SOLUTION SHEET

DirectShear System

Wall shear stress sensors for subsonic and transonic applications

System with standalone Capacitive Sensor Unit (CSU)

PXI CSU

Measure Mean and Fluctuating Wall Shear Stress

The DirectShear® system provides the ability to measure mean and fluctuating wall shear stress, using a flush-mounted differential capacitive sensor.
The Capacitive Sensor Unit (CSU) provides low noise power to the sensor head and conditions the analog voltage signal received from the sensor head for output to a data acquisition system. Stand alone and NI PXI compatible CSUs are available.

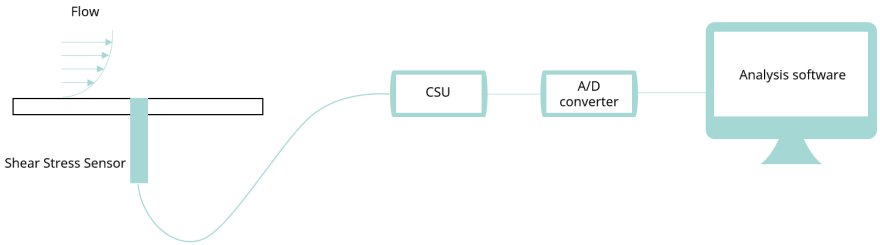
Capacitive sensing at DC is achieved by shifting the sensor baseband frequencies to a modulated signal and demodulating the returned signal from the sensor, enabling simultaneous real-time measurement of both mean and dynamic components.

Key benefits

- Direct measurement of shear stress — no heat transfer calibration
- Non-intrusive — minimal flow disturbance, flush mounted
- Simultaneous mean and fluctuating shear stress measurements
- High resolution, wide dynamic range, and broad bandwidth
- Highly accurate, quantitative measurements

The DirectShear Solution

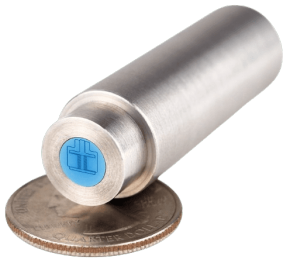
The complete measurement chain comprises a flush-mounted sensor connected to a CSU. The analog output from the CSU is connection to a data acquisition system which comprises analog to digital conversion and data storage. A software package controls data acquisition, storage and analysis and presents the results in graphical or tabular formats.



Overview of the DirectShear System

The DirectShear system comprises the following elements:

- A DirectShear sensor
- A Capacitive Sensor Unit (CSU)
- An A/D converter
- Analysis software



DirectShear sensor head

DirectShear sensor, cylindrical package

- Micromachined floating element shear stress sensor that enables time-resolved, one-dimensional, direct shear stress measurements
- Suite of sensor models for different applications, from 50 to 5000 Pa
- Non-intrusive - backside contacts for minimal flow disturbance
- Detachable cable assembly
- Shoulder and key alignment

DirectShear low-profile sensor head

DirectShear sensor, low-profile package

- Same sensor as in the cylindrical package
- Smaller form factor - better suited to space-constrained testing scenarios, such as in the wing of a model

Capacitive Sensor Unit, stand alone

- Optimized control unit enables high dynamic range and bandwidth measurement
- Low-noise AC
- Rechargeable Li-ion battery
- LED status indicators

DirectShear CSU, PXI version

Capacitive Sensor Unit, PXI

- Compatible with NI PXI data acquisition hardware
- Reduce cost per channel for 2+ channel systems
- Free IC2 DAQ LabVIEW software

A/D Converter

The output of the CSU should be connected to a data acquisition system via a BNC connection. The recommended minimum resolution is 100 nV. Typical AC-coupled signal outputs will not exceed 1 V in magnitude; however, mean output voltages can reach up to 6 V at full scale output without the Zero Offset engaged (see DC Offset Measurement below for Zero Offset operation). The minimum bandwidth of the data acquisition system should be at least twice the measurement bandwidth of interest to avoid temporally aliasing the sensor signal. For fluctuating shear stress or pressure measurements, the input to the data acquisition system should be AC coupled.

DC Offset Measurement

Before and after data acquisition, the DC offset from the output of the circuit should be recorded. The DC offset provides information on whether sensor drift has occurred during operation. The DC offset of the sensor can be monitored at the CSU output by introducing a BNC tee to split off the signal. A digital multimeter with at least 6.5 digits should be set to maximize dynamic range for determining the DC offset of the sensor.

The Zero Offset correction brings the DC offset to nominally 0V. To engage the Zero Offset, press and hold the Zero Offset Button for 3-5 seconds. When the Zero Offset LED comes on, the DC offset will drop. To disengage the Zero Offset, press the Zero Offset Button for less than 3 seconds. The Zero Offset LED will turn off and the DC offset voltage will return to normal.

