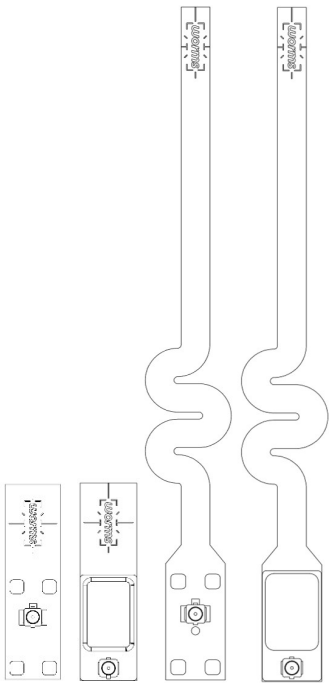
worms

Piezoelectric unidirectional strain sensor

Dragonfly®

type DGF-UNI-**AA**204**xx**-10
type DGF-UNI-**Wx**204**xx**-10



User Manual

Forewords

Information in this document is subject to change without notice. WORMSENSING reserves the right to change or improve its products and make changes in the content without obligation to notify any person or organization of such changes or improvements.

If you need additional help beyond what can be found either online or in this manual, please contact WORMSENSING support. In case of any application-specific issues, please contact us.

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Contents

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

NOTE
Indicate tips, recommendations and important information

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1 Introduction

Thank you for choosing a high-quality product from WORMSENSING. Please carefully read through this instruction manual to make optimum use of the various features of your product. To the extent permitted by law, WORMSENSING does not accept any liability if this instruction manual is not followed, or products other than those listed are used.

Our product and user documentation will provide you with an overview of our product range. Detailed datasheets are available for all products. Please consult the corresponding datasheets available on our website at the following link: Dragonfly® Downloads

If you need additional help beyond what can be found either online or in this manual, please contact WORMSENSING's support.

2 Important information

2.1 Warranty

The products supplied by WORMSENSING are covered by a warranty against faulty material and workmanship. This warranty extends 12 months from the delivery date. When submitting warranty claims, the items of equipment concerned are to be delivered to the manufacturer's works, and full details should be stated as to the nature of the claims.

Settlement of warranty claims may be effected, at the manufacturer's discretion, either through reconditioning or replacement of the faulty items, or through a credit note to their value. Items of products damaged as a result of improper use are not covered by the warranty.

Our responsibility under the warranty is strictly restricted to the above provisions, and we specifically decline any liability for damages incurred consequent upon the use or operation of our products.

2.2 Disposal instruction for electrical and electronics equipment

Do not discard old electronic instruments in municipal trash. For disposal at the end of life, please return this product to an authorized local electronic waste disposal service.

3 Sensor technology

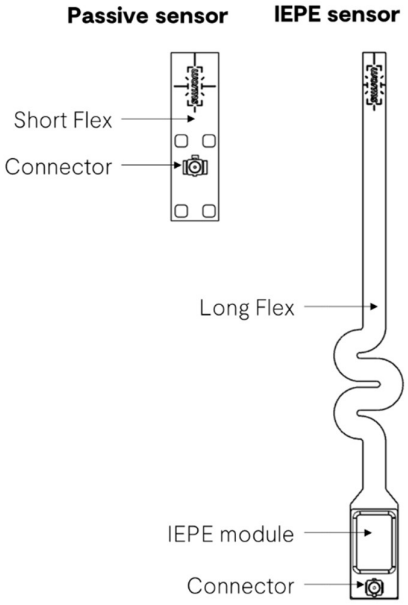
3.1 Functional principle

Dragonfly® are dynamic strain sensors manufactured from an ultra-thin, high-quality crystalline piezoceramic material. With a sensing area of only a few square millimeters (mm^2) and less than 10 µm in thickness, they offer the flexibility and elasticity of a two-dimensional material while maintaining the robustness of a crystalline structure. This unique combination enables easy integration onto a wide variety of surfaces and ensures excellent durability and outstanding signal quality.

