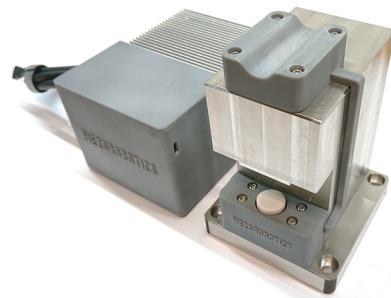


## pr.DMA – PiezoRobotics Dynamic Mechanical Analyzer

The PiezoRobotics' pr.DMA is a dynamic mechanical analyzer instrument for high-throughput characterization of viscoelastic properties of materials as a function of frequency. It is the next generation of material testing, with a compact benchtop design that enables quick data collection from different material samples. The pr.DMA applies a compressive sinusoidal force on the material sample and measures its displacement, by means of a high-force piezoceramic actuator and highly precise sensors. The complex modulus of the material as a function of frequency is calculated onboard by the real-time microcontroller. This is useful in applications that require rapid testing of viscoelastic materials such as in material development, manufacturing quality control or material inspection.

### Key Features

- High-force piezoceramic actuator
- Calibrated sensors and integrated data acquisition
- Embedded real-time microcontroller
- Battery-operated
- USB connection for control and data visualization



### Technical Specifications

Specifications	Value	Notes
Power Supply	12 V <sub>DC</sub> / 3.0 A	for battery charging
Internal Battery Capacity	36 Wh	available output energy
Sample $E'$ Modulus Range	1 MPa – 25 GPa	
Static Compressive Preload	10 – 15 N	customizable up to 500 N
Dynamic Compressive Force	0 – 220 N <sub>0-p</sub>	customizable up to 500 N <sub>0-p</sub>
Force Resolution	0.01 N	
Dynamic Displacement	0 – 23 $\mu\text{m}_{0-p}$	@100 Hz
Displacement Resolution	0.0005 $\mu\text{m}$	
Sweep Frequency Range	1 – 100 Hz	customizable
Sweep Time	26 s	customizable
Output Data	Storage ( $E'$ ) and Loss ( $E''$ ) Moduli	as a function of frequency
Sample Temperature	-40°C to +200°C	heating/cooling not included
Power Connector Type	DC plug 3.5x1.35 mm	for battery charging
Data Connector Type	USB-C	
Dimensions (Testing Unit)	90 x 92 x 138 mm	
Weight (Testing Unit)	4.9 kg	
Dimensions (Controller)	95 x 130 x 76 mm	
Weight (Controller)	0.7 kg	
Operating Temperature	-40°C to +80°C	

## Applications

Viscoelastic Materials Development, Materials Design of Experiments, Manufacturing Quality Control, Material Inspection.

## Mechanical Operation

The pr.DMA can be fastened to a standard optical breadboard by four M6 screws with a spacing of 75 x 75 mm. The material sample to be tested can have a diameter range of 6-16 mm and a thickness range of 0.1-2.0 mm. The actual top contact surface to the sample has a fixed diameter of 6 mm.

After the software initialization of the device, the top contact surface will automatically clamp down the sample. The static compressive preload force is software-controlled, allowing a constant value for every test. The distance between top and bottom contact surfaces is 25 mm, giving a flexible space for the installation of a heating/cooling element, if needed. For operation without heating/cooling element, a stiff spacer is needed to elevate the sample as close as possible to the top contact surface, as the maximum travel range of the clamp is limited to 4 mm.

The actual dynamic test is then carried out. A sinusoidal force of constant amplitude and increasing frequency is applied to the sample and its displacement is measured. By having the correct calibration data of the pr.DMA, it is possible to calculate the mechanical dynamic stiffness of the sample in the frequency domain. The most common way of representing this dynamic stiffness for viscoelastic materials is by the Storage ( $E'$ ) and Loss ( $E''$ ) Moduli as a function of frequency:

$$E' = \frac{\sigma}{\varepsilon} \cos \delta \quad \text{and} \quad E'' = \frac{\sigma}{\varepsilon} \sin \delta$$

where  $\sigma$  is the stress on the sample,  $\varepsilon$  is the strain, and  $\delta$  is the phase angle between stress and strain at a given excitation frequency.

