Microflown Technologies

Charting sound fields

Manual

Impedance Setup

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I. The Impedance setup

The fact that pressure and particle velocity can be measured by the PU probe, allows not only the direct calculation of the acoustic intensity but also the acoustic impedance, obtained from the ratio of both magnitudes, pressure and particle velocity.
With the impedance setup **acoustic impedance, absorption and reflection coefficients** can be measured **in situ**, taking into account not only the first layer of materials but **the whole** damping **structure**. This offers a great alternative to typical methods like the Kundts tube or the reverberant room in which these two requirements are not accomplished.

The setup is based on a known loudspeaker and a PU sensor with which, two measurements are performed to characterize a structure. The first measurement is taken in free field conditions in order to characterize the loudspeaker radiated energy as well as the measurement environment. The second measurement is taken very close to the sample surface, in order to acquire the incident and reflected energy. Booth datasets are then post-processed to:

1) Remove room effects: signal smoothing to avoid reflections from distorting the signals.
2) Model the results: 3 methods are proposed to approximate the structure response, all based on a point source model combined with corrections due to near field and spherical wave fronts.

This post-processing process extends the usability of the setup, being able to be performed in situ, allowing the characterization of already installed structures; and under relatively high reflection and background noise level. The system can also be used to measure non flat and irregular surfaces.

A. Typical applications

- Acoustic impedance measurements
- Absorption coefficient measurements
- Reflection coefficient measurements

II. Compatible Probes

Number of sensors / channels:

- PU: 1 pressure sensor and 1 particle velocity sensor

Packaging:

- Mini: ½ inch, 42 mm handle. Package gain. Mini Lemo connector.
- Impedance: ½ inch, 90 mm handle. No Package gain. Lemo connector.

Maximal threshold level:

- Regular

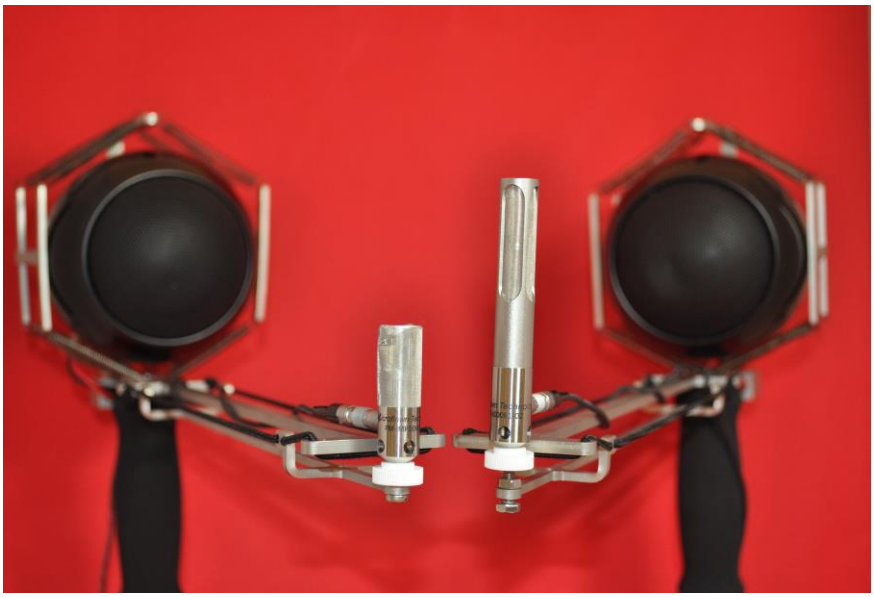


Figure 1: PU mini and PI probes

III. Components list

- Impedance gun
  - Loudspeaker
  - Damping structure
  - Probe holder

IV. Impedance gun characteristics

Physical
Height: 40 cm **Length:** 37 cm **Weidth**:12 cm **Weight:** 1.04 Kg **Distance probe- loudspeaker:** 25 cm
Loudspeaker
Exited frequency range: 80-20 KHz **Electrical impedance:** 8 Ohms **S/N :** > 95 dB **Max SPL:** 111 dB
Probe holder
M4 bolt to attach PU mini/PI mounting

A. Frequency range

The typical usable frequency range is from **300 Hz to 10.000Hz**. These limits **depend on** the **material type** and modelling applied, being:

- In most of absorbing materials extended in the low frequency region.
- In most reflective materials compromised in the high frequency region. The response in this region is typically improved by using the PI probe with the setup.

