## pr.Bolt – PiezoRobotics Bolt

The PiezoRobotics' pr.Bolt is a mechanical fastener with an integrated piezoelectric sensor for the measurement of axial dynamic forces. It is the next generation of highly precise and highly sensitive force sensors, evolved from simple strain gauge load cells, benefiting from more robust electronics and better connectivity. By using the provided signal conditioner, the pr.Bolt converts an input dynamic mechanical force into an analog voltage signal by means of a piezoelectric material, useful in applications that require dynamic force measurement.

### Key Features

- Integrated piezoelectric force sensor
- Tension and compression axial force measurement
- Low voltage output signal
- Broadband frequency response

### Technical Specifications

| Bolt Specifications | Value | Notes |
|---|---|---|
| Sensitivity | 1.366 mV/N | @ 50 Hz (see calibration data) |
| Measurement Range | $\pm 10$ kN$_{0\text{-}p}$ | |
| Frequency Range | 1 Hz to 5000 Hz | |
| Phase Response ($\pm 5°$) | 1 Hz to 5000 Hz | |
| Non-linearity | $\pm 7\%$ | |
| Maximum Force | $\pm 10$ kN$_{0\text{-}p}$ | |
| Maximum Mounting Torque | 100 Nm | for M14 |
| Signal Connector Type | 10-32 UNF Male | |
| Dimensions | DIN6921 $d \geq$ M14 and L $\geq$ 60 mm | customizable |
| Material | Class 10.9 Alloy Steel | |
| Operating Temperature | -40°C to +85°C | |
| **Signal Conditioner** | | |
| Power Supply | 5.0 V / 0.2 A | |
| Output Voltage Range | $\pm 15$ V$_{0\text{-}p}$ | DC offset = 0 V |
| Power Connector Type | DC 3.5x1.3mm | |
| Signal Connector Type | BNC Female | |

## Applications

Vibration Monitoring, Structural Health Monitoring, Load Data Acquisition, Vibration Isolation, Active Vibration Control, Process Control and Automation.

## Electrical Connection

The signal conditioner of the pr.Bolt is powered using a 3.5x1.3mm DC plug on a 5 $V_{DC}$ USB power supply cable. The cable coming from the pr.Bolt is connected to the input channel (10-32 UNF to BNC). The analog output signal of the signal conditioner can be connected to an ADC or a data acquisition system by a BNC cable.
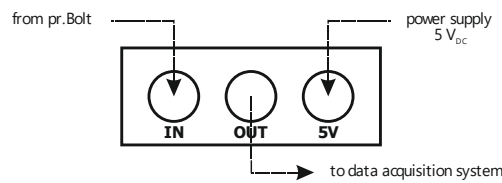


Figure 1. Power and analog signals connections

## Mechanical Mounting and Sensor Operation

The pr.Bolt can substitute any traditional bolt in a mechanical structure, as long as the maximum mounting torque is respected. This will allow the pr.Bolt to quantify the axial dynamic forces going through the bolted joint.
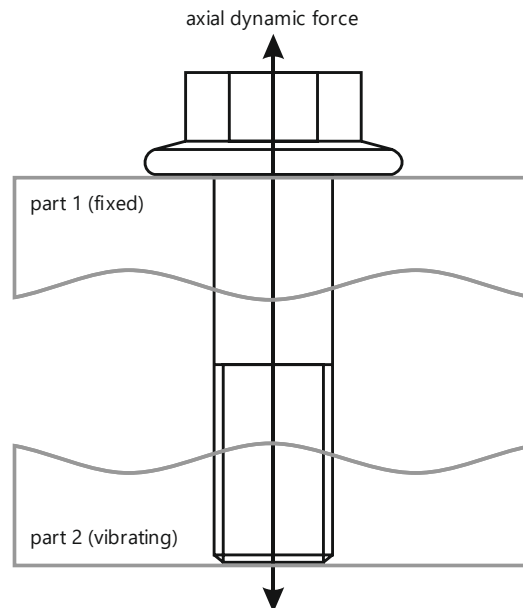


Figure 2. Mechanical mounting and operation of the pr.Bolt

The pr.Bolt has a piezoelectric sensor integrated within the body of the bolt. A dynamic force along the axis of the bolt will cause a dynamic strain to appear within the bolt material and also in the piezoelectric sensor, which will be converted into a dynamic electric charge. This charge is then amplified by the signal conditioner, which outputs an analog voltage signal. By using the correct calibration data, the axial dynamic force of the bolted joint can be measured. A positive output voltage signal from the signal conditioner means the pr.Bolt is in tension. A negative voltage means it is in compression.

The force signal can be used in applications such as vibration monitoring or active force control in a feedback loop. One possible application for the pr.Bolt is to measure the vibration transmission through a rubber element used for vibration isolation. The rubber element is usually bolted across two sides: a fixed part and a part with a vibration source. The pr.Bolt is therefore able to measure the axial dynamic forces going through the rubber element.

## Calibration Data

The analog voltage signal generated by the signal conditioner depends on the input mechanical force along the pr.Bolt (waveform, amplitude and frequency). Figure 3 shows a typical calibration spectrum delivered with each pr.Bolt. The sensitivity is measured when the pr.Bolt is fixed on one side, and allowed to vibrate on the other. A sinusoidal waveform with constant amplitude across all frequencies is used.
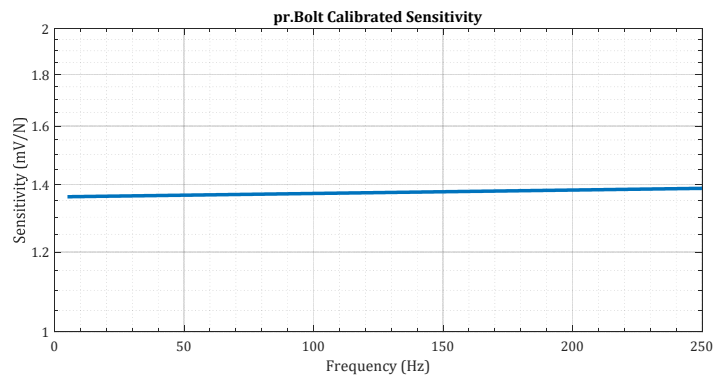


Figure 3. Calibrated sensitivity spectrum

## Dimensions

The preferred construction of the pr.Bolt is done with a standard metric hexagon flange bolt (DIN6921) with a diameter of at least 14 mm and a length of at least 60 mm. We can modify this according to your application.

## Quality and Testing

Each pr.Bolt is individually tested. The calibration data including the sensitivity in the frequency domain is provided with each delivery.

## Customization

PiezoRobotics has the capability to customize the pr.Bolt according to your specific application and requirements. We can modify the dimensions, materials, connectors or other parameters, and integrate with your electronics and IoT Network. We also guarantee much lower prices for high volume purchases. Please contact us for further details.

## Package Content

1 x pr.Bolt

1 x Signal Conditioner

1 x 10-32 UNF to BNC Cable 2m

1 x 5V USB Power Supply Cable