crucial role for capturing and transmitting information in the form of analog signals. Here are the four popular types of analog outputs commonly use in industrial settings:

- 4-20 mA
- 0-10 V
- IEPE (coming soon)
- LOW POWER, designed for IOT module powered on batteries (coming soon)

The CONMONSense sensors can be easily integrated with acquisition systems, which are typically equipped with voltage and/or current channels of type **DC or AC**, as inputs. These systems can be used to process and analyze signals generated by the sensors, providing valuable insights into the performance of the asset being monitored.

When it comes to ultrasound heterodyned sensors called SDT CONMONSense, the electrical range generated at the output of the sensor, in dynamic mode (AC mode), represents the amplified ultrasound signal. This signal can be in the form of voltage or current and can be acquired then analyzed by your acquisition system to provide critical information about the health of the asset.

By utilizing the analog CONMONSense sensors in combination with compatible acquisition systems, you can gain greater visibility into the performance of your systems and take proactive steps to prevent downtime and improve efficiency. The versatility and reliability of analog sensors make them a cost-effective solution for a wide range of industrial applications.

- CONMONSense, version RSV.00X, delivers a **0-10 V analog voltage output, in dynamic mode (AC mode).** The voltage range represents a variable signal (AC), oscillating around VBias, accepted by most industrial equipment. The 0-10 V requires 3 wires, namely GND, SIGNAL and POWER because the power supply (DC Type) and signal (AC type around 3 V DC) are physically separated and, therefore, the wiring requires 3 separate connections. The most appropriate Gain, corresponding to an optimal output range in **[1-5] V** is to be configured by the user.

- CONMONSense, version RSC.00X, delivers a **4-20 mA analog current output, in dynamic mode (AC mode)**. This output standard is widely used in process control instruments, due to its reliability and ease of integration. The cabling requirements vary depending on the configuration. The CONMONSense RSC supports "active loop" and "passive loop". In "loop powered/passive loop configuration", the current loop is utilized as the power supply, which means that only 2 wires are required. On the other hand, in "passive configuration ", one additional connection is necessary to provide power to the sensor (+24 V DC). In both cases, the most appropriate Gain, corresponding to an optimal range of [4-20 mA] is to be configured by the user.

  One of the major benefits of the 4-20 mA output standard is its high immunity to electrical noise, making it ideal for industrial applications where electrical interference can be a problem. This feature ensures accurate and consistent readings over long distances, even in harsh environments where other types of signals may be prone to interference.

- CONMONSense, version **RSC.10X sensors (DC mode),** also called **TRUE 4-20 mA**, focus on measuring the Root Mean Square (RMS) value of the ultrasound signal, over time without the need to configure Gain. This RMS value represents the average energy level contained in the ultrasound band-pass frequency and, therefore, is valuable for analyzing trends, identifying anomalies, and serving as a first line of defense in the detection of variations or potential issues.

- CONMONSense, version **RSIE.00X**, refers to IEPE (Integrated Electronics Piezo-Electric) voltage output, also known as ICP sensor. Thanks to its IEPE circuit, the power supply (DC type) and sensor signal (AC type) are coupled via the same wire (IEPE+), like standard accelerometer, which means that the cabling requires only 2 wires (IEPE+ and IEPE-). The most appropriate Gain is to be configured by the users.

- CONMONSense LOW POWER, version **RSV.11X**: with the rise of Internet of Things (IoT) applications, sensors designed for low power consumption have become essential. These sensors are typically optimized for battery-powered IoT modules and transmit data using low-power communication protocols "LPWAN" such as Bluetooth Low Energie (BLE), Zigbee, etc. Therefore, the analog output signals from these sensors represent only the measured parameter RMS over time, discussed earlier that is not audible but still precious as a first line of defense.

These standard outputs bring the most cost-effective option for implementing ultrasound monitoring, at a low relative cost since both voltage and current analog signal types are common outputs in process control instruments. The CONMONSense sensors are fitted to be flexible and configurable.

In dynamic mode (AC mode), the CONMONSense sensors can accurately reveal ultrasound phenomena from few mV to V, that are amplified to be easily acquired/collected into a reduced range (0-10 V or 4-20 mA). The sensitivities given in the specification at each Gain, enable to correctly rescale the signal.

e. What is the difference between dynamic mode (AC) and static mode (DC)?

