ISTerre
UNIVERSITÉ SAVOIE MONT BLANC

# User manual

IST2018

InfraSound Transducer

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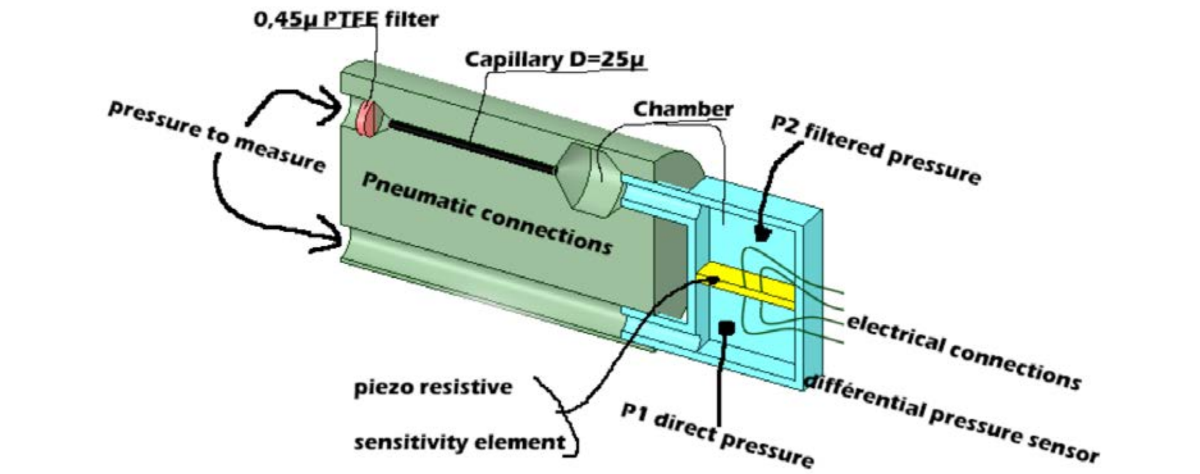
# 1 Description

## 1.1 Principle.

This low-cost Infra Sound Transducer is designed for the detection and analysis of acoustic waves mainly on volcanoes. It is based on a small microelectromechanical differential pressure transducer (MEMS). The reference pressure is balanced through a pneumatic high-pass filter.

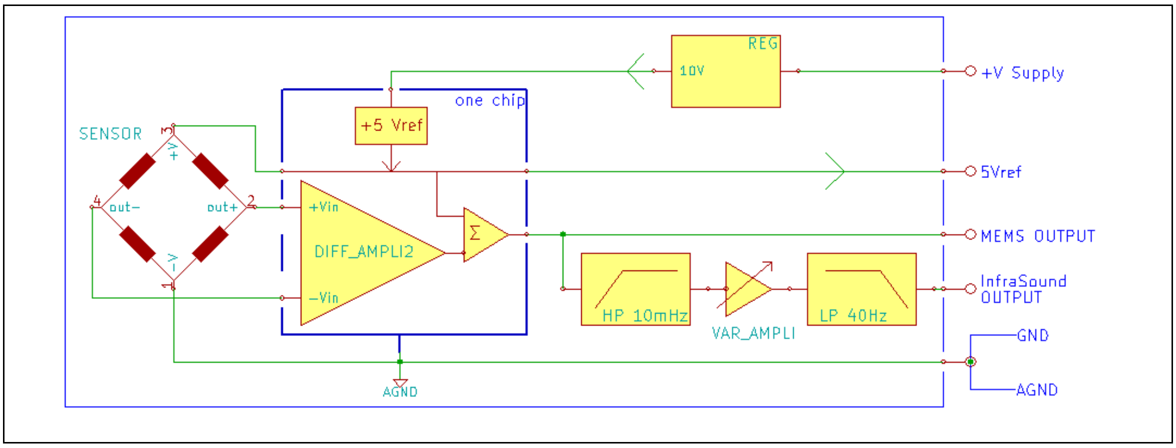



## 1.2 Mechanical packaging.


The mechanical elements of the sensor are produced by 3D printer and filled by epoxy resin that guarantees high robustness in the aggressive environment of most volcanoes. The sensor dimensions (26x53x80 mm) and weight (100 g) makes it very easy to handle and install.

## 1.3 Electrical features

### 1.3.1 Electronic diagram




### 1.3.2 Power supply

The sensor is powered by single input supply (**10.2 Vdc < $V_{supply}$ < 29 Vdc**). The input supply is protected against reverse voltage.

### 1.3.3 Outputs

The sensor has two signals and one 5V reference outputs. The signal outputs are centered on the 5V reference.