B. Comparison of compatible probes

Both probe types, PU mini and PI probes are compatible and usable with the impedance setup and the results are comparable:

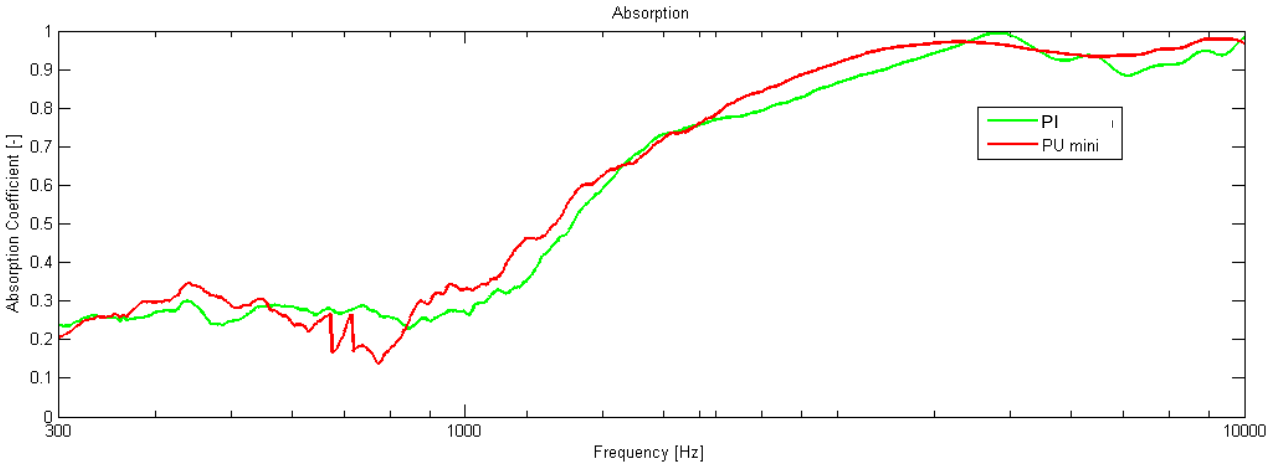


Figure2: Comparison of PU mini and PI probes

The PI probe has proven to be more suitable for very reflective materials. With this type of materials the pillars of the PU mini influence in the very low velocity field, generating disturbances in the high frequency region in the results.