Analog sensors can produce either AC (Alternating current/voltage signal) or DC (Direct current/voltage) outputs depending on the type of sensor and the measurement being made. A DC output produces a constant voltage or current over time, while an AC output alternates in polarity and magnitude over time.

By default, the CONMONSense analog sensors transcribe non-audible signals gathered within the ultrasound resonant band-pass frequency into audible signal, filtered in [250 Hz-4 kHz].

The output signal is of type AC, with an offset of Vbias/Ibias, where the sensitivity expressed in V/V, or in V/A, corresponding to the retained gain, is adjustable by users. To avoid losing information, it is important to sample the signal at a sampling rate of, at least, 10 kHz (see specifications of your DAQ system). The resulting signal is a time waveform that can be post-processed then analyzed (or listened to) for diagnostic purposes. Mathematical techniques, such as spectral transformation and/or calculation of statistical indicators, like RMS, PEAK, CREST FACTOR can be applied to the time waveform to extract advanced information that is essential for trending and alarming. If so, SDT recommends expressing non-normalized indicators in 20 log-dB scale, preferably with a reference 0 dB = 1 µV.

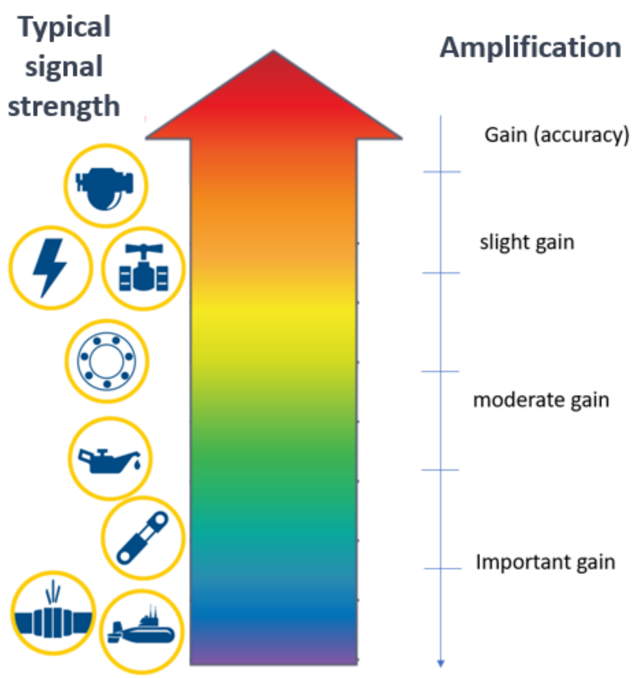
Spectral transformation techniques like FFT or envelop FFT can be used to identify the frequencies present in the signal and their respective amplitudes, providing valuable insight into the underlying vibrational patterns of the asset being monitored. Statistical indicators like RMS, PEAK, and CREST FACTOR can be used to measure the overall intensity of the signal and identify potential issues before they lead to downtime or other problems. These common signal post-processing features, as well as advanced filters capabilities should be present in the acquisition system.

By leveraging the full capabilities of the dynamic mode output of the CONMONSense sensor range, including advanced post-processing and analysis techniques, you can gain a deeper understanding of the behavior of your systems and take proactive steps to ensure their continued performance and reliability.

In the case of limited sampling rates (below 10 kHz), it is still possible to gather ultrasound data with the **RSC.10X True 4-20 mA**. Instead of producing an AC signal, the analog circuit of the sensor will produce a DC signal (current), proportional to the ultrasound RMS. This value represents the average level of energy in the band-pass filter, and it is commonly used for tracking changes over time. In this configuration, the sensor behaves like a Temperature probe. Users can directly assign and check the alarms without consuming too many resources, in terms of signal processing or internal memory. While DC mode (static output) doesn't provide the same level of detailed information as dynamic mode (AC mode), it can be a valuable tool for identifying trends and changes over a long period of time, from a static channel. By interfacing the CONMONSense sensor RSC.10X, users can quickly and easily monitor critical parameters over time, take action, like regreasing bearings, to prevent potential issues before they impact your process.
The selection of the compatible CONMONSense sensor depends on the specifications/capabilities of your acquisition system as well as on the type of channel.

f. How to configure the gain G (for dynamic mode only)?

To enhance accuracy, the full measuring range of CONMONSense, covering from mV to V, is divided into 6 amplification stages, slightly overlapped, configurable by users. These amplification stages mounted within the sensor increase or decrease the signal strength and improve the signal-to-noise ratio. This adjustment is important and must be done during the installation because the signal of interest often needs to be amplified or attenuated before it can be accurately acquired then analyzed.