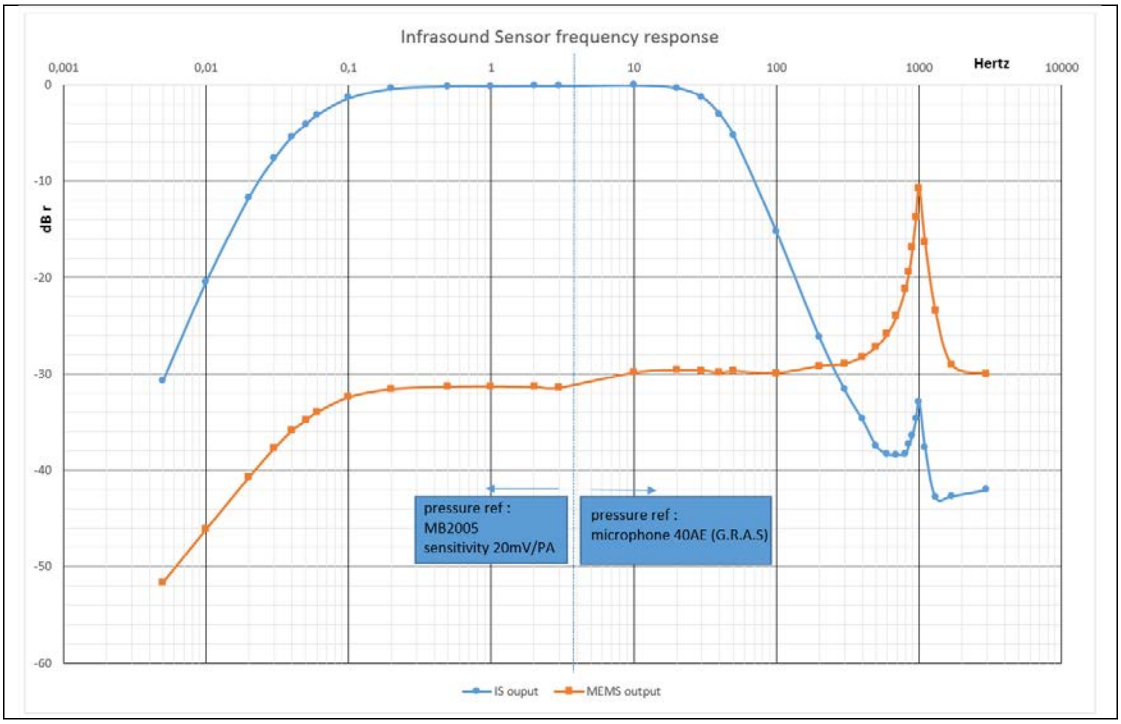
1. **'MEMS output'** has an approximate sensitivity of 550 µV $Pa^{-1}$, depending on the MEMS characteristics.
2. **'Infrasound (IS) output'** is calibrated to deliver 20 mV $Pa^{-1}$. A 10 mHz highpass filter controls the temperature offset of the sensor. A 40Hz low-pass filter reduces the high-frequency noise.

## 1.4 Typical frequency response

The point-by-point calibration was obtained by using a MB2005 Martec absolute microbarometer and a 40AE G.R.A.S. microphone as references.

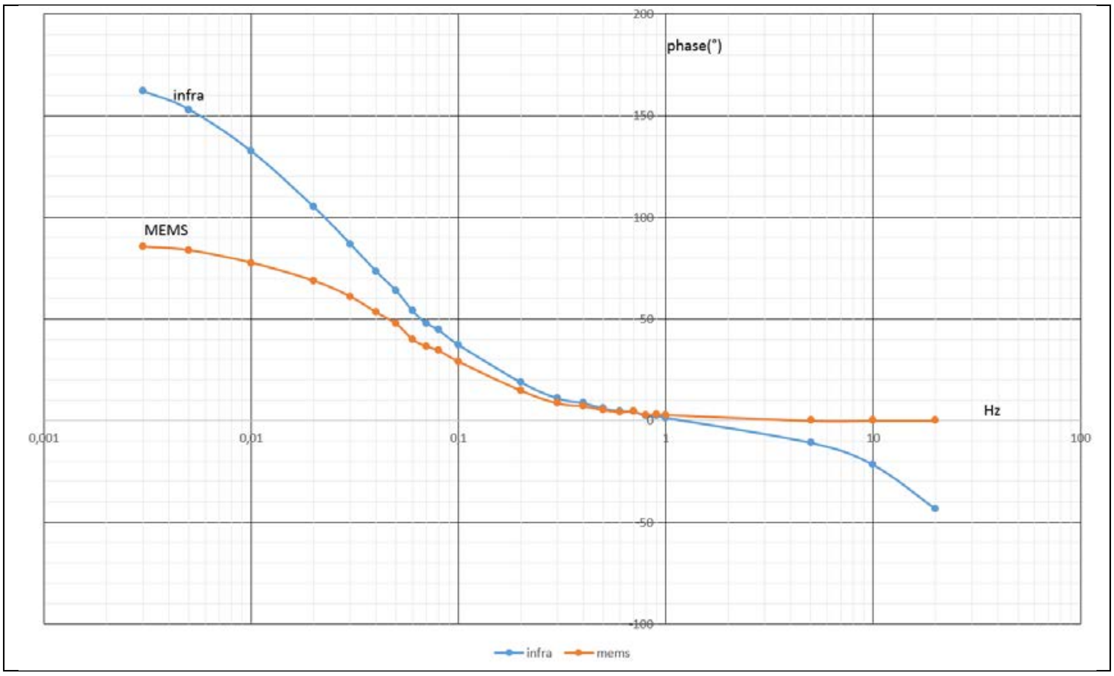
The sensitivity of each sensor is measured and supplied to the user.

