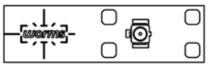
Piezoelectric unidirectional strain sensor

Dragonfly® DGF-UNI-Wx204xx-10

Dragonfly® DGF-UNI-AA204xx-10



User manual

For any question concerning the use of our products,

please contact us

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November 2025

Contents

DANGER
Indicates dangerous situation that may result in serious injury

CAUTION
Indicates hazards that could damage the sensor or result in performance degradations

NOTE
Indicate tips, recommendations and important information

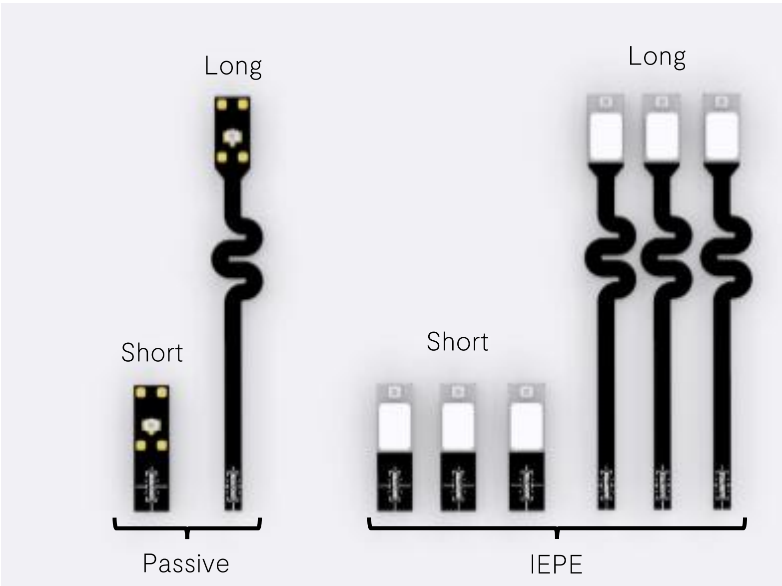
1 Introduction

Dragonfly® sensors are dynamic strain gauges made from an extremely thin piezoceramic monocrystal material. The active area is less than 10 µm thick, giving it the flexibility and ductility of a 2D material. The flexibility of the entire sensor greatly simplifies its integration on objects, and its crystalline nature results in high durability and high signal quality.

Dragonfly® sensors are made from a piezoelectric material that generates charges when deformed. Their ability to sense low amplitude deformations, with great accuracy and sensitivity, on a wide frequency range makes it a suitable candidate for measuring dynamic strains induced by stresses, forces, torques, or any other physical phenomenon and detect events on various materials, components and structures. The amplitude and frequency of the signal is directly proportional to the mechanical deformation of the piezoelectric material. A reciprocating force thus results in an alternating and proportional output voltage.

The three different IEPE sensitivity (1.08, 10.8 and 108 mV/µdef) are developed to adapt the measurement range to the expected magnitude and to use the best resolution of your ADC (Analog to Digital Converter), resulting in a measurement range from 50 µm/m to 3000 µm/m. IEPE sensors ensure the signal quality even with cable lengths of more than 100 meters between the sensors and the acquisition systems.

This user manual describes the installation and measurement of Dragonfly® sensors. It is valid for both passive (Dragonfly® DGF-UNI-AA204xx-10) and IEPE sensors (Dragonfly® DGF-UNI-Wx204xx-10) in short or long form factor. Dragonfly® sensors are strain sensors, which must be glued to the surface of the part on which deformation (strain) needs to be measured. The accuracy of the strain measurement depends on the quality of the bonding. The objective of this document is to provide all the necessary information for effective sensor installation.

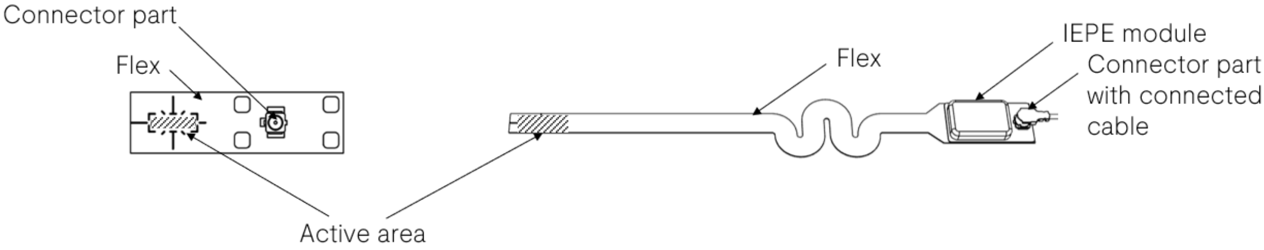


References

For information on sensor specifications, please refer to the sensor datasheets available in [Dragonfly® Downloads].

2 Quick-start guide

2.1 Glossary



Passive Dragonfly® short sensor

IEPE Dragonfly® long sensor

2.2 Required tools

To install the sensor, you will need:

Please refer to the "Glue and protective layer selection" section of this manual to select the right glue reference.

2.3 Surface preparation

The deformation of the test object will be transmitted to the sensor through the glue interface. Surface preparation is an important step to ensure good adhesion of the glue to the test object.

The sensor bending radius is limited to 2cm according to the sensor datasheet. Make sure the curvature of the surface is above this bending radius.

Roughening

- Any paint or coating on the test object should be removed to ensure the best contact between the sensor active area and the test object.
- Use sandpaper to roughen a 3 cm² surface where the sensor will be installed. Make some variations in the direction of roughening like small circular movements.
- Generally, a classic thin grain is suitable (grade 100 to 600).
- The final aspect should be flat and homogeneous.