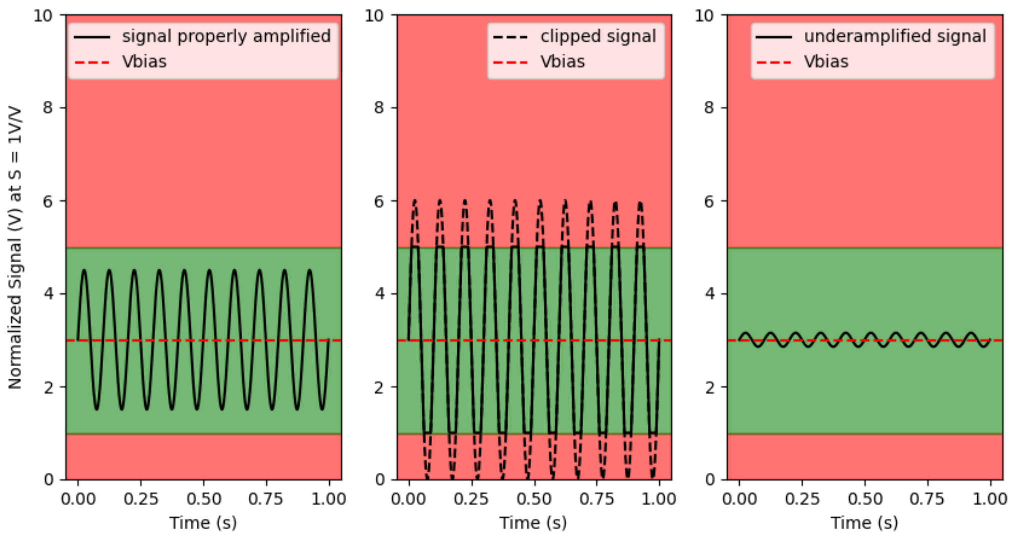
Once the sensor is installed and configured with your acquisition system, users may need to adjust the gain.
In practice, the sensors RSC.00X and RSV.00X are preconfigured at the maximum gain (+60 dB), without any warrantee that these settings are suitable to the measurement point being monitored.

Note: Always prefer using the gain of the sensor rather than the gain of the acquisition system.

As a guideline for CONMONSense RSV.00X 0-10 V:

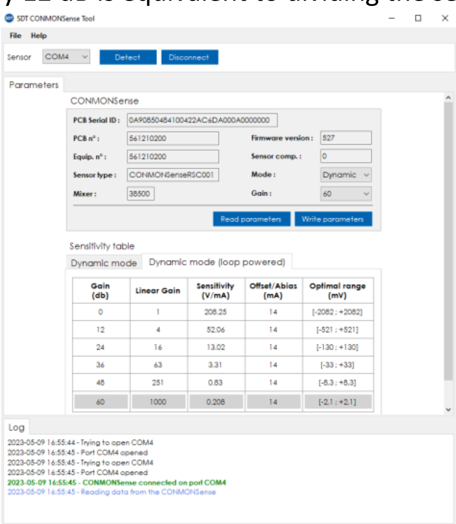
- Refer to the specs sheet of the sensor then configure the DAQ accordingly.
  Factory settings are dynamic mode (AC mode) at G=+60 dB, sensitivity = 1200 V/V.
  For the initial settings, user can apply normalized sensitivity=1 V/V to directly observe the output range [0-10 V].
  The optimal output voltage range is **[1-5] V** (at the normalized sensitivity=1 V/V and before removing Vbias=3 V) or **[-1.7-1.7] mV** (considering sensitivity=1200 V/V, without Vbias, see Table 4).
- Check if most samples are contained within the optimal range. If samples are not contained within [1 V, 5 V] or [-2V, +2V] (Vbias removed), the gain must be adjusted.