### 1.4.1 Amplitude (dB)

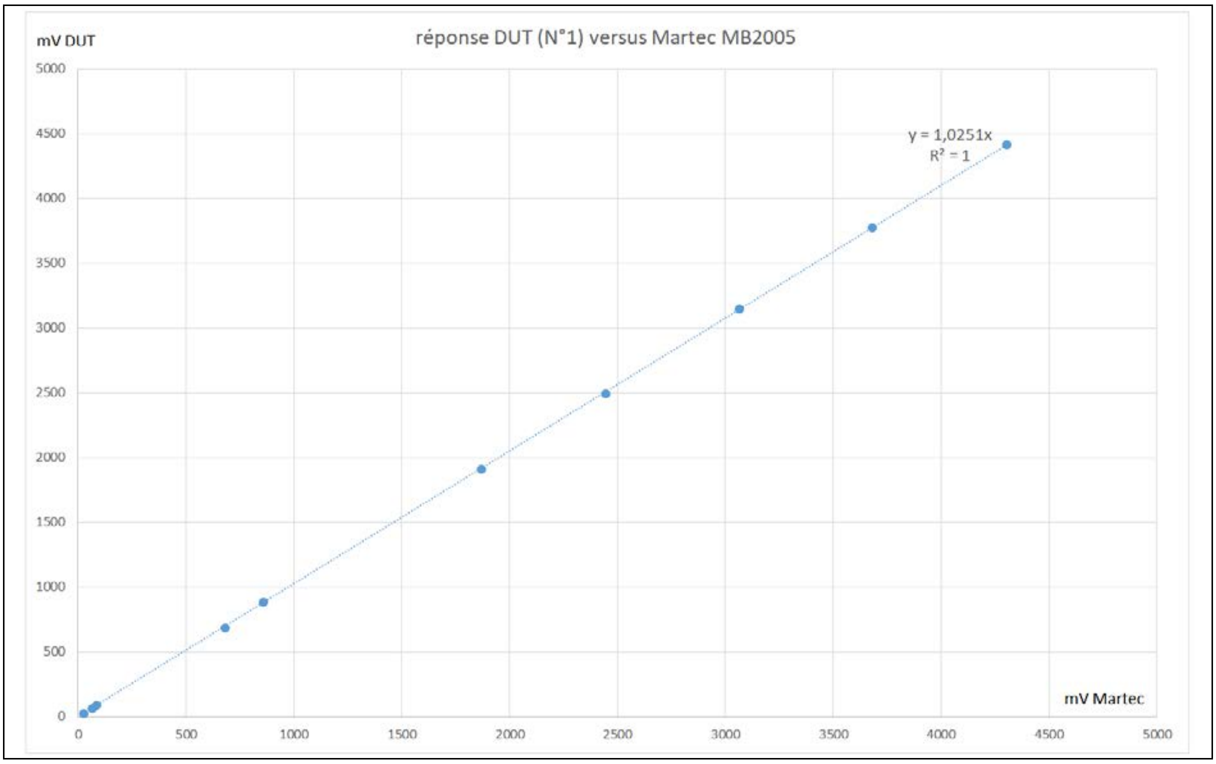



On the 'MEMS output' (red), the high pass filtering is produced by the pneumatic filter alone.
On the 'IS output' (blue), the filtering is the result of both the pneumatic and a 10 mHz electronic filters.

### 1.4.2 Phase (°)




## 1.5 Linearity




The linearity is good with respect to the MB2005 sensor, with a mean relative deviation of 0.66 %. (Measured on 'IS output' between 1.2Pa and 220Pa).

# 2 Specifications

## 2.1 MEMS pressure

**Pressure range**: **+/- 1 245 Pa**
Maximum burst differential pressure: 124 544 Pa
Maximum common mode pressure: 547 995 Pa

## 2.2 Temperature

Operating range: -20 to 80°C
Storage: -40°C to 85°C

## 2.3 Signal outputs characteristics.

The loading impedance must be **> 4 kΩ**.
The **signal outputs** are, with respect to sensor AGND, $\mathbf{V_{out}=V_{signal}+5\ V_{Vref}}$, with $\mathbf{V_{out}}$ **max=9.2 V**.
**Background noise**, approximately 0.05 Pa rms (on 'IS' output).

### 2.3.1 'Infrasound Output'

19.6 < **Sensitivity** < 20 **mV Pa$^{-1}$**
-10 < **offset** < 10 mV
**Range**: **+/-230 Pa** for +/-4600 mV; with $V_{signal} = V_{out} - 5V_{ref}$

### 2.3.2 'MEMS Output'

0.5 < **Sensitivity** < 0.6 **mV Pa$^{-1}$**
-170 < **offset** < 120 **mV**
**Range**: **+/-1245 Pa** for +/- (684 mV-$V_{offset}$); with $V_{signal}=V_{out}-5V_{ref}$

### 2.3.3 $5V_{ref}$

The reference voltage is accurate to +/-0.5 % (max) with +/-35 ppm/°C drift (max).