If you are bonding on a material with an important porosity such as concrete, use a first coat of HBM X60 (without applying the sensor) to reduce the porosity (i.e. fill the microscopic holes) and then prepare and glue the sensor on this new flat surface repeating the process described here.

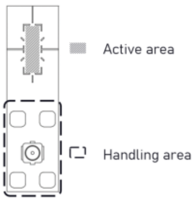
Cleaning

- Clean the surface using microfiber fabric or cleaning paper and a solvent such as isopropyl or ethylic alcohol.
- Be sure that all particles have been removed by having a look at the cleaning paper; this one should not exhibit any visible particle.

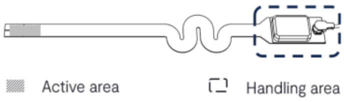
2.4 Handling recommendations

Warning: before they are installed on test objects, Dragonfly® sensors must be handled with care. Brand new sensors from our factory are exempt from any pollution and we therefore recommend not to clean them.

Short Dragonfly®



Long Dragonfly®

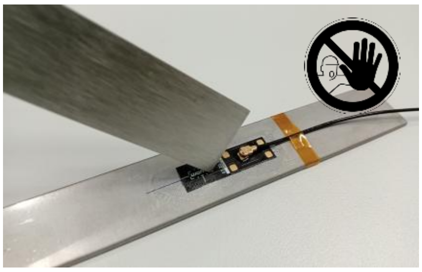


Manipulation

- Sensors should be manipulated by the connector area prior to wire installation.
- Avoid any contact with the active area.

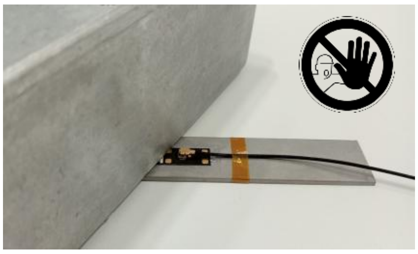
Bending

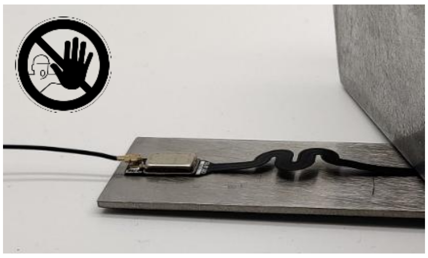
- Avoid any bending of the sensor prior to installation.
- Avoid touching the active area directly with unprotected fingers to preserve sensor cleanliness.



Localized pressure points

- Avoid putting sharp objects on the sensor to avoid degradation of the active area.





Loads

- Avoid applying any mechanical load over any part of the sensor to avoid degradation of the electrical shield and preserve sensor integrity.

2.5 Unboxing

Sensors are sold in a box under a blister cover. Once the surface is ready to be instrumented, use the following instructions to remove the sensors from their packaging.

Remove the blister

Use tweezers
or the provided hand-vacuum tool

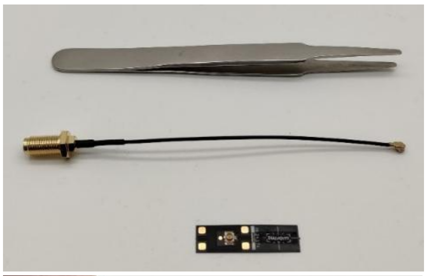
Manipulate the sensor by the connector area

- Handle the sensor by the connector area to avoid any bending of the active area.
- For passive sensors (left), use the hand-vacuum tool on a flat surface in the connector area.
- For IEPE sensors (right), use the hand-vacuum tool on the metallic cover.

2.6 Cable installation

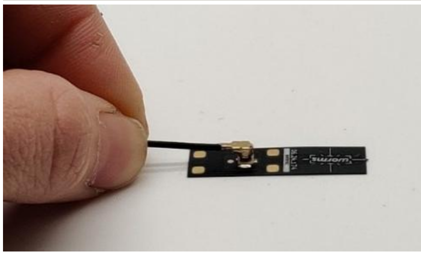
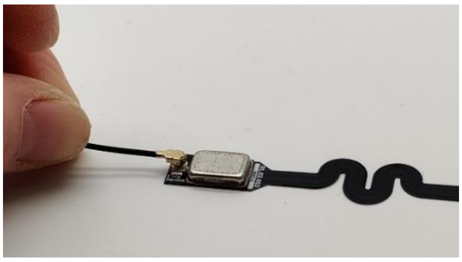
Sensors and cables are sold separately to provide our customers with the most suitable connection solution. It is recommended to install the cable on the sensor prior to installing the sensor on the test object. In certain cases, it might be more convenient to install the cable after sensor installation (e.g.: for long cable lengths or specific applications). The cable installation procedure remains the same.

Short Dragonfly®	Long Dragonfly®



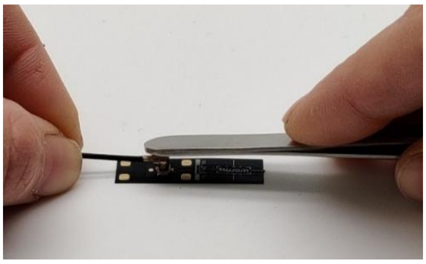
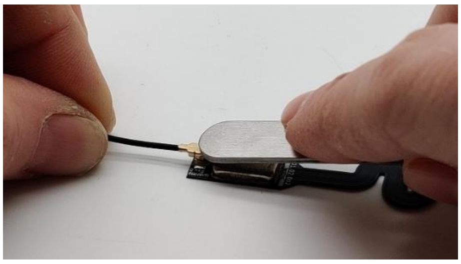

Preparation

- Place the sensor and the cable on a clean flat surface.
- A rigid tool will be needed to make the connection. Here we use the back side of tweezers.