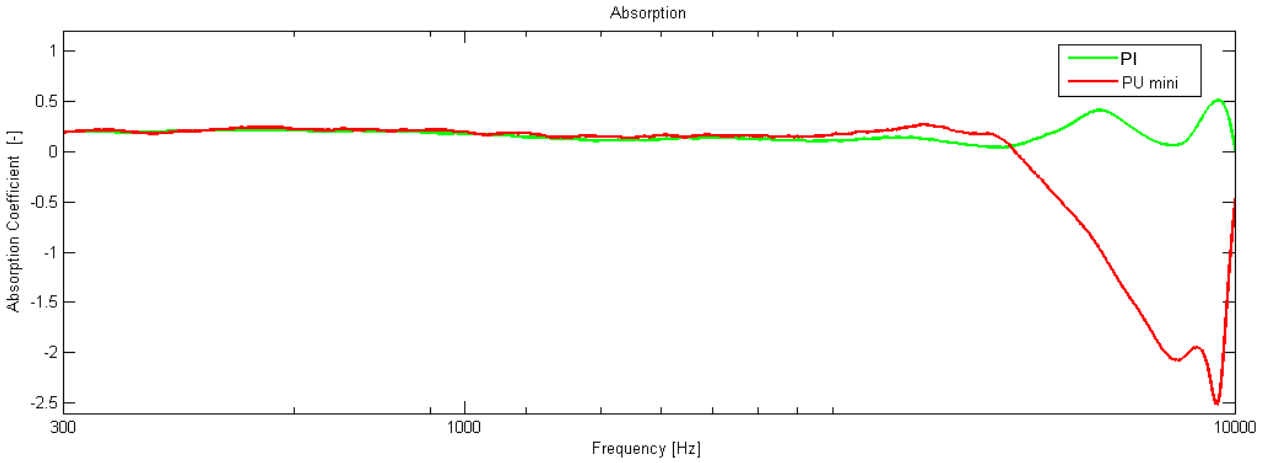
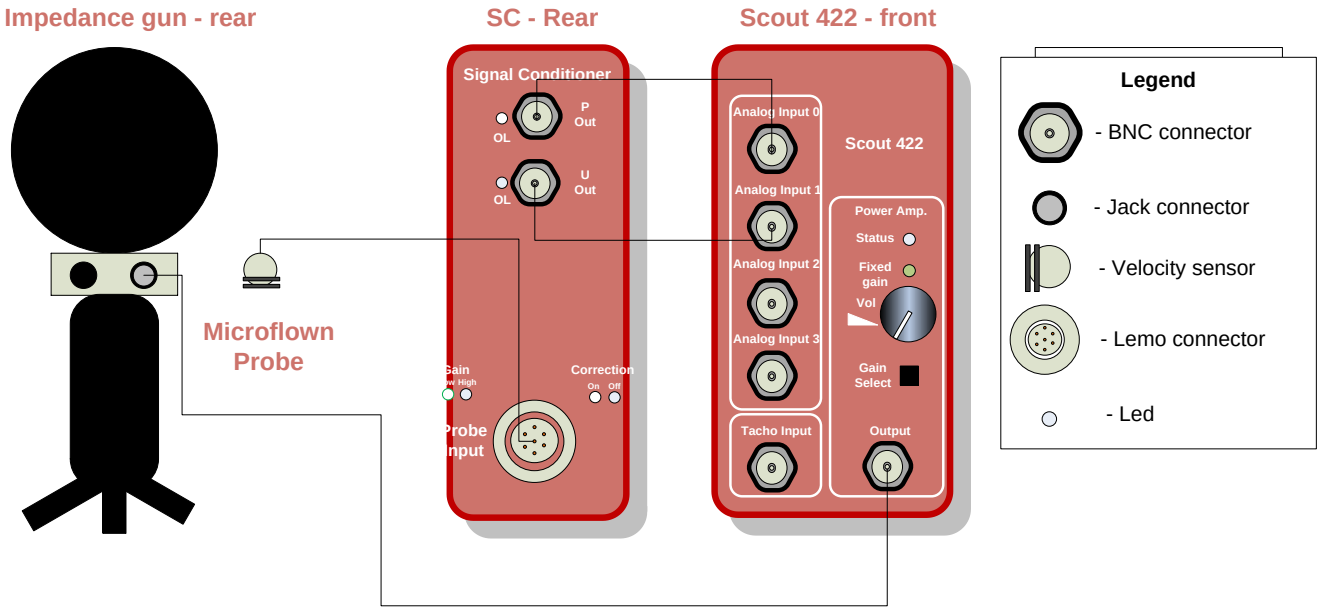