## 2.4 Power supply

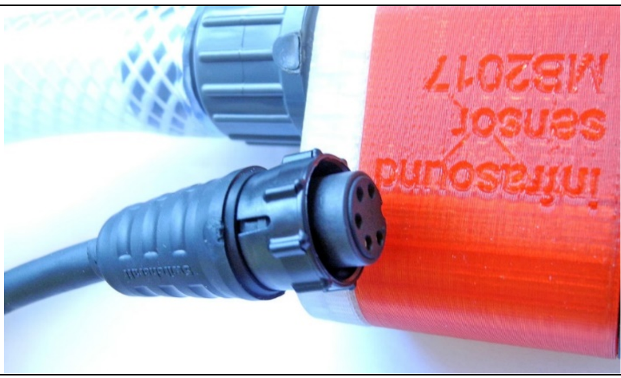
Vdc min = 10.2 V
Vdc nominal = 12 V
Vdc max = 29 V

Current supply = 3.6 mA (for null differential pressure)
Current supply = 3.8 mA ('IS output' saturated connected at a load impedance >1 MΩ)

**Reverse voltage protected**, in case of mistake just reconnect correctly the Sensor.

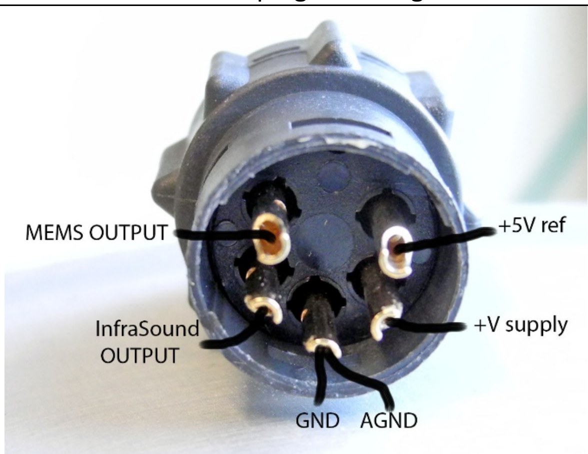
# 3 Electrical connections

## 3.1 A ‘Switchcraft EN3C5FX’ watertight plug makes easy the connection of IST2018.



## 3.2 Wiring

View of the plug soldering face




## 3.3 Optional 1 m-long PE cable (AlphaWire 25096BK005)

| **Fonction** | **Color** |
|---|---|
| MEMS OUTPUT | orange |
| InfraSound OUTPUT | green |
| GND | black |
| AGND | brown |
| +V supply | red |
| +5V ref | Yellow |

## 3.4 Suggestion for field wiring

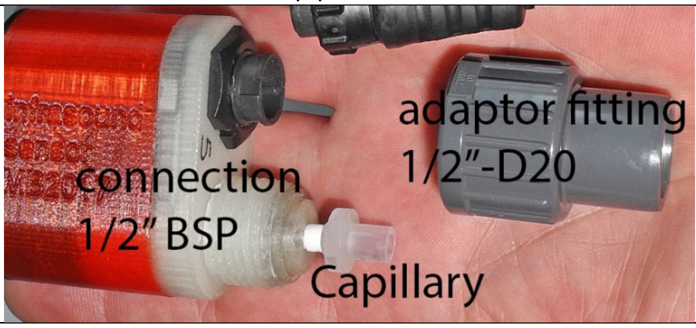
The optional 1m PE cable is well adapted to the ‘Switchcraft’ connector. It is a high performance cable, his price is about **10 € for 1 m**.

To use several IST2018 at long distances from the recorder (e.g. array of sensors), we suggest to use ‘PTT cable’ such as 74FT or 92FT connected to the optional 1 m PE cable. These low cost (**~1 € per meter**) cables are mechanically well-adapted to the field conditions.

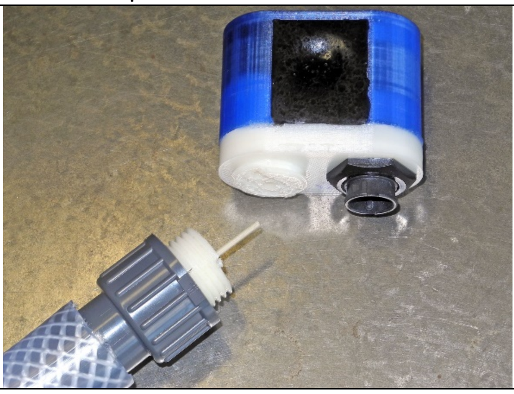
# 4 Pneumatic connection

## 4.1 Description

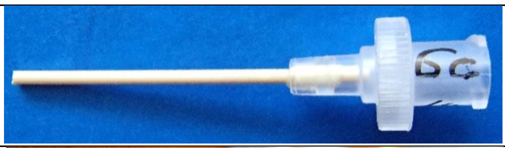
The pneumatic connection is based on a ½'' BSP thread.
The IST2018 is delivered with an adaptator fitting. This adaptator protect the capillary tube and allows the use of a 20 mm internal diameter pipe.




