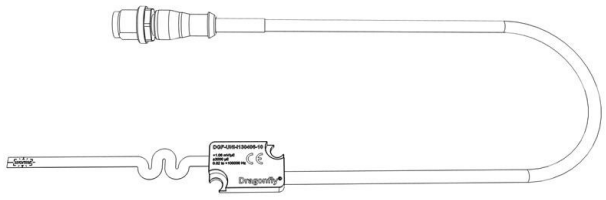
worms

Piezoelectric unidirectional strain sensor

Dragonfly®

type IO DGF-UNI-Ix304xx-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.

WORMSENSING
2 Rue des Murailles,
38170 Seyssinet-Pariset
France

contact@wormsensing.com
www.wormsensing.com

Contents

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

NOTE
Indicate tips, recommendations and important information

Intentionally left blank

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

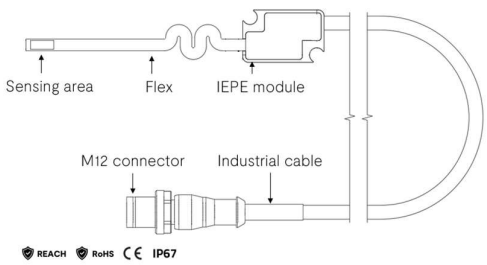
3.1 Functional principle

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 industrial grade types (Dragonfly® IO DGF-UNI-Ix304xx-10).

Dragonfly® IO sensors are suitable for industrial application as they are IP67 and fitted for M12 standard connection.

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® IO 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® IO (G1)	DGF-UNI-I130406-10	Industrial / Unidirectional / IEPE 1.08mV/με
Dragonfly® IO (G10)	DGF-UNI-I230406-10	Industrial / Unidirectional / IEPE 10.8mV/με
Dragonfly® IO (G100)	DGF-UNI-I330406-10	Industrial / Unidirectional / IEPE 108mV/με

4 Quick-start guide

4.1 Required equipment

Cleaning equipment

1. Ethanol
2. Acetone
3. Degreaser

Gluing equipment

1. HBM X60 Glue
2. Polyimide tape
3. Pen
4. Teflon sheet
5. Cutter
6. 2 magnets
7. Protective coating HBM SR180

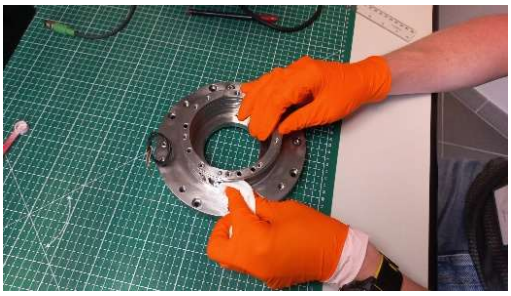
4.2 Surface preparation

The deformation of device surface 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 device surface.
The sensor bending radius is limited to 2 cm according to the sensor datasheet. Make sure the radius of curvature of the surface is larger than 2 cm.

Surface preparation

- Any paint or coating on the device surface should be removed to ensure the best contact between the sensor sensing area and the device surface.
- The final aspect should be flat and homogeneous.

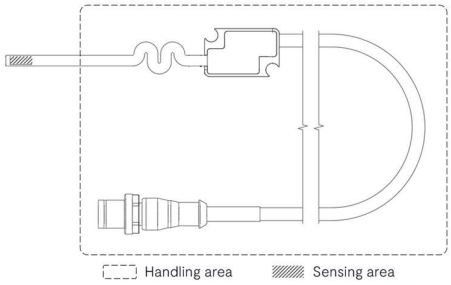
If you are bonding on a material with an important porosity, use a first coat of HBM X60 (without applying the sensor) to reduce the porosity (i.e. fill the microscopic holes).