Based on piezoelectric technology, Dragonfly® sensors generate electrical charges when mechanically deformed. Their high sensitivity and accuracy allow them to detect very low-amplitude strains across a broad frequency range. This makes them ideally suited for measuring dynamic strains caused by stresses, forces, torques, and other physical phenomena, as well as for event detection on diverse materials, components, and structures. The amplitude and frequency of the output signal are directly proportional to the mechanical deformation of the piezoelectric material.

As strain sensors, Dragonfly® devices must be bonded directly to the surface of the component under test. Measurement accuracy depends critically on the quality of the bonding process. The purpose of this document is to provide all necessary guidance to ensure proper installation and reliable strain measurement.

3.2 Product overall description



This user manual provides detailed instructions for the installation and operation of Dragonfly® sensors. It applies to both passive types (Dragonfly® DGF-UNI-AA204xx-10) and IEPE types (Dragonfly® DGF-UNI-Wx204xx-10), available in short and long form factors.

The typical measurement unit of Dragonfly® is microstrain (µε). It represents a relative deformation equal to one micrometer of elongation or contraction per meter of original length (µm/m). To match different measurement requirements, Dragonfly® sensors are available with three IEPE sensitivity level (1.08, 10.8 and 108 mV/µε), enabling optimal adaptation of the measurement range to the expected strain level and maximizing the resolution of the ADC (Analog-to-Digital Converter). This results in a measurement range from 50 µε to 3000 µε. IEPE technology also preserves signal integrity over cable lengths exceeding 100 meters between the sensor and the acquisition system.

3.3 Product list

Name	Part Number	Description
Dragonfly® S	DGF-UNI-AA20405-10	Unidirectional / Passive / Short Flex
Dragonfly® L	DGF-UNI-AA20406-10	Unidirectional / Passive / Long Flex
Dragonfly® IEPE S (G1)	DGF-UNI-W120405-10	Unidirectional / IEPE 1.08mV/με / Short Flex
Dragonfly® IEPE L (G1)	DGF-UNI-W120406-10	Unidirectional / IEPE 1.08mV/με / Long Flex
Dragonfly® IEPE S (G10)	DGF-UNI-W220405-10	Unidirectional / IEPE 10.8mV/με / Short Flex
Dragonfly® IEPE L (G10)	DGF-UNI-W220406-10	Unidirectional / IEPE 10.8mV/με / Long Flex
Dragonfly® IEPE S (G100)	DGF-UNI-W320405-10	Unidirectional / IEPE 108mV/με / Short Flex
Dragonfly® IEPE L (G100)	DGF-UNI-W320406-10	Unidirectional / IEPE 108mV/με / Long Flex

4 Quick-start guide

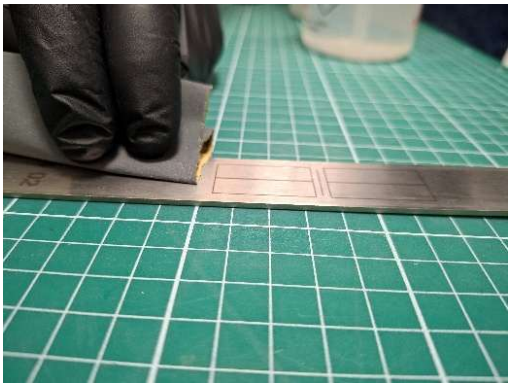
The deformation of the test object will be transmitted to the sensor through the glue interface. Thus, surface preparation and gluing should be performed carefully.
The sensor can be glued to a flat or curved surface; bending radius is limited to 2 cm according to the sensor datasheet.

4.1 Required tools

1. Cutter
2. Kapton tape
3. Tweezers
4. Teflon paper
5. Glue
6. Ruler
7. Marker
8. Cleaning paper
9. Ethanol
10. Sandpaper (for rough surfaces)

Refer to the “Glue and protective layer selection” section of this manual to select the right glue references.