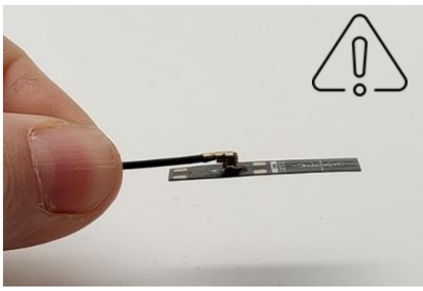
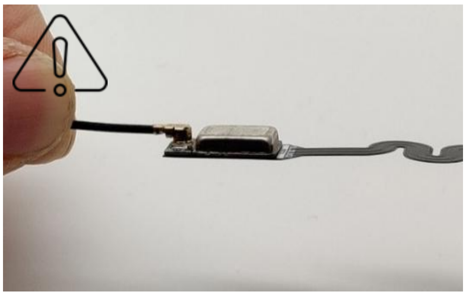
Plug the connector

- Carefully place the cable's UFL connector over the sensor connector.
- Make sure they are precisely centered.

Apply pressure on the connector

- Use a rigid object to apply vertical pressure on the connector. Make sure to maintain the parts in the same vertical alignment.
- A soft "click" can be felt when the connector engages.

Handling

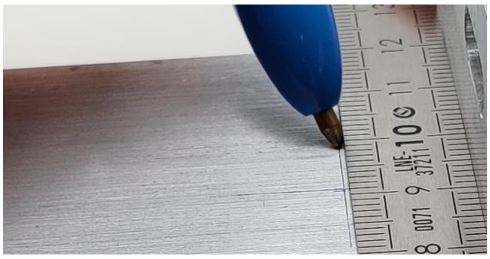
- Once the cable is connected, it can support the sensor's weight without problem.
- Manipulate the sensor by the cable for installation.

⚠ Once installed, the cable should not be disconnected and reconnected as small UFL standard is not designed for multiple reconnections

2.7 Sensor installation

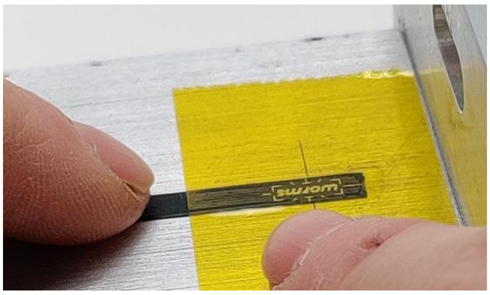
The recommended gluing procedure is described below. This gluing technique allows a precise alignment of the sensor with the expected principal direction of deformation (operator's experience) or to comply with a specific location (e.g.: for comparison with a finite element model calculation).

A demonstration video is available here https://youtu.be/WMm4LXUvn8U. Long and short form factor sensors are glued using the same procedure. The whole length of the sensor is glued in one go for the short version of Dragonfly®. On the long version, the sensor active area is glued first. Then, the connector part is also glued.



Position Identification

- Make alignment marks on the surface where the active area of the sensor will be positioned.



Align the sensor by covering it with tape

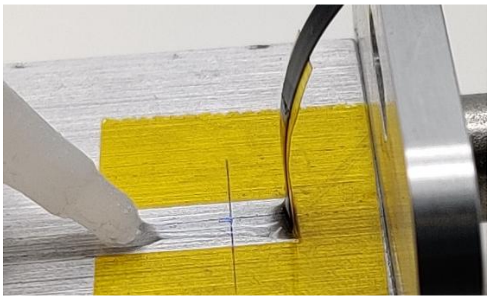
- Use a low adhesion tape (such as Kapton®) to place the sensor on the alignment marks as described in the above video at 0:19.
- Classic Scotch™ tape is also suitable (best choice is the repositionable one that is translucid).

Cut the tape on the sensor sides

- Use a cutter to cut the tape on both sides of the sensor as described in the above video at 0:31.
- Make the cut approximately 1 mm from the sensor edge to avoid damaging the sensor. This distance is not critical but try to be as close as possible to lower the risks of bending the sensor at the next step.

Lift the sensor

- Gently lift the sensor while checking the tape is cut properly.
- Keep the sensor as flat as possible during this step to avoid going over the sensor allowable bending radius (a curvature as pictured is normal).

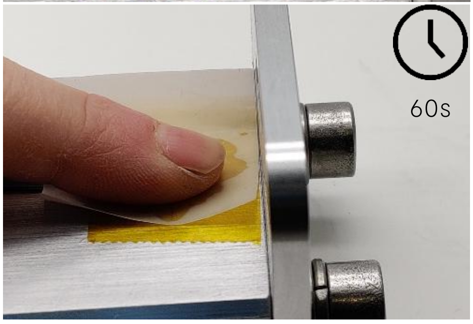


Apply glue

- Apply glue on the whole lifted area. Check "Glue selection" section to select the right glue reference.

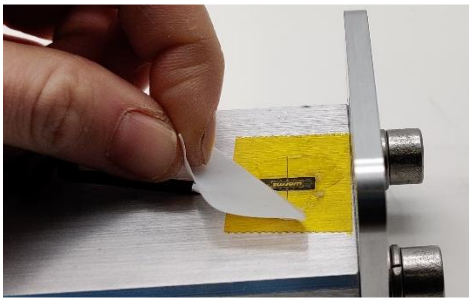
Lower the sensor

- Use the tape as an alignment hinge.