Figure 3: Comparison of PU mini and PI measuring reflective steel plate

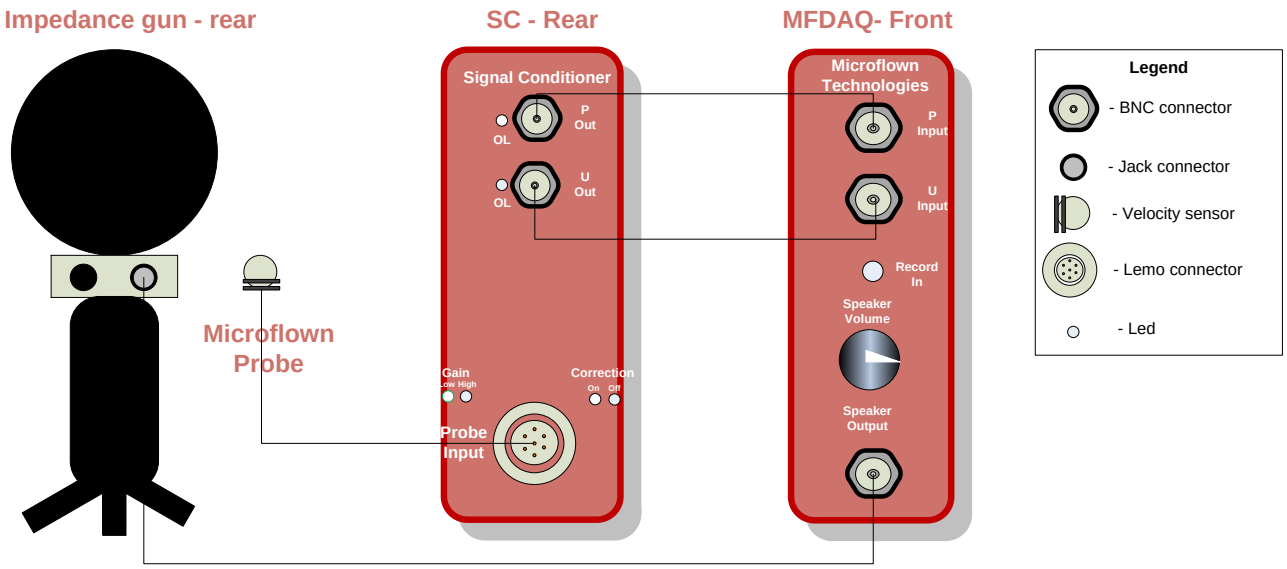
V. Cabling and Schematics

A. Schematics

1. With Scout Frontend



2. With MF DAQ



3. Hardware connections

a) Probe

(1) Probe mounting

To mount the probe, bolt it to the M4 bolt installed in the front part of the impedance gun and fasten the plastic disc to make sure the probe is fixed and properly oriented (Figure 4).