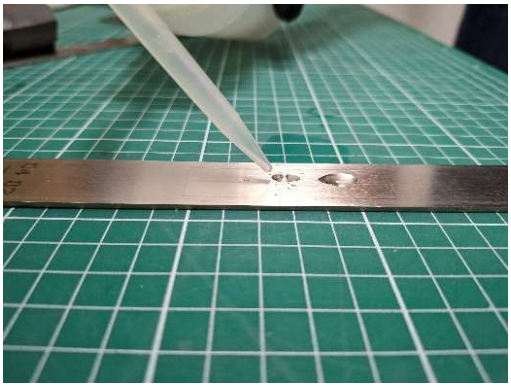
4.2 Surface preparation



Surface smoothing

- Any paint or coating on the test object should be removed to ensure the best contact between the sensor sensing 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 smoothing like small circular movements.
- Generally, a classic thin grain is suitable (grade 100 to 600).
- The final aspect should be flat and homogeneous.

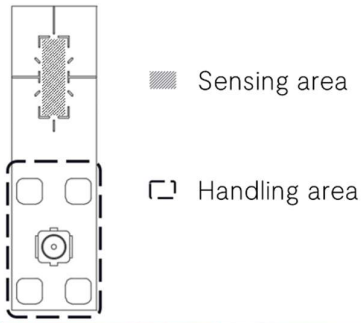
If you are bonding on a material with an important porosity, use a first coat of HBM X60 (without applying the sensor) to reduce the porosity (i.e. fill the microscopic holes). Prepare and glue the sensor on this new flat surface, repeating the process described here.



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 particles.

4.3 Handling recommendations

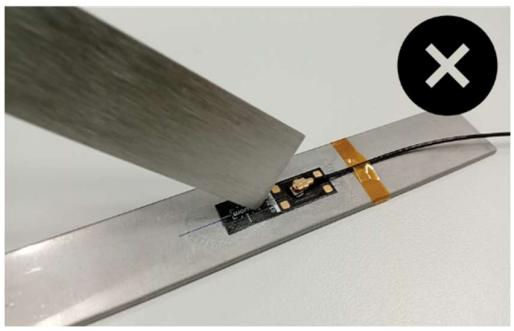


Manipulation

- 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 cleaning them.
- Sensors should be manipulated by the handling area prior to wire installation.
- Avoid any contact with the sensing area.

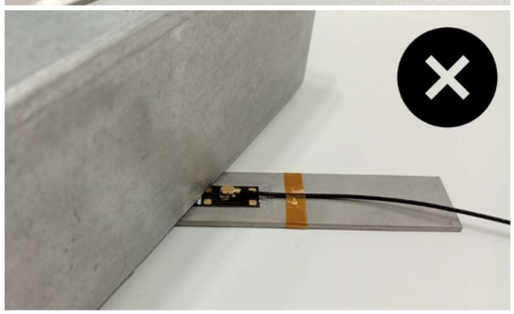
Bending

- Avoid any bending of the sensor prior to installation.



Localized pressure points

- Avoid putting sharp objects on the sensor.



Loads

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

4.4 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

Manipulate the sensor by the handling area

- Handle the sensor by the handling area. Use tweezers or the provided hand-vacuum tool.
- For passive sensors, use the hand-vacuum tool on a flat surface of the handling area.
- For IEPE sensors, use the hand-vacuum tool on the metallic cover.

4.5 Sensor installation

The following gluing technique allows for 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. The whole length of the sensor is glued in one go for the short version of Dragonfly®. On the long version, the sensor sensing area is glued before the handling area.

⚠ 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.

Position Identification

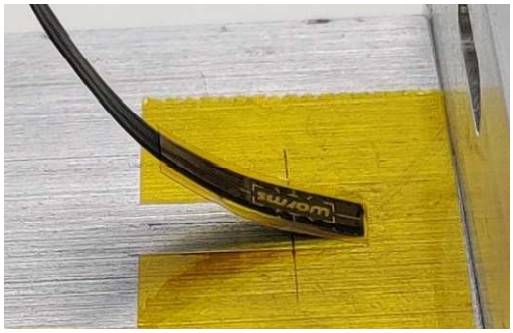
- Make alignment marks on the surface where the sensing area will be placed.

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.