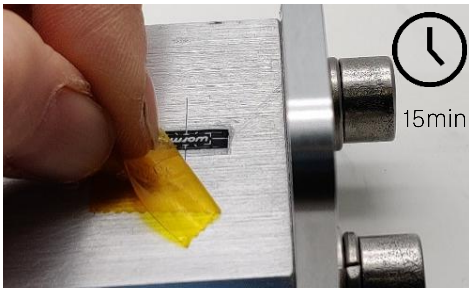
Apply pressure through a Teflon sheet (>60 seconds)

- Place a Teflon® (PTFE) sheet over the sensor.
- Apply a gentle homogeneous vertical pressure on the complete bonding area and try to chase air bubbles from the bonding starting from the hinge to the flex (normal gentle pressure with one finger is enough)
- For cyanoacrylate hold the pressure for at least 60 seconds with a finger. Epoxy glues have longer curing time and require mechanical clamping, see “Clamping procedure” section in Annex.



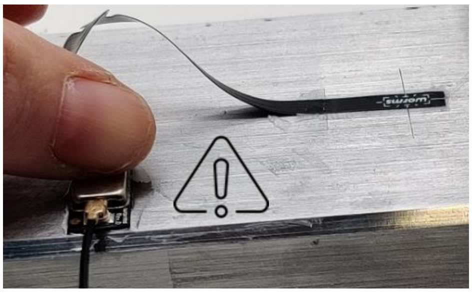
Remove the Teflon® (PTFE) sheet

- Gently remove the Teflon® (PTFE) sheet.



Remove the tape after 15 min

- Wait for the complete glue curing time. For cyanoacrylate wait at least 15 min.
- Pull the tape at an angle by the corner as pictured to minimize the stress on the sensor fresh bonding.
- Removing the tape too soon could result in sensor damage.

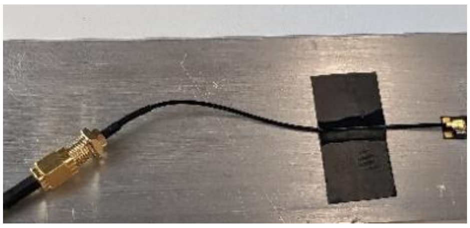


Glue the connector part if you are using long Dragonfly®

- Glue the connector where it is appropriate for your test environment.
- The connector glue interface is not critical. It can be glued using the same glue, or simple double-sided tape.
- It is not recommended to leave the connector area free to move because it could be damaged by vibrations and shocks.

Bend or twist the flex

- The flex can be bent or twisted to reach tight areas.
- Once bent, the flex should not be flattened and bent again multiple times to avoid damaging the sensor shielding and internal wires.



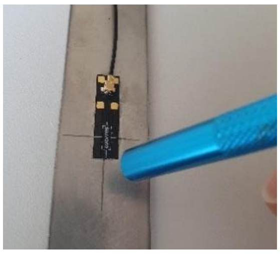
Secure the wire

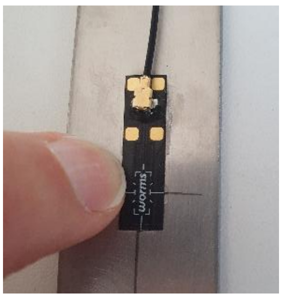
- Secure the wire with adhesive tape to prevent direct pull on the bonding interface. Any tape or glue is suitable.

2.8 Quick functional test

It is recommended to perform simple functional tests to test the mechanical response of the sensors after bonding. The purpose is to check sensor response, cable integrity and proper wiring of the channel[1].

With the sensor(s) properly bonded, connected to the acquisition system (or to an oscilloscope) and the sensitivity / coupling properly set, perform the following simple tests:





Response test

First have a look at the sensor noise in the time domain. As Dragonfly® sensors are very sensitive and exhibit very low noise, the peak-to-peak value should not exceed 0.2 to 0.4 µm/m (the measured value depends on the acquisition system noise).
Using your finger or a small object (pen for example), give 3 consecutive shocks on the test object as pictured on the left, close to the sensor. Check that the high frequency content is detected properly by the sensor with 3 consecutive shocks.
Apply a pressure close to the sensor with your finger and check that the sensor is responding with a low frequency deformation (a few µm/m can be applied this way depending on the stiffness of the test object).

NB: If the structure is very stiff the sensor may be within its limit of detection.

[1] Wormsensing team can help you select the acquisition and conditioning system matching your application.

Further spectral analysis and troubleshooting

Please refer to further detailed spectral response and common fault detection, description and countermeasures in the “Troubleshooting” section.

2.9 Applying a protective layer (Optional)

For rough environments (humidity, heat, light), applying a protection layer on the sensor is advised to keep the performance of the Dragonfly® sensor and preserve the bonding quality in the long term.

After sensor and cable installation, we recommend checking the sensor before applying any protective layer. Please refer to the section “Glue and protective layer selection” and “Capacitance sensor check” sections.

The protective layer should cover the glued area by at least 3 mm from each side.

3 Glue and protective layer selection

The interface between the sensor and the test object must be thin and rigid to transmit the deformation of the test object to the sensor.

Double-sided tape is not considered as a bonding technique and **must not** be used for installation as it will not adequately transmit the deformation to the sensor (low pass filtering).