Examples with a sinewave:

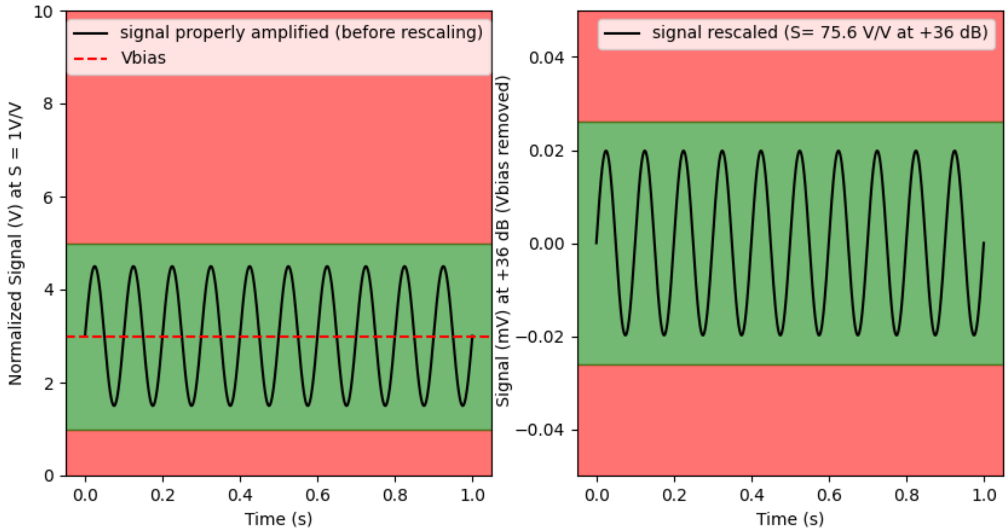


- In the case of clipped samples (case 2), decrease the gain by 12 dB, via the pulse method that can be done "online" by generating 2 successive pulses between the communication line and the sensor ground or use the SDT configuration box (off-line) and its PC freeware then reconnect the sensor to the acquisition system.

Note: Decreasing the gain by 12 dB is equivalent to dividing the sensitivity by 4.



- If necessary, repeat the last operation until you measure an AC signal oscillating around 3 V Bias +/- 2 V (PEAK), at the normalized sensitivity (S= 1 V/V).
- Once the appropriate gain is configured, refer to the datasheet to apply the corresponding sensitivity in your acquisition system. Depending on the capabilities of the DAQ system, users can reapply numerical filters, to strengthen the analog one, calculate statical indicators, FFT, etc.