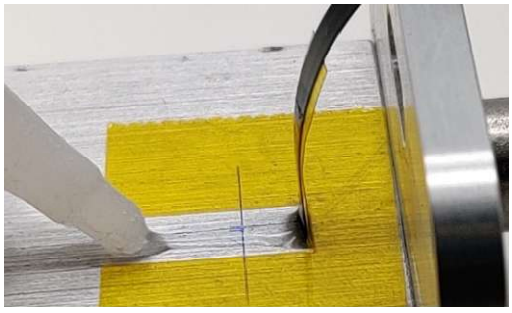
Cut the tape on the sensor sides

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

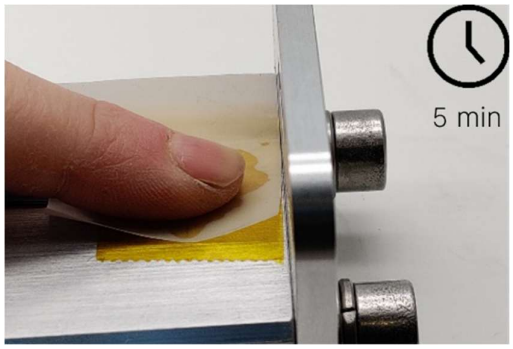


Apply glue

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

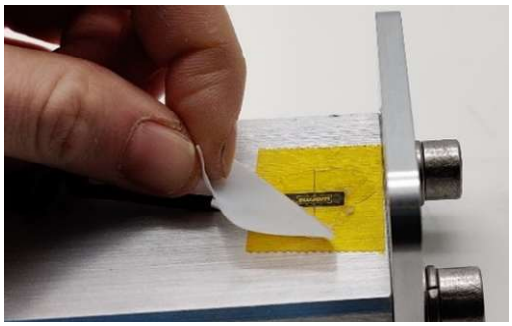
Lower the sensor

- Use the tape as an alignment hinge.



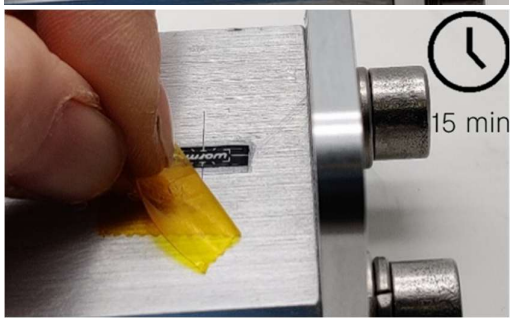
Apply pressure through a Teflon® sheet

- 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)
- If you are using Loctite401, hold the pressure **for at least 5 minutes** with a finger. Epoxy glues have longer curing time and require mechanical clamping, see “Clamping procedure” section in Annex.



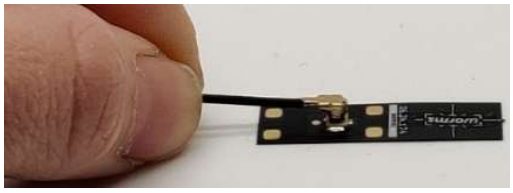
Remove the Teflon® (PTFE) sheet

- Gently remove the Teflon® (PTFE) sheet.



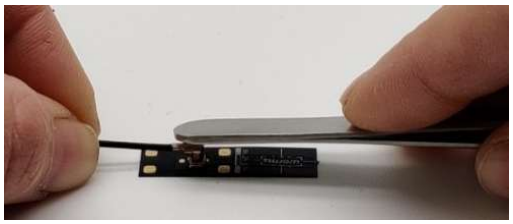
Remove the tape after 15 min

- Wait for the complete glue curing time. (15 min for Loctite401).
- Pull the tape at an angle by the corner as pictured, to minimize the stress on the sensor's fresh bonding.
- Removing the tape too soon could result in sensor damage.