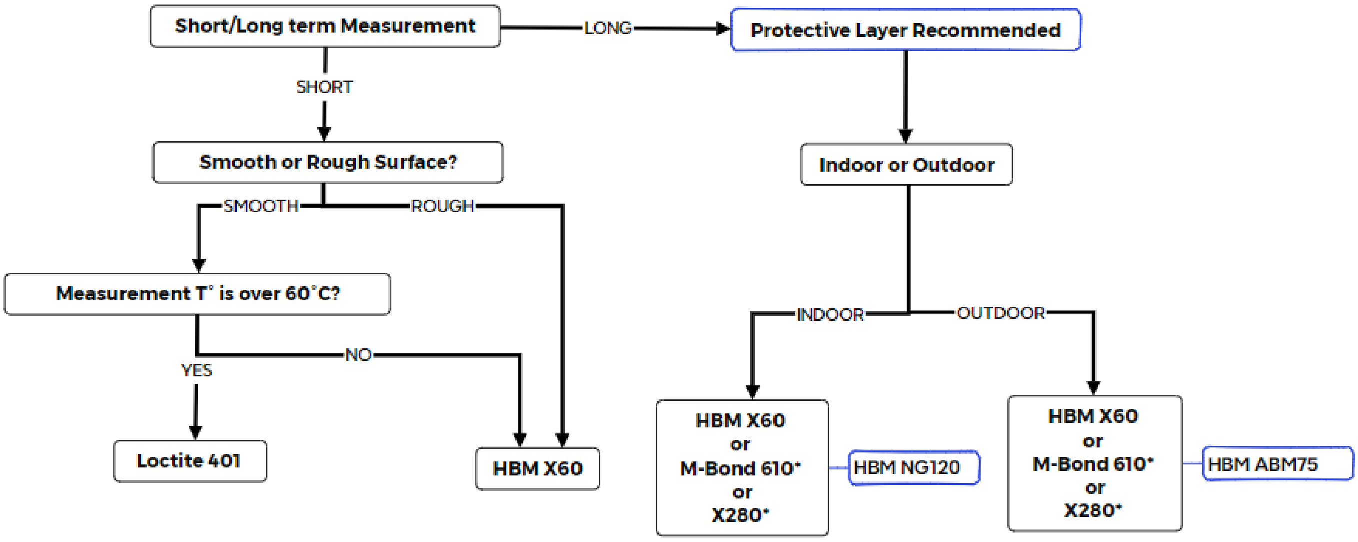
Clamping (without bonding material) the sensor **is not** to be considered as a bonding technique, it will not transmit the deformation to the sensor. The sensor **should not** be flattened with a solid object after gluing. Use soft material to apply the pressure (thumb or a flexible patch made of silicone rubber).

Manipulating glues can be harmful and requires specific caution, please follow carefully the manufacturer recommendations and safety datasheets.

With epoxy compounds, long time curing is necessary, please refer to paragraph.

Glue Selection

The following schematic helps you choose the right type of glue (and protection) for different contexts. The following recommended glues have been qualified for Dragonfly® specifically for their ability to cure fast at room temperature.



*Curing time over 4h is necessary for these types of glue.

4 Data acquisition with Dragonfly®

There are several options to measure with Dragonfly® sensors. This chapter describes the characteristics of both passive and IEPE Dragonfly® sensors. A guide is available in appendix 3 to help select the sensor corresponding to your application.

4.1 Passive Dragonfly® sensors

The Dragonfly® passive sensor behaves electrically as a capacitance, in parallel with a leakage resistor. It can be measured in two different modes (Charge or Voltage) depending on the needs of the user, and on the available acquisition systems[2].

Charge mode (recommended)

The Dragonfly® can be connected to an external charge amplifier before entering the acquisition system.

Pros	Cons
Acquisition at low frequencies (quasi-static)	Charge amplifier required
	Limited cable length or use of low noise cable

When operated in charge mode (using a charge amplifier), the cut-off frequency (f_{lc}) is determined by the charge amplifier itself and can be as low as 0.01 Hz with a dedicated design. Piezo-electric sensors cannot measure infinitely slow strain variations, due to the leakage current in the amplifier. However stable measurement over several tens of seconds is possible with a limited error (<1%) and dedicated charge amplifiers.

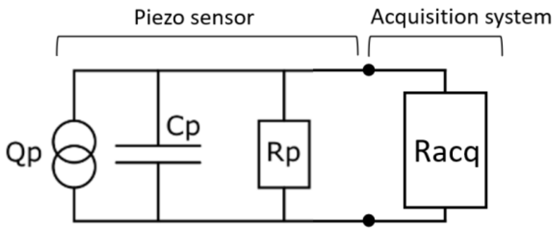
[2] Wormsensing team can help you select the acquisition and conditioning system matching your application.

Voltage mode (not recommended for low frequency applications)

It is possible to directly measure the output voltage of Dragonfly® sensors. However, the low frequency content can disappear as it gets filtered out by the impedance matching between the sensor and the measuring device as explained below.

Pros	Cons
Simple acquisition hardware	The low cut-off frequency depends both on the sensor and on the acquisition system and is typically higher than 1 Hz.
Low power consumption (direct measurement)	Limited cable length or use of low noise cable. Cable capacitance will lower down the sensor sensitivity.

A piezoelectric sensor equivalent electrical schematic is shown below.



In voltage mode, the lower cut-off frequency (f_{lc}) is determined by the sensor electrical properties (R_p and C_p) and the acquisition system input impedance (R_{acq}).

$$R_{eq} = (R_p * R_{acq})/(R_p + R_{acq})$$

$$f_{lc} = \frac{1}{2\pi C_p R_{eq}}$$

The lowest achievable cutting frequency is typically of the order of 1 Hz for acquisition systems with a relatively high input impedance (10 MΩ)

Cables in voltage & charge mode

Standard coaxial cables may create triboelectric noise when they are deformed. The friction produced by cable deformation generates charges that are not related to the mechanical deformation of the sensor but by cable movement. Special low noise coaxial cables exist (Microdot) to mitigate this problem. If this is an issue in your context, IEPE Dragonfly® sensors are immune to triboelectric noise from the cables as they are pre-amplified.