## 4.2 The pneumatic connection is fragile! Be careful!

| Example of a **broken connection** | Precautions |
|---|---|
|  | ¤ Avoid any lateral constraints on the thread.<br>¤ Screw the adaptor gently, only by hand. |

## 4.3 Capillary precautions.

| | |
|---|---|
|  | The capillary is stuck in a syringe filter. The filter is a PTFE 0.45 µm membrane PP-housing. |
|  | **Very important:** the capillary must be well inserted into the ½''BSP connector.<br>Any leak would increase the pneumatic high pass corner frequency. If the leak is too important, the obtained value of pressure can be close to **zero**. |

# 5 Field installation

## 5.1 Two important points

1. Protect the IST2018 from direct solar radiation.
2. Protect the pneumatic inputs from possible obstructions.
   The first precaution to take is to point the sensor input downwards.
   Depending on field conditions, it may be necessary to install a bug filter.

## 5.2 Examples of installation

| Installed on a 'wind filter'. | Sensor with its solar protection. |
|---|---|
|  |  |

| Installed directly on a tree, north oriented, the forest being a 'wind filter'. | Example of 'bug filter'. |
|---|---|
|  |  |

# 6 Connection to seismic digitizer.

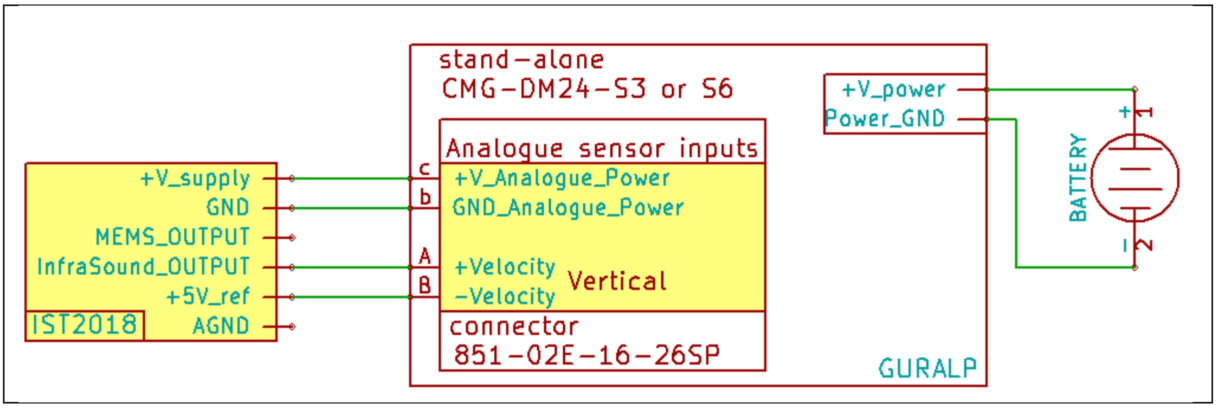
## 6.1 Introduction

-Initially, the sensor was designed to be connected on a seismic recorder (GURALP for our laboratory) in order to record, at the same time, seismic and acoustic signals. For convenience, the same power source supplies the sensors and the recorder.

- The two outputs are single: $V_{out}=V_{signal}+5V$ with $V_{out}$ max=10 V
- A 5 V output is available.
- The signal can be measured in single mode or, better, in differential mode, $V_{mes}=V_{out}-5$ V. (The results presented in the specifications section were measured in differential mode).

## 6.2 GURALP CMG_DM24 DIGITIZER.

### 6.2.1 Connecting to the 'Analogue sensor inputs' connector

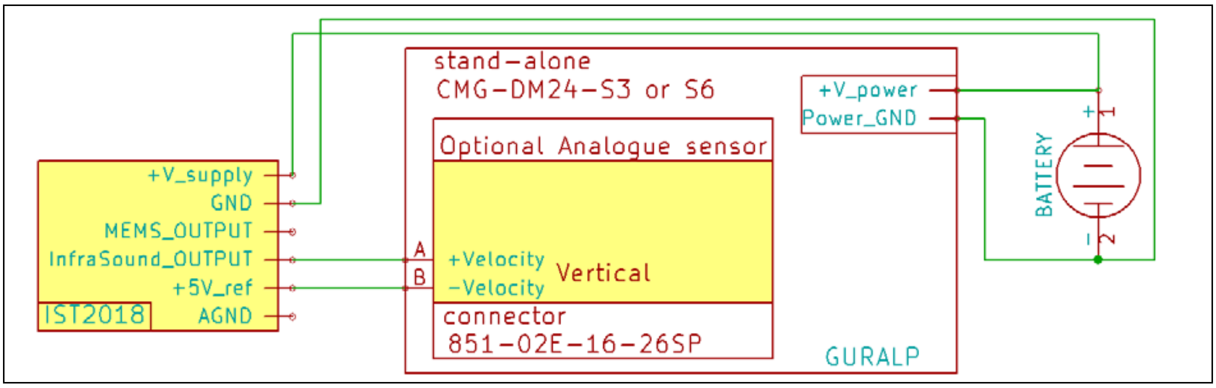



It is possible to connect two other 'IST2018' devices, one on 'NORTH/SOUTH' entry and the other on 'EAST/WEST' entry.