Plug the connector

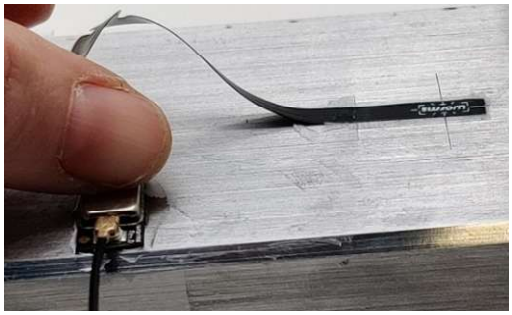
- Carefully place the cable’s UFL connector over the sensor connector.
- Make sure they are precisely centered.



Apply pressure on the connector

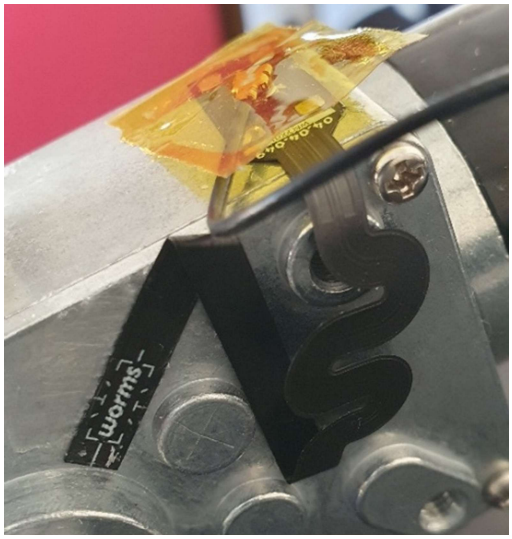
- Use a rigid object to apply vertical pressure on the connector. Make sure to maintain the parts in the same vertical alignment.
- A soft “click” can be felt when the connector engages.

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



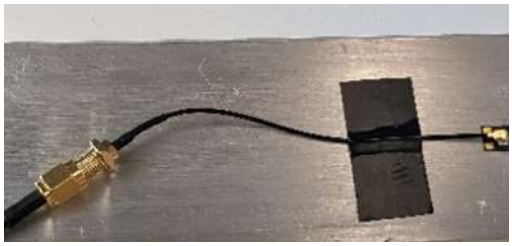
If you are using long Dragonfly®, glue the handling area

- Glue the handling area 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 handling 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.



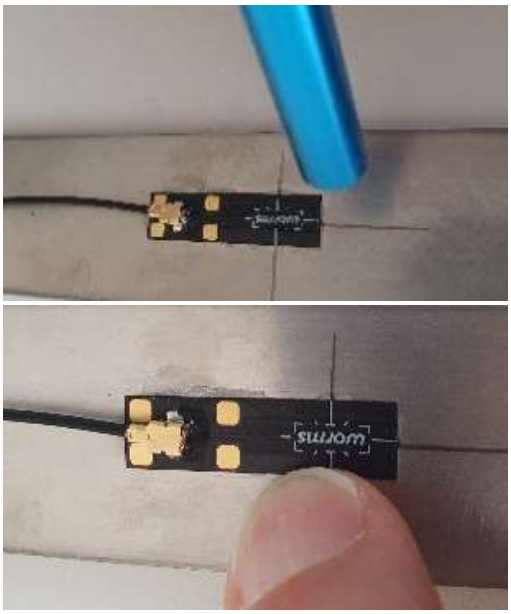
Secure the wire

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

4.6 Quick functional test

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

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



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. Check the sensor datasheet Dragonfly® Downloads for noise specification (the measured value depends on the data 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.
- 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.

Further spectral analysis and troubleshooting
Refer to further detailed spectral response and common fault detection, description and countermeasures in the "Troubleshooting" section.

4.7 Applying a protective layer (Optional)

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

Refer to the section "Glue and protective layer selection" section to select the right protective layer.

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

5 Glue and protective layer selection

Manipulating glues and protective layers can be harmful and requires specific caution. Follow carefully the manufacturer recommendations and safety datasheets.

With epoxy compounds, long time curing is necessary. Refer to the specific glue user manual.

The following recommended glues and protective layers have been qualified for Dragonfly® specifically for their ability to **cure fast at room temperature**. Please refer to their respective datasheet for conditions of use.