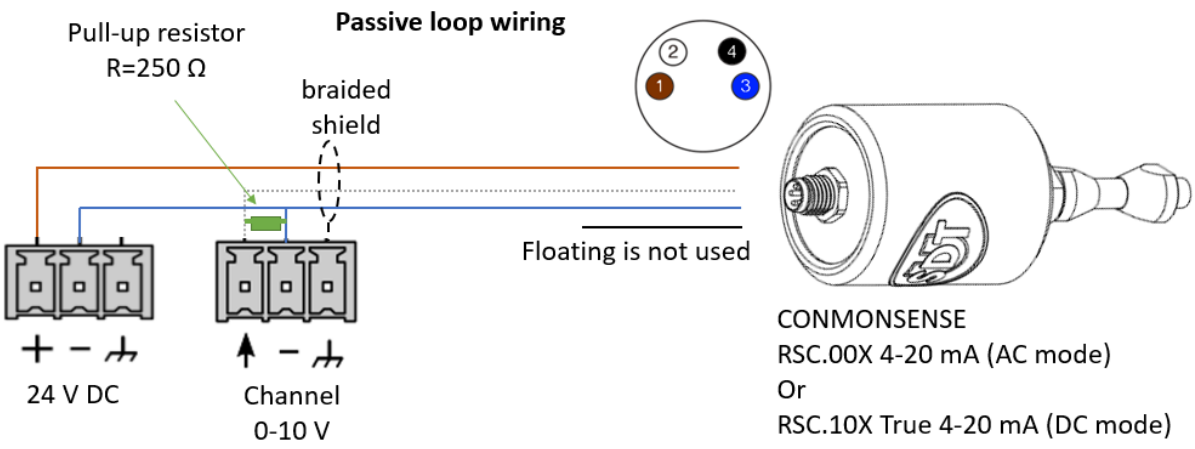


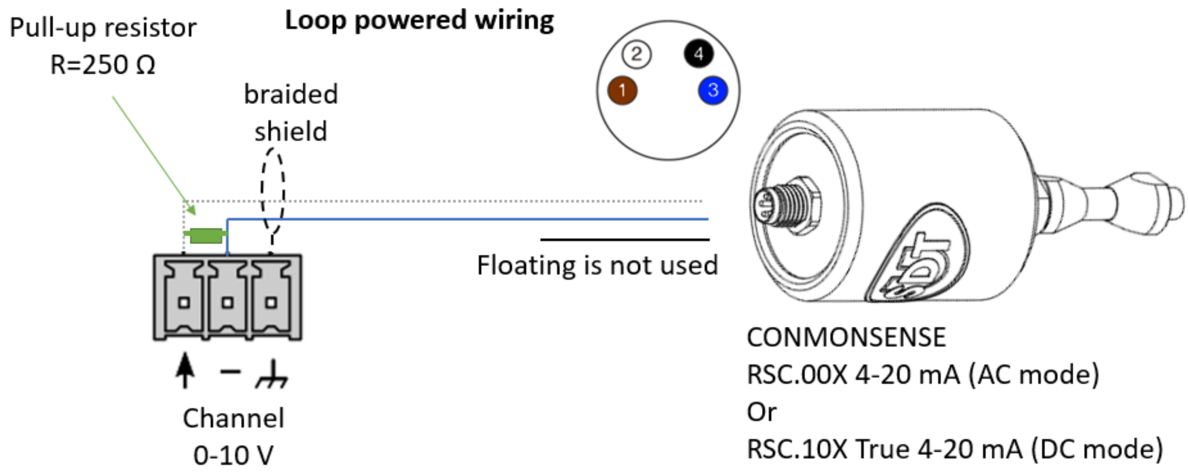
Important note: The static mode is not discussed in this application note and the functionality will be progressively removed from RSC.00X and RSV.00X. For simplicity reason, SDT recommend using the CONMONSense TRUE 4-20 mA, version RSC.10X, that is only available in static mode (DC current output). You don’t have to worry about the amplification settings. Note that the output in current can also be converted into Voltage with a load resistor, as shown in the diagrams below.

The value of the resistor allows for the transformation of the current loop into voltage, based on Ohm’s law. In application of this famous law U = R x I, selecting a resistor value of R= 250 Ω modifies the output optimal range as follows:

- 4 mA x 250 = 1 V
- 20 mA x 250 = 5 V

By using the resistor in this manner, the current loop signal, that can be self-powered or passively powered, is converted into a voltage output within the specified range.





The CONMONSense sensors are available in static mode (DC output) to provide RMS values representing the ultrasound energy in the filters. Users cannot access the time waveform or the spectrum, but they can directly assign and check the alarms without consuming too many resources. The post-process is light for the acquisition system and does not require high sampling rate. Static channels are typically used for this application.

Otherwise, in case of sufficient sampling rates, CONMONSense can be configured in dynamic mode (AC output) to provide analog heterodyned ultrasound signals. In this case, once the signal is acquired, some advanced calculations can be done in post-process (by your system, depending on its features or capabilities) to extract additional indicators, calculate spectrum or even to play back audible signals. Dynamic channels, having a sampling rate of at least 10 kHz, must be used for this application.

The limit between these two modes, acting as a sensor selection criterion, is imposed by the following considerations by the specifications of your acquisition system. Moreover, the minimum sampling rate of 10 kHz represents approximately 2.56 x times the Upper Band-pass frequency [4 kHz] that is, at least, required to correctly acquire the signal while avoiding aliasing.

2. Choosing the right sensor: a basic methodology

Permanent data collectors, supervision systems, PLCs, have various input specifications and signal capabilities to guide the interfacing with the CONMONSense sensors.

Proceed as follows:

1) Define your application (ultrasound pillar) according to the table discussed above.
   a) Structure borne/contact sensor IP 65
   b) Airborne IP 40
   c) Airborne IP 65

2) Find out the type of input supported by your acquisition system.
   a) Type 4-20 mA or 0-20 mA (AC or DC mode)
   b) Type 0-10 V (AC mode only)
   c) Type IEPE-ICP (AC mode only)
   d) Type Low Power (DC mode only)

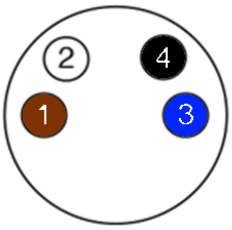
3) Find out the type of mode supported by your acquisition system.
   a) DC mode (static mode)
   b) AC mode (dynamic mode)
      - For AC mode, find out the (maximum) sampling rate, usually expressed in kilohertz [kHz] or kilo samples per second [ksps] that must be, at least > 10 kHz.