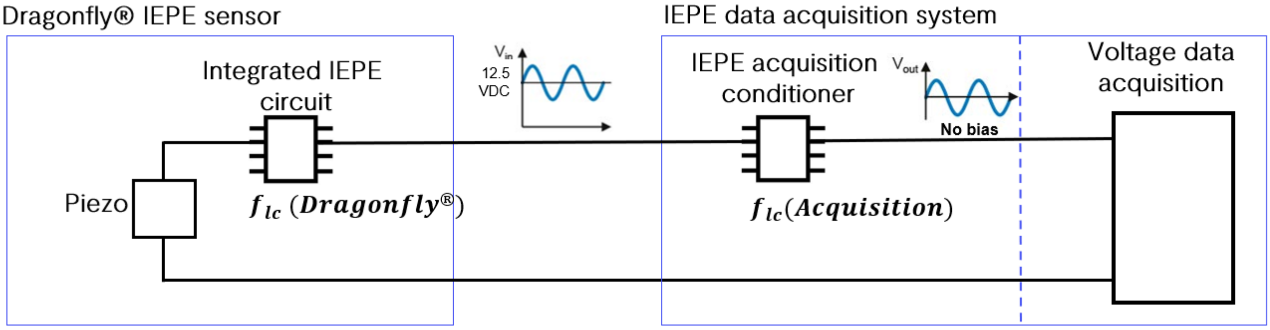
4.2 IEPE Dragonfly® sensors

IEPE Dragonfly® sensors integrate an onboard charge amplifier, which is powered by a constant biasing current supplied by the acquisition system featuring an IEPE conditioner[3]. These sensors are compatible with all acquisition systems which follow the IEPE standard (also called ICP®, CCLD, Iso Tron or Delta Tron depending on the manufacturer). This standard is widely adopted for accelerometers.

Pros	Cons
Acquisition at low frequency (quasi-static)	Power consumption through the IEPE
Long cable distances (above 100 m) are possible with simple coaxial cables	

[3] Wormsensing team can help you select the acquisition and conditioning system matching your application.

Below are the schematics of a typical IEPE interface.



Warning: IEPE Dragonfly® sensors will not work if the supply current is not activated in dedicated IEPE inputs coupling. The supply current must be in the range between 2 mA and 20 mA.

The lower cut-off frequency of the Dragonfly® measured by an IEPE acquisition system depends on two components:

- The charge amplifier embedded in the Dragonfly® sensor itself, whose lower cut-off frequency is $f_{lc}(\text{Dragonfly®})$ in the sensor datasheet.
- The cutting frequency of the IEPE input depends on the acquisition system only. Manufacturers try to have the best performances as possible in the low frequency domain, the lower cut-off frequency may typically vary in the range $f_{lc}(\text{Acquisition}) =$ 0.01 Hz to 1 Hz. Please refer to the technical information regarding your acquisition device.

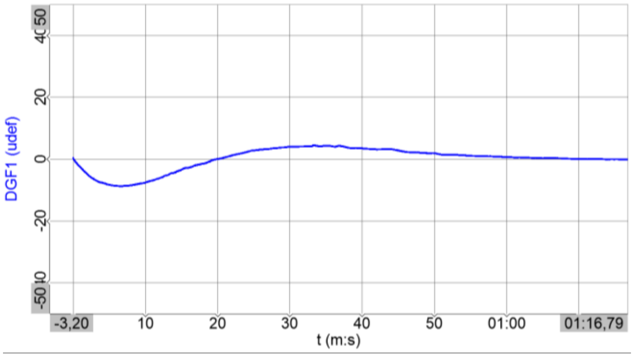
The final cutting frequency of the IEPE sensor connected to the IEPE acquisition system will be the highest cutting frequency: $f_{lc} = \max(f_{lc}(\text{Dragonfly®}), f_{lc}(\text{Acquisition}))$

Cables in IEPE mode

As the signal is pre-amplified, standard coaxial cables can be used over long distances, up to more than 100 meters with reduced frequency bandwidth.

Signal stabilization after power-up

When the IEPE Dragonfly® is connected to the IEPE acquisition system input, the current charges the embedded charge amplifier, which results in low frequency oscillations of the measured signal (a typical signal is presented below). Please wait until the signal has stabilized before starting your measurements.



- Right after power-up, the signal is expected to fluctuate before stabilizing at zero as shown in the example besides.
- Wait for a few minutes after connecting the Dragonfly® to the IEPE supply before starting your measurements.

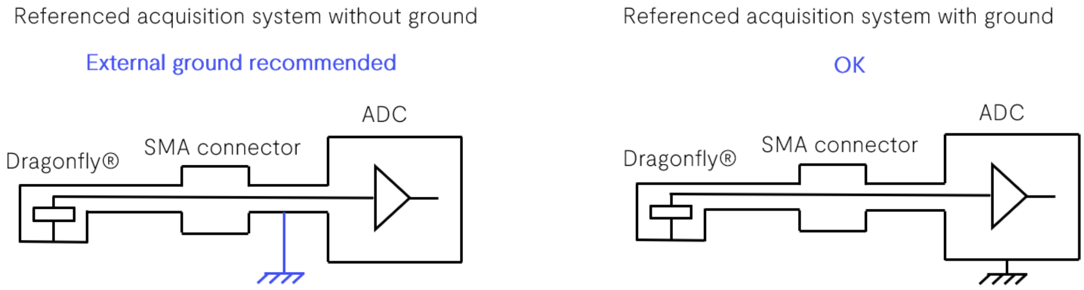
5 Grounding and shielding

Grounding is the process of connecting an electrical system to the ground to create a safe and reliable pathway for electrical current. In a state-of-the-art acquisition chain, grounding is necessary to drive unwanted charges to the ground and avoid discrepancies in the measurement data. The figure below describes the best procedure to ground an acquisition chain using an external ground or by using the acquisition system grounding. Dragonfly® sensors are shielded by design, making them immune to strong EMI (Electro Magnetic Interferences) through its UFL connection and coaxial cable. However, the internal shielding cannot replace a proper grounding of the acquisition chain.

Coaxial wires (BNC, SMA or microdot standards) should be used on the complete line to ensure the best performance.

The signal must be acquired in “referenced” mode: the negative pin of the sensor (the shield of the coaxial cable) must be connected to the ground.