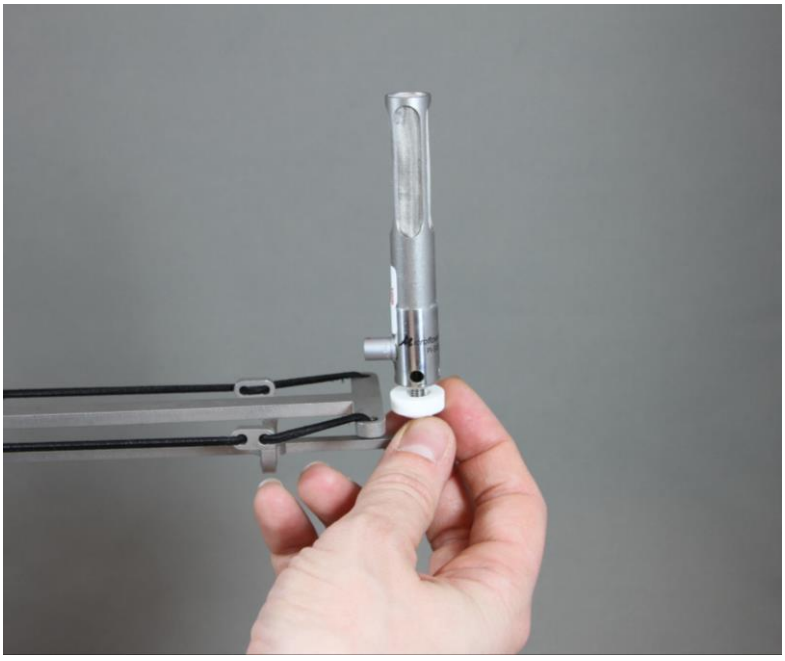


Figure 4

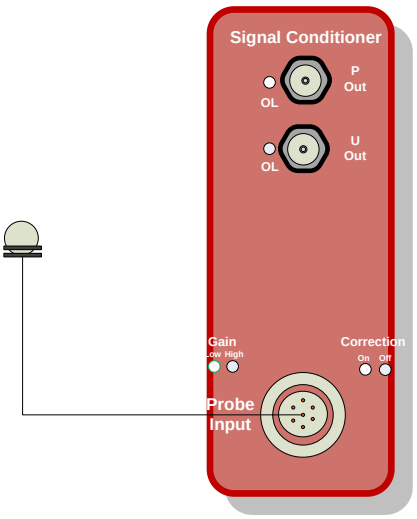
- The sensor should be oriented with the connector pointing to the loudspeaker (Figure 5).

Figure 5

(2) Probe connections

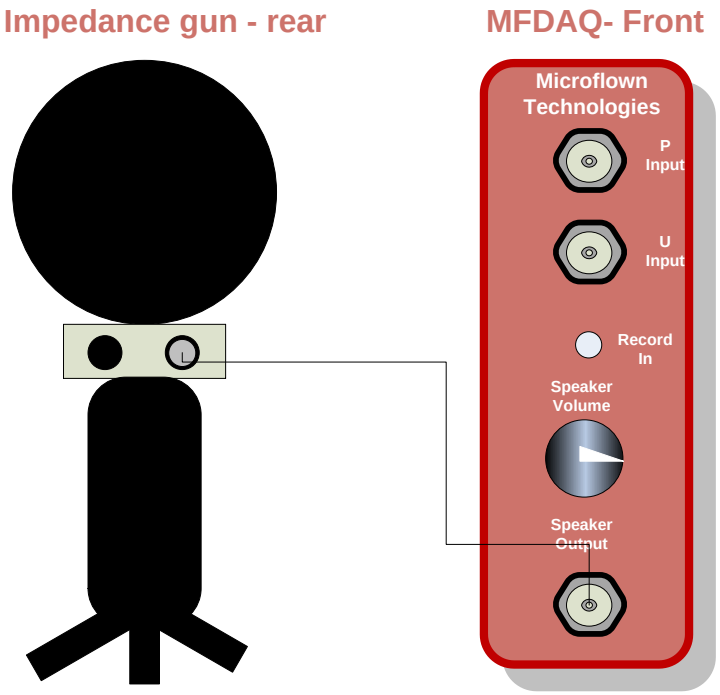
Figure 6

1. Connect first the 7 pin end of the cable to the signal conditioner
2. Pass the cable through the impedance gun structure (Figure 6)
3. Connect the 4 pin end to the probe



b) Loudspeaker

Connect the DAQ output to the jack connector installed in the impedance gun structure, beneath the loudspeaker sphere.



B. Cables and connectors

Impedance setup is compatible with 4pin-7pin standard cable. For information about the pinning and connections please consult the 4pin-7pin standard cable datasheet.

VI. System recommendations and limitations

A. Sample size

The required sample size depends on the material type. The porous materials present variations on the absorption coefficient due to the sample size, being explained by the different quantity of air contained in the sample.
For this reason, 2 different strategies can be deployed, with different limitations:

- If the sample needs to be characterized as it is mounted on a structure then the sample size cannot be changed and the measurement result will display the absorption value of the structure with the mounted layers and sizes.

- If the material absorption needs to be characterized, it is recommended to use samples of at least **30 x 30 cm**.