After the sample has been tested, the clamp automatically releases the sample.

## Electrical Connection

The controller is connected to the testing unit by a 1-meter cable and a 10-pin wire to board connector. The controller is connected to a PC by a USB-C to USB-A cable for software control and visualization of the measurement results. The system is able to perform measurements with the internal battery, which can be recharged with the included 12 V<sub>DC</sub> / 3.0 A power supply.

## Embedded Actuator, Sensors and Electronics

The sinusoidal force on the material sample is generated by a piezoceramic actuator specially designed for applications where a high force is needed, and displacements in the micrometer range are sufficient, for example when testing very stiff polymers. The actuator is driven by our proprietary software-controlled and high-power piezoelectric amplifier.

The pr.DMA also includes a highly-sensitive piezoelectric force sensor and a displacement sensor, both capable of measuring the dynamic response of the sample with high resolution.

The embedded real-time microcontroller is responsible for the automatic clamping system with preload force control, for driving the piezoceramic actuator and for acquiring the data from the sensors. The high sampling rate (> 100 kHz) allows a precise measurement of the phase angle between stress and strain. The calculation of the complex modulus of the material as a function of frequency is performed onboard.

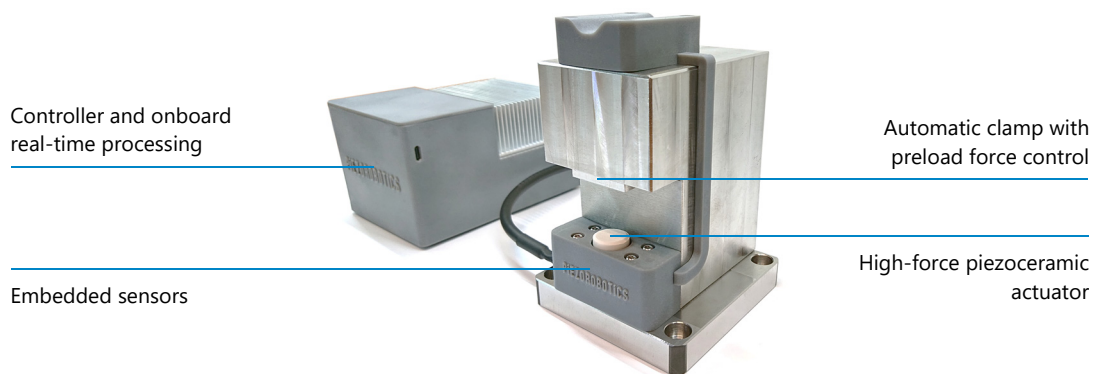


Figure 1. Components of the pr.DMA

### Software Operation

The pr.DMA is software-controlled via a USB connection to a PC and serial communication (COM port). Any serial terminal software (PuTTY, Python, etc.) can be used for controlling the pr.DMA, which gives the user flexibility when it comes to connectivity and automation. To perform a measurement:

- 1) Make sure the battery is fully charged (green LED on the charger) then disconnect the charger;
- 2) Connect the controller's 10-wire cable to the testing unit;
- 3) Connect the controller's USB cable to the PC;
- 4) Open the serial terminal;
- 5) Wait for successful serial connection and device initialization (~30s);
- 6) Follow the instructions on the terminal until the measurement data is obtained.

The measurement data is in comma-separated table format and can be plotted by any software (Excel, Matlab, etc.)