NOTE *Output drift can occur due to temperature and humidity fluctuations during the course of a test. Consult the sensor data sheet to determine the effect of changes in environmental conditions during testing.*

Analysis Software

The PXI version of the CSU comes with free IC2 DAQ LabVIEW software. The user must have a LabVIEW license to run it.

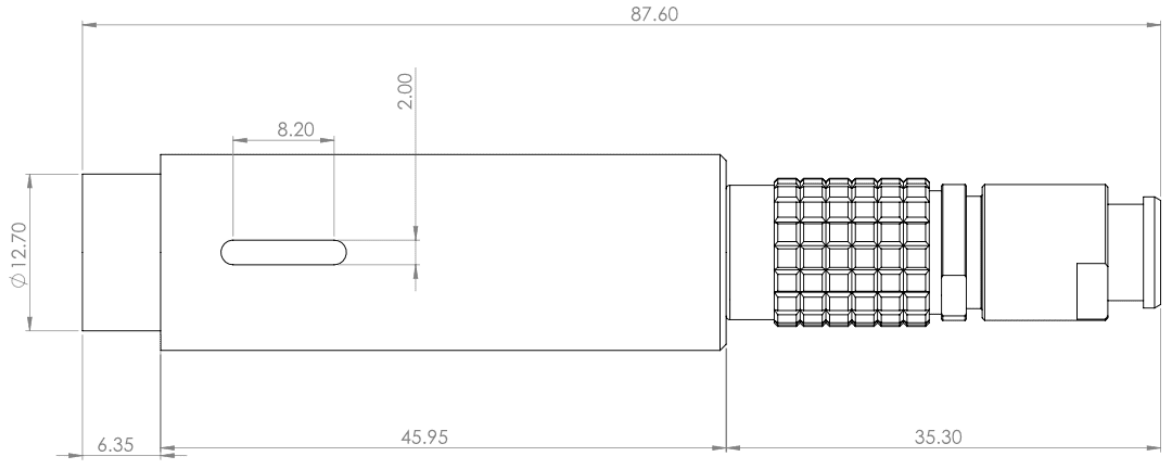
Technical specifications

Sensor Model Cylindrical/ Low-profile	Shear Stress (Pa)	Bandwidth (kHz)	Sensitivity (mV/Pa)	Resolution (mPa)	Element Size
0041-A-00 / 0043-A02	50	1.5	40	0.1	2mm x 0.4mm
0041-F-00 / 0043-F-02	100	2.5	10	1	2mm x 0.4mm
0041-B-00 / 0043-B-02	300	5	1	1	1mm x 0.2mm
0041-C-00 / 0043-C-02	1000	10	0.3	5	0.5mm x 0.15mm
0041-D-00 / 0043-D-02	5000	20	0.08	10	0.5mm x 0.15mm

Cylindrical package dimensions

- Sensor Head Diameter: 12.70 mm (0.5″)
- Mounting Shoulder Length: 6.35 mm (0.25″)
- Sensor Body (Mounting Shoulder) Diameter: 15.88 mm (0.63″)
- Total Length without connector: 52.30 mm (2″)
- The main body of the sensor head optionally contains a 2 mm x 8 mm keyway for proper alignment with the flow direction

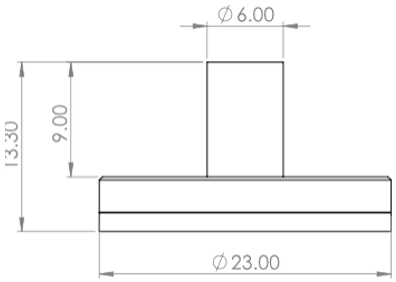
Dimensional drawing in mm

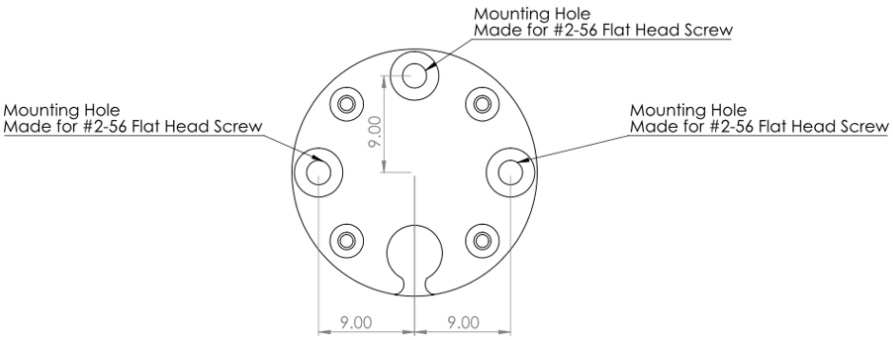


Low-profile package dimensions

- Sensor Head: 6 mm diameter, 9 mm length
- Sensor Base: 23 mm diameter, 4.3 mm length
- Total Length: 13.3 mm

Dimensional drawing in mm





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