In this configuration, we obtain:

- Sensor power consumption: **43.2 mW for each IST2018**.
- Sensitivity : **20 mV Pa$^{-1}$**
- Range : **+/-250 Pa for +/-5V**

### 6.2.2 Connecting to the 'OPTIONAL ANALOGUE SENSOR THROUGH-PUT& 16-BIT AUXILIARY INPUTS'.




The only difference with §6.2.1 is that the 'IST2018' power supply is **directly connected to the battery**.

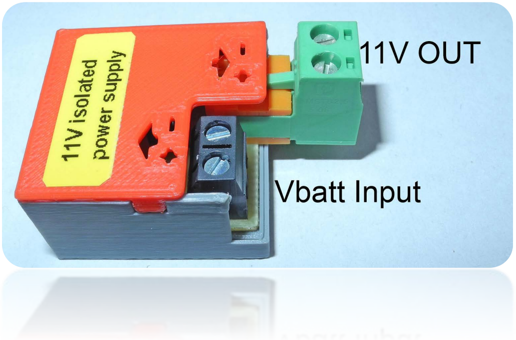
## 6.3 Use of an isolated power supply.

With some digitizers, like **Taurus** (Nanometrics Inc.), it is **necessary** to separate the sensor power from the digitizer power. It is possible to use either separate batteries, one for the sensor and one for the digitizer or an isolated DC/DC converter power supply for the sensor. The DC/DC converter is easier to install but increases the power consumption.
It is possible to use any DC/DC isolated converter of the market; the input voltage must be compatible with the digitizer power voltage and output ranging from 10.2 V to 24 V.

### 6.3.1 Our optional isolated power supply.

We propose a small-size (3x3x2cm) low power DC/DC converter able to power up to **five 'IST2018' sensors**.

#### *6.3.1.1 Device view*




#### *6.3.1.2 Characteristics*

$V_{out}$= 11.3 V at 0mA; 10.6V at 21mA. The max output current is **21mA**.
10.2 V < $Vdc_{in}$ < 28 V
**Reverse input protected**, in case of mistake just reconnect correctly.

#### *6.3.1.3 Power consumption*

The use of a DC/DC converter increases the power consumption.

| number of sensors | Current supply mA/12V | Power consumption mW | Sensors power consumption without DC/DC converter ; mW |
|---|---|---|---|
| 1 | 8.5 | 102 | 43.2 |
| 3 | 15.5 | 186 | 129.6 |
| 5 | 22.5 | 270 | 216 |

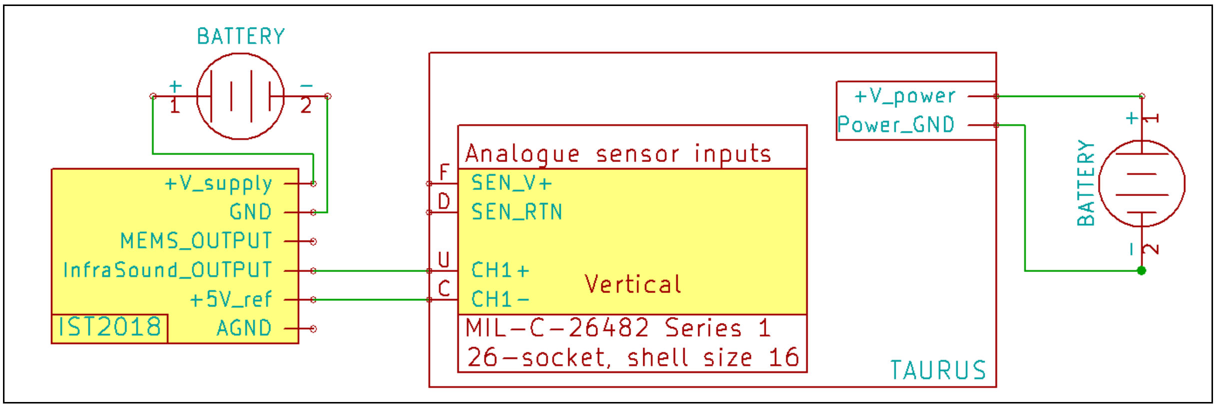
## 6.4 TAURUS, Nanometrics Inc. portable digitizer.