In some cases, the acquisition system is not directly grounded. Adding an external ground can help to reduce ambient electromagnetic radiation noise on the measured signal (see figure below).



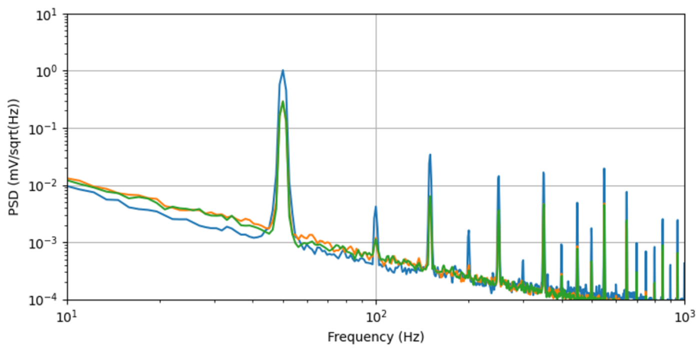
6 Troubleshooting Dragonfly® signals

6.1 The sensor does not seem to work

If you have carefully followed the installation procedure but notice that the sensor is not behaving as expected, please refer to the following steps to help identify issues in your acquisition chain:

1. Check that the sensor is properly bonded and that the UFL connector is wired
2. Check that all cables are properly connected the whole way between the sensor and the data acquisition system
3. Check that input and output are not reversed if using an external conditioner
4. Make a shock or gentle push close to the sensor and have a look at the time waveform, the sensor should respond
5. In case of doubt, check cables continuity and insulation
6. If the sensor is not responding, proceed to sensor check as described in “Sensor check” section.
7. Check that the value of the sensitivity configured for Dragonfly® in the acquisition system corresponds to the value indicated in the datasheet
8. Check the acquisition mode (Charge mode or IEPE) and make sure you are using the suitable conditioner
9. Check the conditioner filters that could explain unexpected frequency contents and/or integration/derivation tuning to explain unexpected value response
10. In case of doubt, contact us at contact@wormsensing.com

6.2 EMI noise



The Dragonfly® sensor is shielded from the active area to the connector.
If you encounter EMI noise in the measured signal, please check the grounding of your measurement system. EMI noise typically arises as peaks in the spectrum of the measured signals at multiples of the network frequency (50 Hz or 60 Hz) as shown in the picture enclosed. Please also check that you have used **shielded cables** and connectors from the sensor to the acquisition device.

6.3 Sensor check

The following sensor check procedure is optional and is only indicated for verification purposes.
The sensor can be checked before and/or after installation.

Passive sensor

For passive sensors (DGF-UNI-AA204xx-10) we recommend using the capacitance meter BK890C from BK Precision.
The device must perform measurements using a sine wave of ±0.5 V amplitude at 1 kHz. Take the first measurement with the cable alone (C_{cbl}) and then connect the Dragonfly® sensor to take the total capacitance value (C_{tot}). Deduce the sensor value with the following formula:

$$C_{DGF} = C_{tot} - C_{cbl}$$

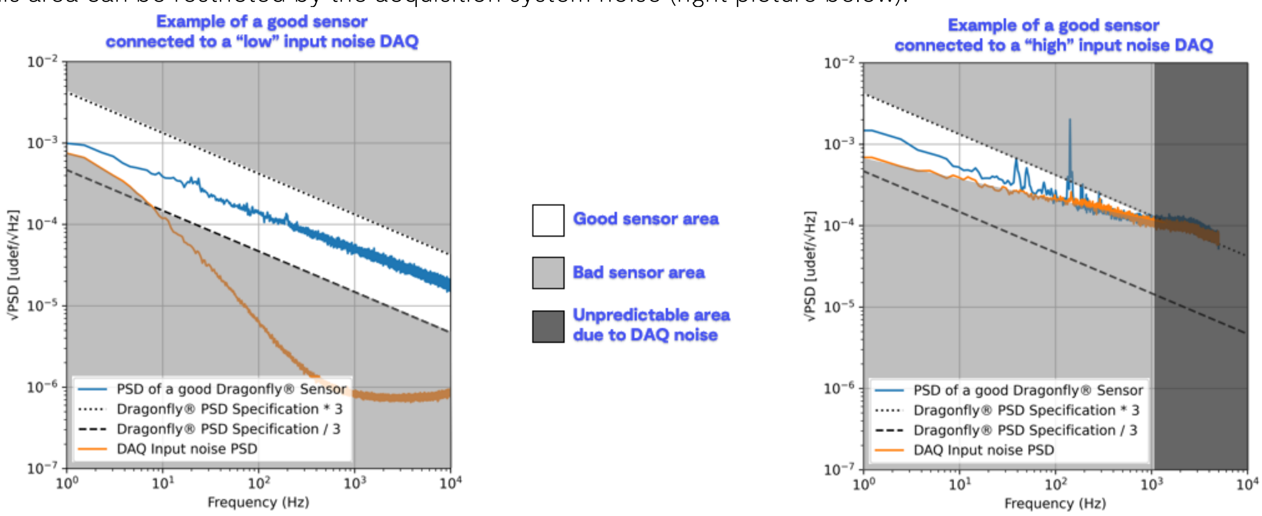
Check that the value corresponds to the sensor capacitance (C_p) range in the sensor spec sheet.
The capacitance of the sensor alone is 6.3 nF ±10%.

IEPE sensor

The IEPE sensor integrity can be checked looking at the sensor noise.

The sensor noise must be in the area defined between two lines (left picture below):
- Specified noise divided by 3 (called lower limit)
- Specified noise times 3 (called upper limit)

This area can be restricted by the acquisition system noise (right picture below).