Cleaning

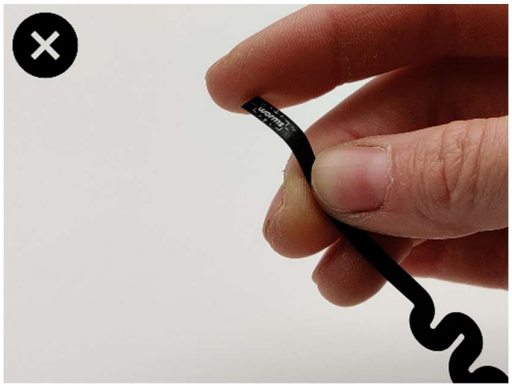
- Use degreaser to remove oil and grease from the device surface.
- Clean the surface using microfiber fabric or cleaning paper and a solvent such as isopropyl or ethylic alcohol.
- Be sure that all particles have been removed by having a look at the cleaning paper; this one should not exhibit any visible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

4.3 Handling recommendations



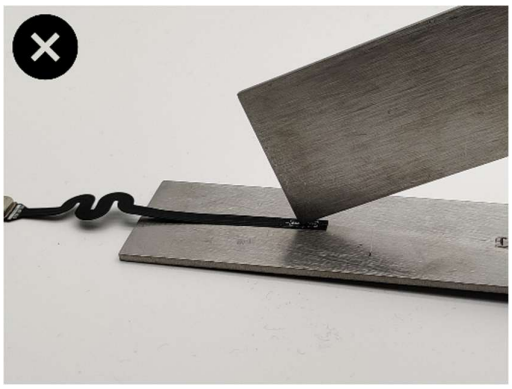
Manipulation

- Before they are installed on device surface, 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.
- Avoid any contact with the sensing area.



Bending

- Avoid any bending of the sensor prior to installation.



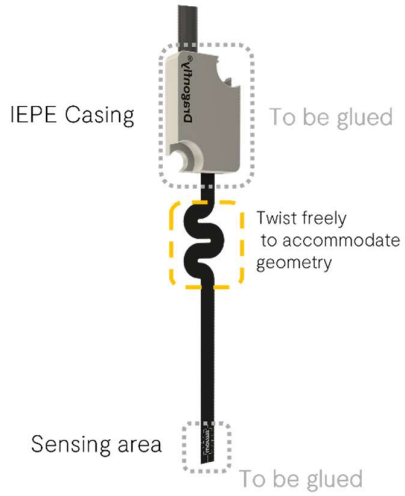
Localized pressure points

- Avoid putting sharp objects on the sensor.

4.4 Unboxing

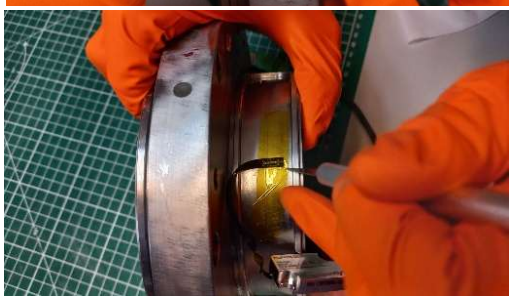
Sensors are sold in a box. Once the surface is ready to be instrumented, use the following instructions to remove the sensors from their packaging.

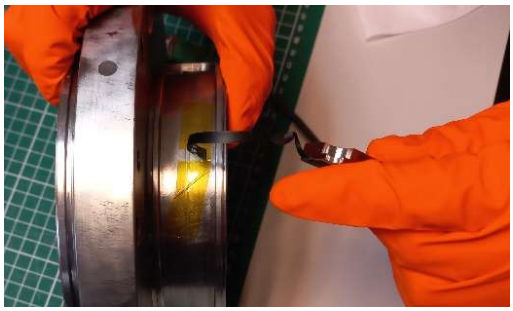
4.5 Sensor installation

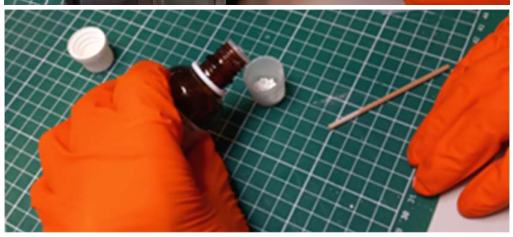


The following gluing technique allows for a precise alignment of the sensor with the expected principal direction of deformation (operator's experience) or to comply with a specific location (e.g.: for comparison with a finite element model calculation).