3. Installation

Installation, cabling operation, settings and maintenance should only be undertaken by specialist personnel and following the safety and accident prevention regulations. Before starting the installation, read the instructions provided with your acquisition system. Stop the installation work if you have any doubt and contact your distributor or SDT for assistance.

Once you are ready for a new installation, refer to the wiring diagrams and locate the channel with its different inputs. Make sure that you have purchased the optional accessories for mounting and/or configuring the sensor.

Refer to the specifications of the sensor available on SDT website. All CONMONSense sensors are equipped with a standard M8-4 pins- MALE connector. The wiring depends on the type of sensor. However, the top view pinout (aka front plate of the sensor) is compliant with IEC 60947-5-2, as follows:

Top view pinout	Description
	1=POWER SUPPLY (Brown) or IEPE + 2=AC or DC SIGNAL (White) 3=GROUND (Blue) or IECE - 4=COMMUNICATION LINE-GAIN SELECTOR - should be left floating if not used (Black) (5)=braided shielded - can be connected to the chassis ground

Any cable with an M8-4 pins FEMALE<>FREE END shielded connector is suitable for installation. Maximum recommended cable length is 30 m, based on the EMC tests that SDT has successfully passed. While longer cable lengths can be considered, it is important to be aware of potential implications, such as SDT's non-responsibility in case of malfunctions outside the provided technical specifications and the possibility of noisy signals due to environmental disturbances. Ultimately, the decision to use longer cable lengths is at your discretion. If you choose to do so, as mentioned before, it is advisable to use the CONMONSense 4-20 mA sensors, as they are better suited for this purpose. Additionally, if voltage outputs are required, users can still connect a load resistor, as discussed above, to convert the current loop into a voltage output.

Once the sensor is connected, you need to configure the acquisition system according to the default configuration of the sensor. Please refer to the technical documentation of the sensor as well as your acquisition system to understand the procedure.

The default/factory configurations are listed below:

CONMONSense	**Factory settings**	**Full range**	**Optimal range**
RSV.00X	Gain = +60 dB, AC mode only*	[0-10] V	-/+ 2 V around V_{bias} = 3 V
RSIE.00X	Gain = +60 dB, AC mode only		-/+ 2 V around V_{IEPE}
RSC.00X	Gain = +60 dB, AC mode only*	[0-40] mA	-/+ 8 mA around I_{bias} = 12 mA
RSC.10X	DC mode only	[4-20] mA	4 mA to 20 mA
RSV.11X	DC mode only		0.28 V to 1.4 V

*DC mode available in RSV.00X & RSC.00X will be abandoned to the benefit of RSC.10X only (+ resistor if voltage output is required).

4. Long time support and calibration

All our contact sensors are factory calibrated, which ensures interchangeability and accuracy within their specific resonant band-pass. The different amplification stages are electronically compensated.

However, to maintain their accuracy over time, we offer a calibration service that is more likely recommended for our handheld solutions (data recorder + sensors) due to their use in the field. In these cases, we can do a full check of the acquisition chain (+ calibration).

Our calibration service is an additional offering that we provide to our customers to ensure that their devices perform at their best. We typically recommend that calibration is performed annually, depending on the sensor type and usage conditions. In some cases, calibration is required by certain regulations.

For permanent installation with CONMONSense, periodic calibration is no longer required or recommended as Industrial DAQ systems are usually not periodically calibrated but still can be done upon demand, like any standard accelerometer.

CONMONSense Buying Guide

Applications

			Mechanical / Lubrication — Structure borne (X=1)	Leaks / Electrical — Airborne (IP65 X=2 - IP40 X=3)
Acquisition System	**VIGILANT** Powered by SDT			
	Output	Ref		
	0-10V	(RSV.00X)	☐	☐
	IEPE	(RSIE.00X)	☐	
	PLC (See specific documentation)			
Dynamic Input (>10kHz)	0-10V	(RSV.00X)	☐	☐
Dynamic Input (>10kHz)	IEPE	(RSIE.00X)	☐	
Dynamic Input (>10kHz)	0-20mA/4-20mA	(RSC.00X)	☐	☐
Static Input	True 4-20mA	(RSC.10X)	☐	

This document can do downloaded here: https://sdtultrasound.com/support/downloads/.

03			
02			
01	CMA 31/05/2023	Original version	CGI
Rev.	**Writer**	**Nature of modification**	**Approved**

The information herein is believed to be accurate to the best of our knowledge.
Due to continuous research and development, specifications are subject to change without prior notice.