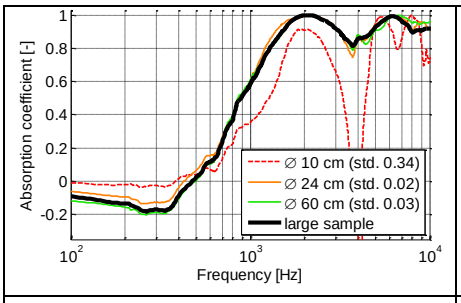


Figure7. Polyuretan

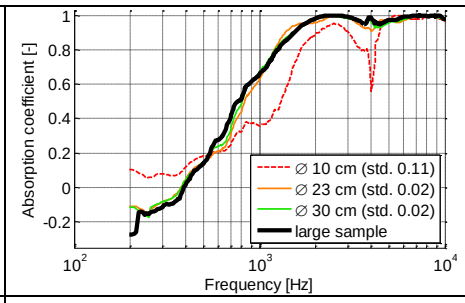


Figure 8. Stone wool measurements

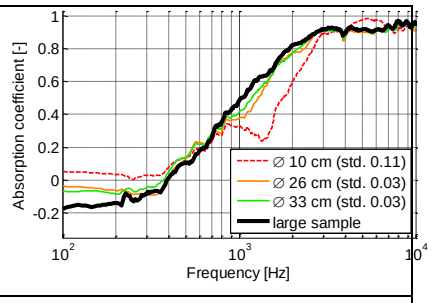


Figure 9. Measurements on Flamex

B. Distance probe-sample

Depending on h (distance probe-sample) the results can present discrepancies at low frequencies. In simple models like "mirror source" near field effects of waves inside the sample are not considered.

Small deviations for larger values of h at high frequencies are caused by interferences of incoming- and reflected sound waves.

Nevertheless, in practical situations it is hard to perform measurements with probe-sample distances larger than **30mm to 50mm** because of difficulties with limited sample sizes, background noise, parasitic reflections from other objects, and because the sound that is reflected from the sample becomes weaker compared to the incoming sound.

For these matters, the probe should be always placed as close as possible from the measured surface.

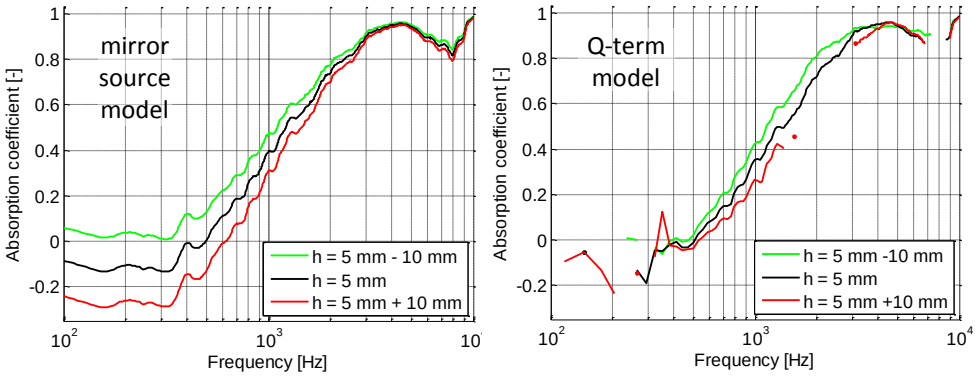


Figure 10. Misestimating the probe-sample distance: h *=5 mm±10mm.*

C. Measurement environment

The effect of the background noise in the absorption estimation error can depend on:

- The absorption values of the sample: being less affected the measurements taken in samples with a high absorption values than very reflective samples
- The distance probe- sample: being less affected the closer the measurement is taken
- The angle noise-setup: its effect is very low as the noise not only travels via the air but also via the sample itself.
- The frequency range: more deviations in high frequencies and where strong reflections appear.