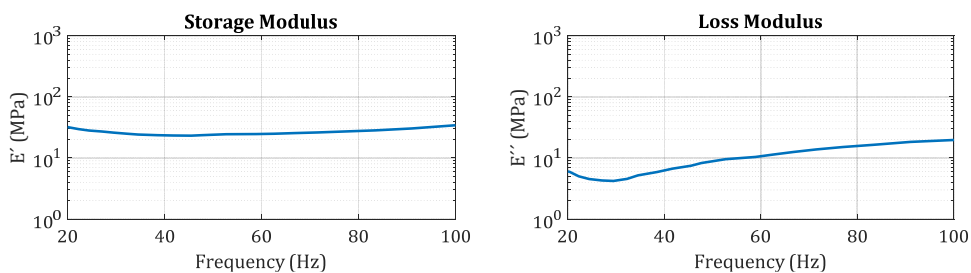


Figure 2. Example plot of data obtained from a measurement (storage and loss moduli)

## Calibration

The piezoelectric force sensor and the displacement sensor in the pr.DMA are calibrated using our state-of-the-art laboratory equipment. The calibration data is already uploaded in the microcontroller's software for each delivery.

## Safety

Internally, the pr.DMA produces potentially lethal voltages of up to 200 V. All the cables, electrical connectors, plastic casing and metal heatsink are safely isolated. Nevertheless, safety precautions should always be observed.

## Customization

PiezoRobotics has the capability to customize the pr.DMA according to your specific application and requirements. We can modify the frequency range or force levels, customize the software, include other metrics and integrate it with your system. We also guarantee much lower prices for high volume purchases. Please contact us for further details.

## Dimensions

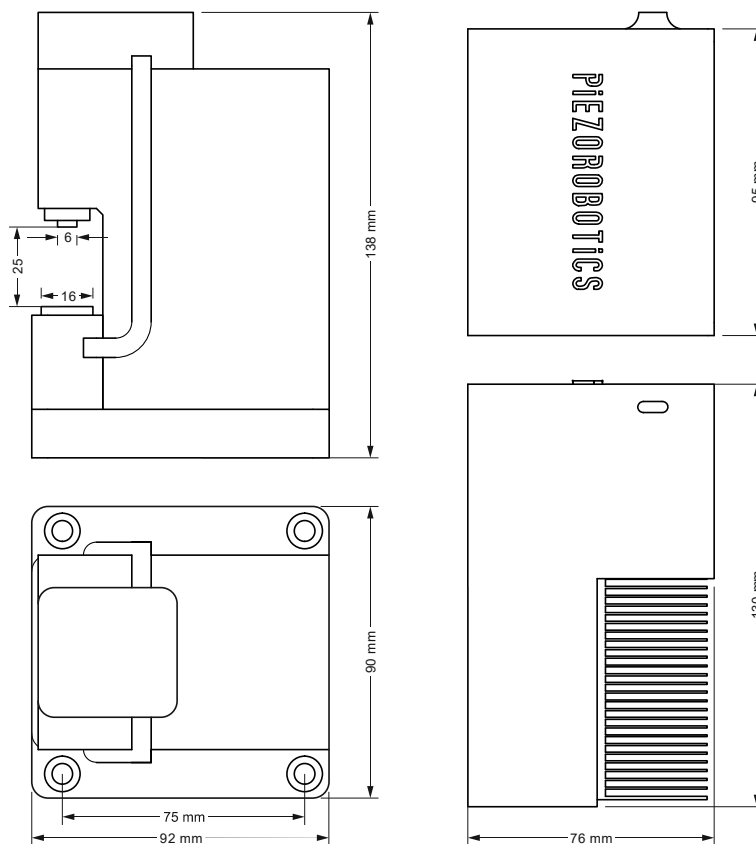


Figure 3. Dimensions of the pr.DMA (Testing Unit on the left, Controller on the right)

## Package Content

1x pr.DMA (Testing Unit + Controller)

1x Battery Charger (100-240 V<sub>AC</sub> to 12 V<sub>DC</sub> / 3.0 A Power Supply)

1x USB-C to USB-A Cable

4x Mounting Screws M6x15 mm