For proper operation, the 'IST2018' power supply and the digitizer power supply must be separated. Two solutions are described in sections §6.4.1 and §6.4.2. For these solutions, there is no GND connection between 'IST2018' and digitizer, so the outputs are floating. It is possible to connect two more sensors (CH2 & CH3).
In these configurations, we obtain:

- Sensitivity : **20 mV Pa$^{-1}$**
- Range : **+/-250 Pa for +/-5V**

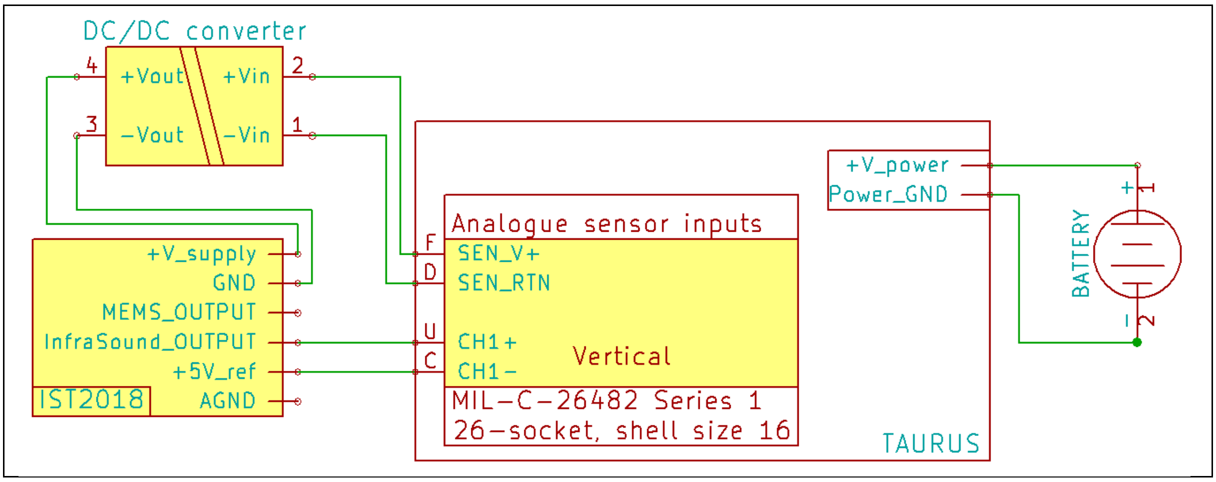
### 6.4.1 A power supply with two batteries requires less power.

IST2018 power consumption: **43.2 mW for 1 sensor**; **129.6 mW for 3 sensors**.




### 6.4.2 A DC/DC isolated converter power supply is easier to install.

IST2018 power consumption, with our DC/DC converter: **102 mW for 1 sensor; 186 mW for 3 sensors**.



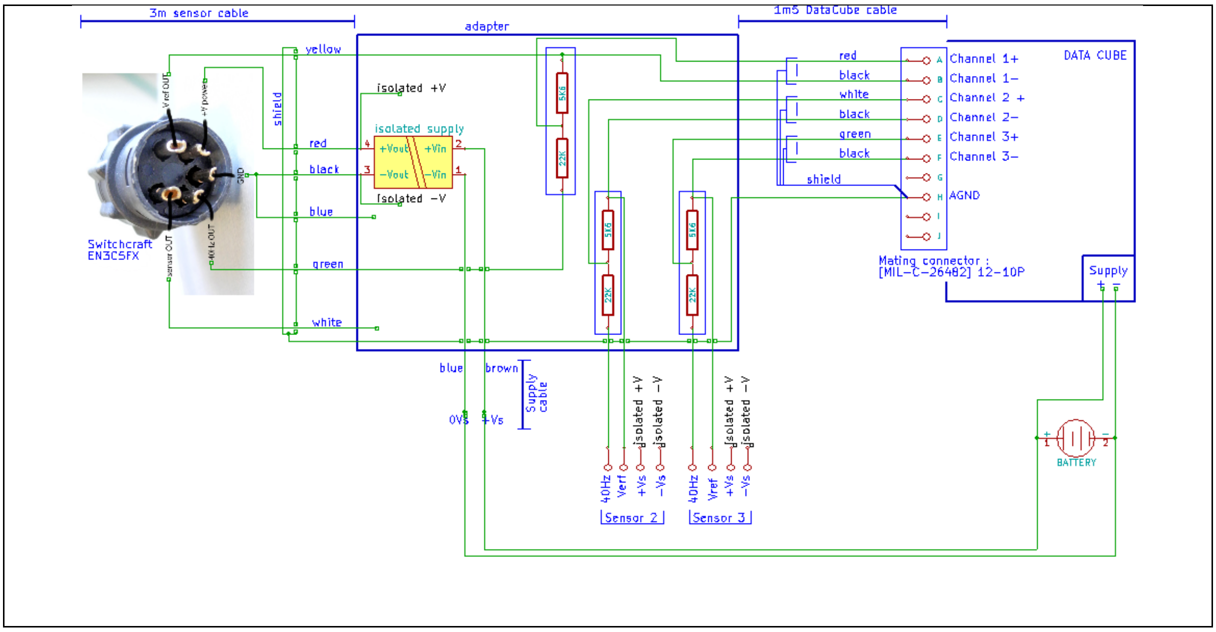
## 6.5 DataCube

### 6.5.1 Issue.

The DataCube input range is too low with respect to the sensor output.
Common mode voltage should be < 1 V and amplitude -1 V to +1 V. (Info: Karl-Heinz Jäckel)

### 6.5.2 Solution with DC/DC isolated converter.

Example of a 3 sensors adaptor, (see picture §6.3.1.1).