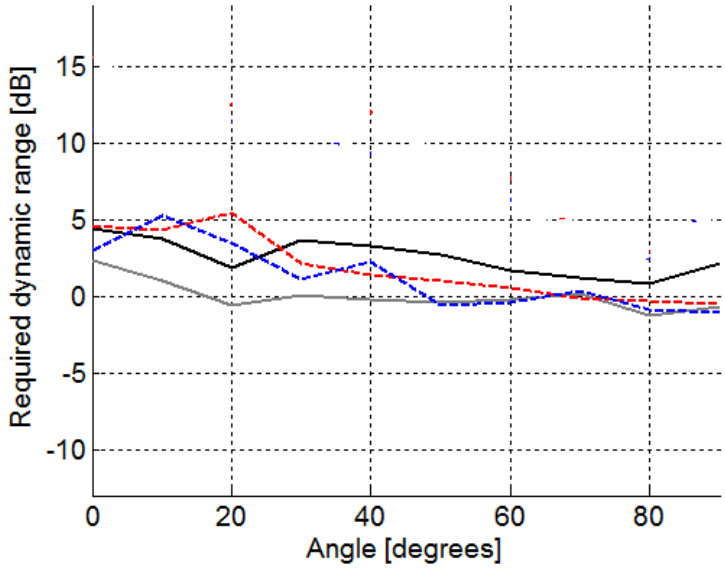


Figure11 Required dynamic range S/N with Mirror model for a maximum error of 0,1 for different samples

The loudspeaker level should sufficiently exceed the background noise level, being a difference of **10 dB** sufficient enough to achieve good absorption estimation.

Reflected waves can introduce small variations in the calculated response. To **reduce** these **deviations**, several **smoothing** options are available in the software. Each option has its pros and rollbacks, being recommendable to follow this criteria:

- If the surrounding objects are far from the measured structure “Impulse response” is the most recommended to be applied.
- If multiple reflections appear in the measurement, with small amplitude compared to the direct signal “Moving average” algorithm is most recommended.

D. Absorption modelling

To calculate the actual impedance/absorption/reflection coefficients, the system is considered a point source radiating. Several corrections are applied to take into account the near field effects and spherical wave fronts in order to obtain the **plane wave impedance/reflection or absorption** that we are mostly familiar with. To extract the plane wave absorption properties 3 models are proposed in the software. The following table presents the ups and downs of each of the models:

Model	Plane wave	Mirror source	Q-term
Bandwidth	-	+	+
Speed	+	+	+/-
Robustness	+	+	-
Accuracy	-	+/-	+/-
Main disadvantage	Low frequency errors	Negative absorption values are found because only plane sound waves inside the same are considered	

NOTE: for a deep understanding of the mathematics behind the models please read: http://www.microflown.com/files/media/library/books/microflown_ebook/ebook_6_impedance.pdf