- Glue: Loctite 401, HBM X60, M-Bond 610* and X280*.
- Protective layers: HBM SG250, SR180, NG120, and ABM75.

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

6 Grounding

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.

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.

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.

7 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 to help select the sensor corresponding to your application.

7.1 Passive Dragonfly® sensors

The Dragonfly® passive sensor behaves electrically as a capacitance, in parallel with a leakage resistor.
Dragonfly® need to be connected to an external charge amplifier before entering the acquisition system.
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.

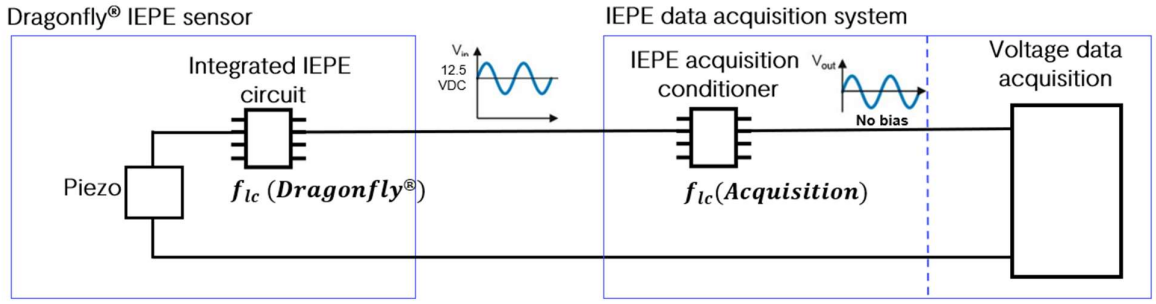
Standard coaxial cables may create triboelectric noise when they are deformed: the friction produced by cable deformation generates charges that are not related to the mechanical deformation of the sensor but by cable movement. Special low noise coaxial cables exist to mitigate this problem. If this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

7.2 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[2]. 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).

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

Below are the schematics of a typical IEPE interface.



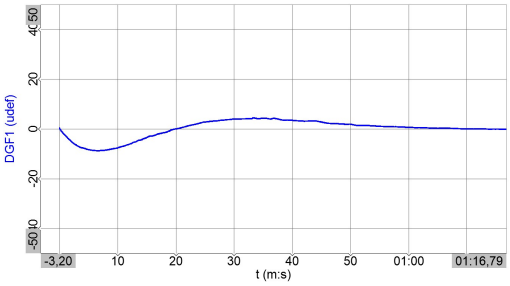
IEPE Dragonfly® sensors will not work if the supply current is not activated in dedicated IEPE inputs coupling. The supply current must be in the range between 2 mA and 20 mA.
The lower cut-off frequency of the Dragonfly® measured by an IEPE acquisition system depends on two components:

- The charge amplifier embedded in the Dragonfly® sensor itself, whose lower cut-off frequency is $f_{lc}(\text{Dragonfly®})$ in the sensor datasheet.
- The cutoff frequency of the IEPE input depends on the acquisition system only. The lowest cut-off frequency may typically vary in the range $f_{lc}(\text{Acquisition}) =$ 0.01 Hz to 1 Hz. Refer to the technical information regarding your acquisition device.

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

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.

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 in laboratory environment is presented below).



Right after power-up, the signal is expected to fluctuate before stabilizing at zero as shown in the example besides.

Wait for 3 minutes after connecting the Dragonfly® to the IEPE supply before starting your measurements.

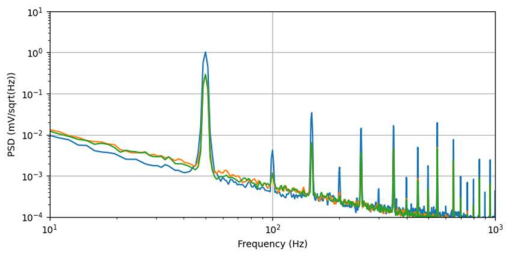
8 Troubleshooting Dragonfly® signals

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

8.2 EMI noise



The Dragonfly® sensor is shielded from the sensing area to the connector.
If you encounter EMI noise in the measured signal, 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. Check that you have used **shielded cables** and connectors from the sensor to the acquisition device.