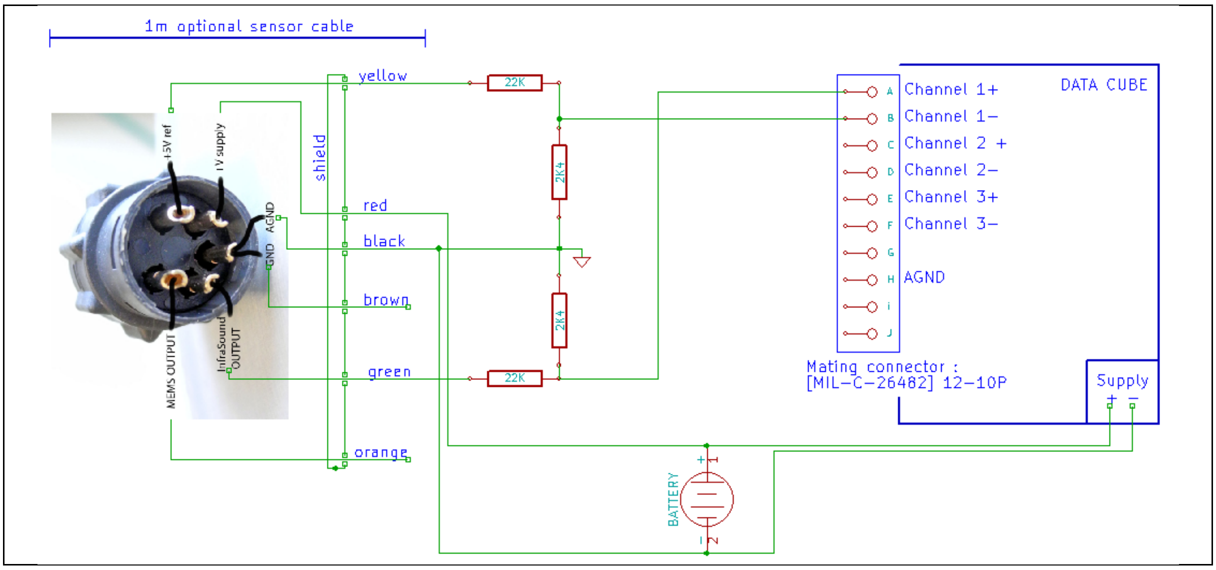



In this configuration (resistors divide the signal by 5), we obtain:

- Sensor consumption: **102 mW for 1 sensor, 186 mW for 3 sensors connected.**
- Sensitivity : **4 mV Pa$^{-1}$**
- Range : **+/-250 Pa for +/-1V**

### 6.5.3 Solution without DC/DC isolated converter

Example for one sensor connected.




In this configuration (resistors divide the signal by 10), we obtain:

- Sensor consumption: **43.2 mW for 1 sensor, 129.6 mW for 3 sensors connected.**
- Sensitivity : **2 mV Pa$^{-1}$**
- Range : **+/-250 Pa for +/-0,5 V**

### 6.5.4 Choosing a solution.

We prefer the solution with a DC/DC converter (§ 6.5.2), because of its better sensitivity and easier connection, although the consumption increases.

The sensitivity can be adjusted by modifying the resistor divider. For example without divider the sensitivity is **20 mV Pa$^{-1}$,** the range **is +/- 50 Pa for +/-1V** (In this example, check that the DataCube supports, without damage, 10 V on its differential input. This is the maximum output voltage of IST2018).

# 7 Appendix

## 7.1 Specifications of the InfraSound Transmitters 2018 delivered to University of Liverpool, July 2018

| IST2018 | Infra Sound output | | | MEMS output | | |
|---|---|---|---|---|---|---|
| SN | Sensitivity mV/Pa$^{-1}$ | hp filter mHz (-3dB) | Offset mV | Sensitivity mV/Pa$^{-1}$ | hp filter mHz (-3dB) | Offset mV |
| 01 | 19.8 | 50 | 7.5 | 0.56 | 48 | -17 |
| 09 | 19.7 | 53 | -3 | 0.5 | 51 | -164 |
| 10 | 19.9 | 55 | 5.6 | 0.54 | 53 | 51 |
| 11 | 19.6 | 50 | 9.2 | 0.53 | 48 | -7 |
| | | | | | | |
| 06 | 19.6 | 53 | -4 | 0.54 | 49 | 118 |
| 13 | 19.7 | 50 | -7 | 0.51 | 49 | -92 |
| 15 | 19.6 | 53 | 8 | 0.54 | 51 | 81 |
| 16 | 19.5 | 56 | 8 | 0.53 | 55 | -67 |
| 18 | 19.8 | 56 | 3 | 0.54 | 55 | 28 |