- 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

- Identify the sensing area position on the system and twist the flex part to fit the device geometry.
- The minimum bending radius of the sensing area is specified I the sensor datasheet.
- From 1 cm of the sensing area, one time 1 mm minimum bending radius can be applied on the flex part.

Align the sensor by covering it with tape

- Use a low adhesion tape (such as Kapton®) to place the sensor on the device surface.

Cut the tape on the sensor sides

- Use a cutter to cut the tape on both sides of the sensor.
- 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.

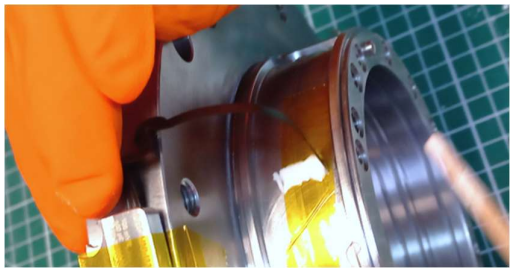
Lift the sensor

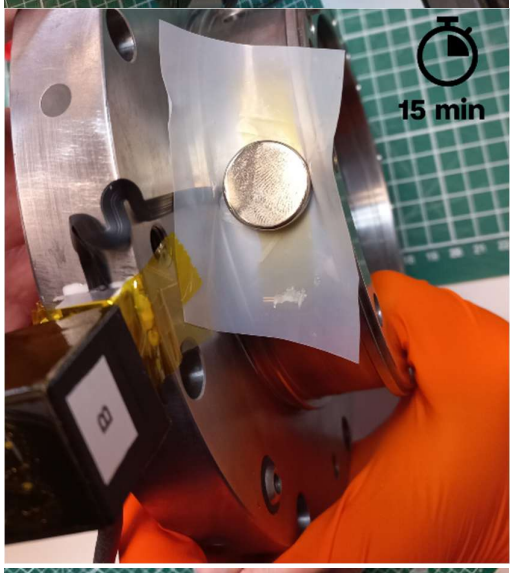
- Gently lift the sensor while checking if the tape is cut properly.
- Keep the sensor as flat as possible during this step to avoid going over the sensor's allowable bending radius (a curvature as pictured is normal).

Prepare glue[1]

- In case of HBM X60 glue, mix homogeneously powder and liquid following the manufacturer instructions.
- The interface between the sensor and the device surface must be thin and rigid to transmit the deformation of the device surface to the sensor.

[1] Go to “Glue and protective layer selection” section for glues recommendation.





Glue the sensor and IEPE casing

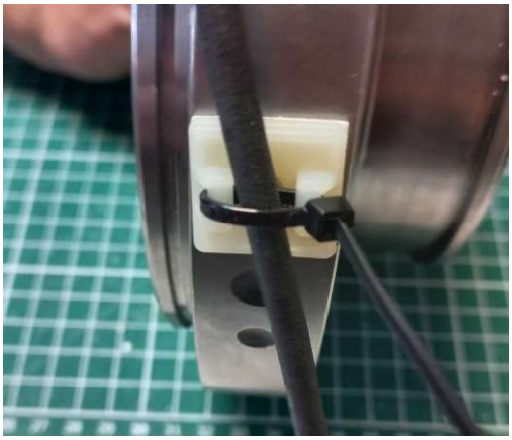
- Apply glue to the whole lifted area.
- Apply glue under the IEPE casing.

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)
- Hold pressure **for at least 15 minutes** with a magnet (10-20 N) or a finger on the sensing area and on the IEPE casing.

Remove the tape

- Wait for the complete glue curing time. The glue left in the cup is an indicator of the glue curing time.
- 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.