8.3 Sensor check

The following sensor check procedure is optional and is only indicated for verification purposes.

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 datasheet.
The capacitance of the sensor alone is 6.3 nF ±10%.

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

- The pressure can be applied with a specific F-Clamp
- Use a moderate clamping force (10-20 N)

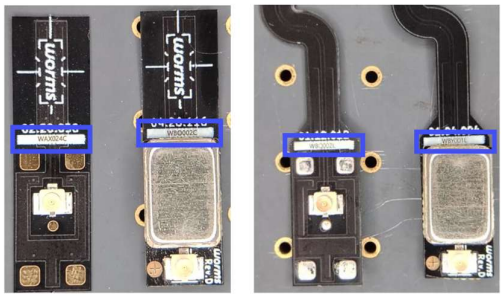
Use a silicone rubber patch covered with Kapton tape to apply a uniform pressure

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

⚠ Be careful to position the magnet gently to avoid it slamming against the sensor surface upon contact. We recommend first holding the magnet next to the sensor, then lifting one side of the magnet to bring it into contact with the sensor.

Appendix 2 - Sensor identification

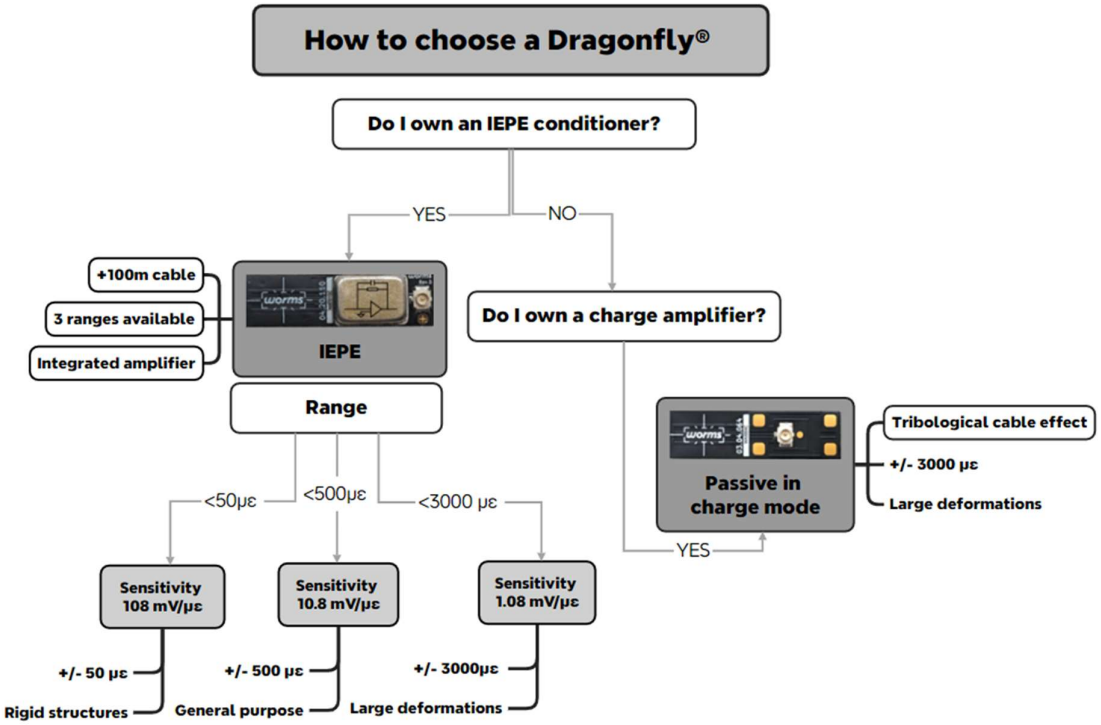


All our sensors are manufactured with care to provide the best user experience. However, if an unexpected response is to be found during acquisition, please contact us. Provide the following reference identification pictured in the blue rectangle below (for instance WBO002C).

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) 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 before are now accessible.

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