E. Result deviation

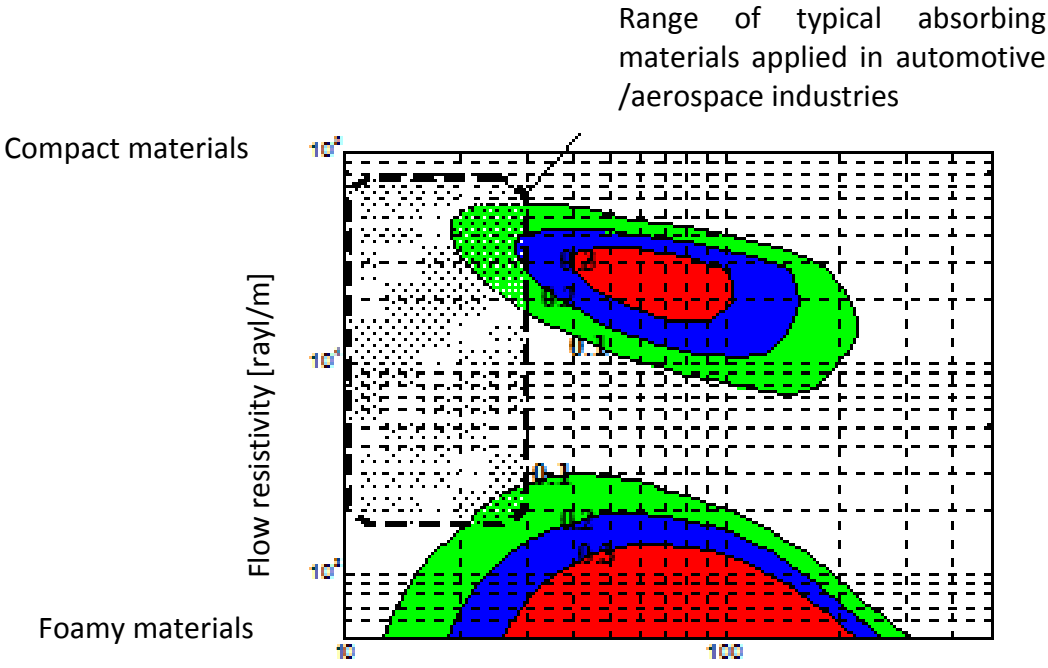


Figure 1. Maximum deviation between absorption results

F. Measurements under an angle

Measurements performed under an angle different to normal incidence **are possible**, but the probe should be rotated in the same angle for both measurement steps: the free field calibration and material test.
Further investigation needs to be carried out in order to assess the maximum usable incidence angle.

G. Airflow effect

The velocity sensor response is affected by airflow being able to stand **up to 2 m/s**.
For wind speeds **above** this value, special **wind caps** manufactured by Microflown technologies can be used to protect the sensor.
These wind protectors are usable with the impedance setup as long as there are kept on the probe for **booth measurement steps**: free field calibration and material testing.

VII. Usage and precautions

A. Usage and operation

- Make sure the probe is correctly oriented and properly fastened so that its orientation is kept constant from free field measurement to material measurement.
- Make sure that hardware and software settings are also kept constant from free field measurement to material measurement.

B. Precautions and not to does

Use parts, connector and power supplies provided with the equipment. WARNING: Do not use the device with any cable or extension cable not supplied by Microflown Technologies.
In case of losing some part please consult with Microflown Technologies before using a similar item.

VIII. Technical contact

For any problem or doubt with your equipment, please contact Microflown Technologies Customer service:

- Mail: cs@microflown.com
- Skype: cs.microflown
- Telephone: 0031(0) 88 001 08 11 Monday to Friday, from 9:00 to 17:00 (UTC+1).

IX. Warranty policy, repairs and replacements

A. Warranty and replacement or substitution

1. Full warranty (year 1 and 2)

The warranty period starts on the date of the invoice.

During the first two years (24 month) the Seller offers a warranty on all its Products, except for trading items and third party manufactured items. The Seller warrants that all Products will be free from defects in materials and workmanship for this period of two years. During this two years period, the Seller will repair or replace products free of charge. Products damaged by accident, abuse, misuse, natural disaster or by any unauthorized disassembly, repair or modification are not covered by this warranty. The incurred transportation costs of returning the Products to Seller will be borne by the Buyer. The logistical cost for returning the Products back to the Buyer will be borne by the Seller. Several Product come with a "VOID if seal is broken" sticker, the warranty is void at all time when this sticker is broken.

2. Grace period (year 3 and 4)

During the third and fourth year the Seller offers a Grace Period. In the Grace Period the Products purchased at an earlier date can be replaced by completely new state of the art Products of the same scope of the original purchase. This applies only for the Products known as standard probes and signal conditioners. In the first year of the Grace Period, (year 3) customers have an option to replace their products for 25 % of the actual ex works end user price. The full freight and packaging charges apply.

In the second year of the grace period, (year4) customers have an option to replace their products for 50 % of the actual ex works end user price. The full freight and packaging charges apply.

The new products are accompanied by a new warranty. Both the two years warranty and grace period becomes applicable again from the date of invoice.

3. Repairs outside warranty policy

Alternatively two years after the purchase, small repairs might be offered all time against estimated costs to be quoted. Repairs come with six months' warranty with the same condition as the two year warranty