Protect the sensor[2]

- Apply protection on the sensing area and on the part exposed to rough environments (humidity, heat, light, projections).
- The protective layer should cover the glued area by at least 3 mm from each side.
- If the environment is particularly exposed to projections, we advise designing a covering part to protect the sensor.

Secure the wire

- Secure the wire to avoid any damage.

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[3] after bonding.

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, 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.

[2] Go to “Glue and protective layer selection” section for protective layer recommendation.
[3] Wormsensing team can help you select the acquisition and conditioning system matching your application.

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

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

- Glue: 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 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.

Dragonfly® IO sensors are shielded by design, making them immune to strong EMI (Electro Magnetic Interferences). However, the internal shielding cannot replace a proper grounding of the acquisition chain.

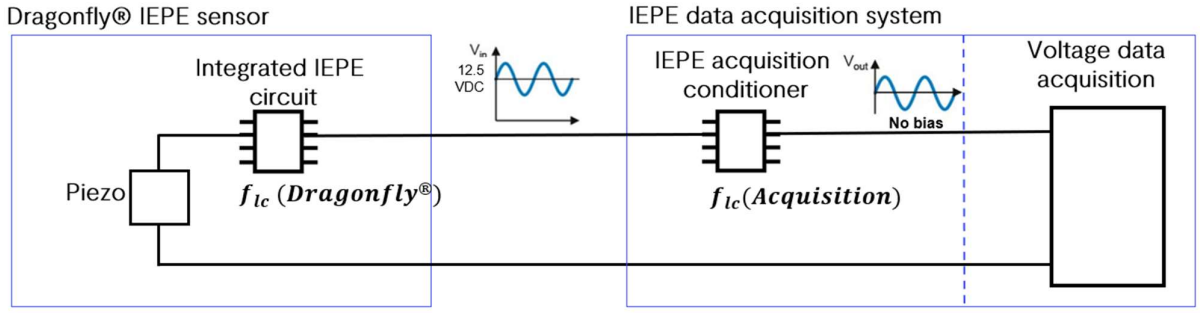
Industrial shielded wires should be used on the complete line to ensure the best performance.

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®

Dragonfly® IO sensors integrate an onboard charge amplifier, which is powered by a constant biasing current supplied by the acquisition system featuring an IEPE conditioner[4]. 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).

Below are the schematics of a typical IEPE interface.



Dragonfly® IO 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:

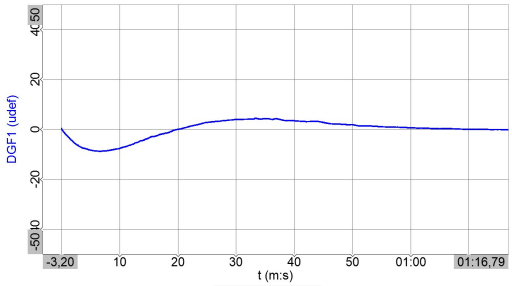
- The charge amplifier embedded in the Dragonfly® sensor itself, whose lower cut-off frequency is $f_{lc}(\text{Dragonfly®})$ in the sensor datasheet.
- The cutoff frequency of the IEPE input depends on the acquisition system only. The lowest cut-off frequency may typically vary in the range $f_{lc}(\text{Acquisition}) =$ 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 shielded industrial 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 is presented below).

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



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.

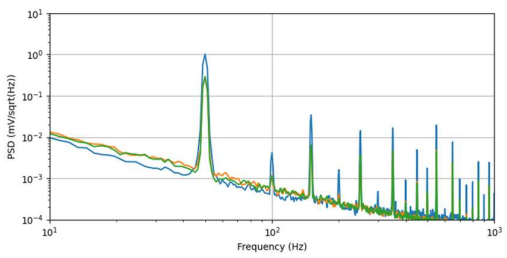
8 Troubleshooting Dragonfly® signals

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 M12 connector is correctly connected.
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. Make sure you are using an IEPE acquisition system.
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. 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 DAQ noise specification.
9. 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.

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

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 CBT0006L-057).

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

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