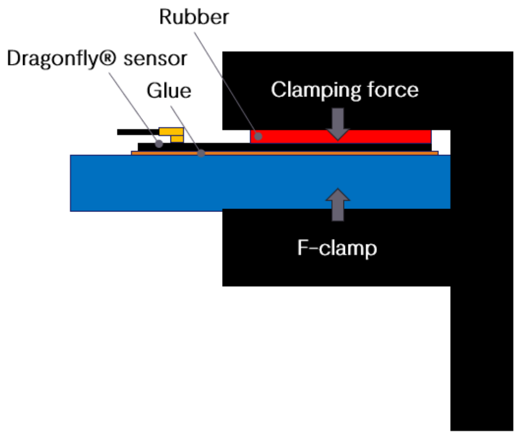


1. Define the "good sensor area": with no sensor connected, acquire a signal during 30 s. Define the good sensor area as shown on the above pictures.
2. Connect the sensor and acquire a signal during 30 s.
3. Check if the sensor noise curve (excluding peaks) is above the lower limit and under the upper limit, in the defined area.

Appendices

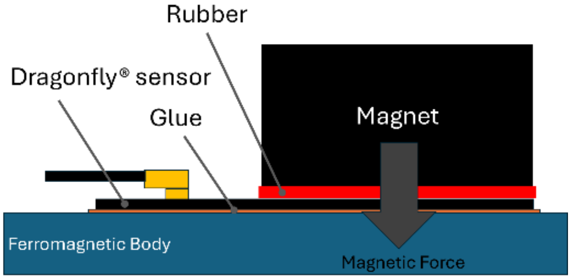
Appendix 1 - Clamping procedure

With epoxy compounds, a long curing time is necessary. To clamp the sensor, the following solutions can be used:



Clamping with a clamping fork or an F-clamp

- When the thickness is important, the pressure can be applied with a specific F-Clamp
- Use a moderate clamping force (10-20 N)
- Use a silicone rubber patch covered with Kapton tape to apply a uniform pressure



Clamping with a dedicated magnet

- The force (10-20 N) can also be applied with a magnet if the test object is ferromagnetic material.
- Use a silicone rubber patch covered with Kapton tape to apply uniform pressure

Appendix 2 - Sensor identification

All our sensors are manufactured with care to provide the best user experience. However, if an unexpected response is to be found during acquisition, please contact us.

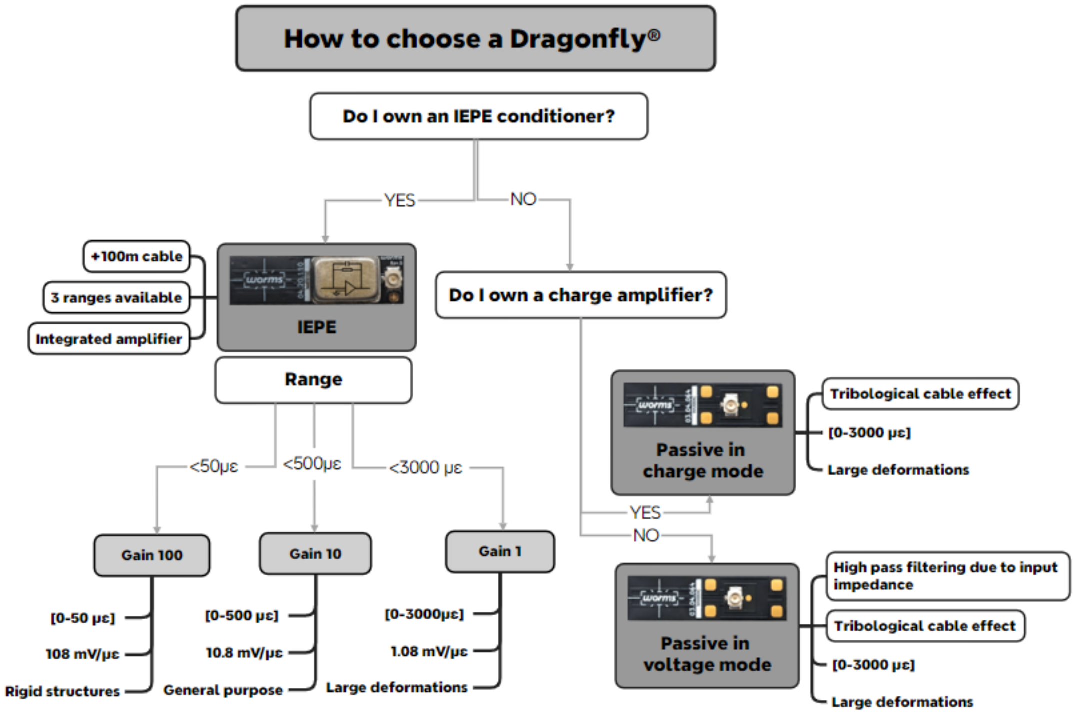
Provide the following reference identification pictured in the blue rectangle below (for instance WBO002C).

Add the number indicated on the packaging and the reference of the delivery sheet as pictured on the figure below.

Appendix 3 - Choose the right Dragonfly® sensor and conditioning system

The objective of the following chapter is to detail the recommended methods and provide general best practice for optimal measurement.

A passive Dragonfly® is a piezoelectric sensor with its UFL connection (-17 pC/με in charge mode and −2.70 mV/με in voltage mode) while the IEPE (Integrated Electronics PiezoElectric) version is completed by an additional charge / voltage converter (1.08, 10.8 or 108 mV/με).



For more information

The sensitivity of Dragonfly® sensors outperforms the sensitivity of traditional strain gauges, so many events and small deformations which could not be measured are now accessible.

- Check our whitepapers to see how Dragonfly® behaves in real situations.
- Consult our web site at www.wormsensing.com
- Contact us at contact@wormsensing.com