

Supplementary Material

Rotational angle detection with torsional quasi-zero stiffness design: precise mechanical sensing for energy harvesting

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Supplementary Table 1. Details of Relevant Tools and Software

This table provides detailed information on the tools and software used in this study. It includes the model/version, manufacturer, and specific details for each item. The tools and software listed are essential for the simulations, experimental procedures, and data collection performed during the research.

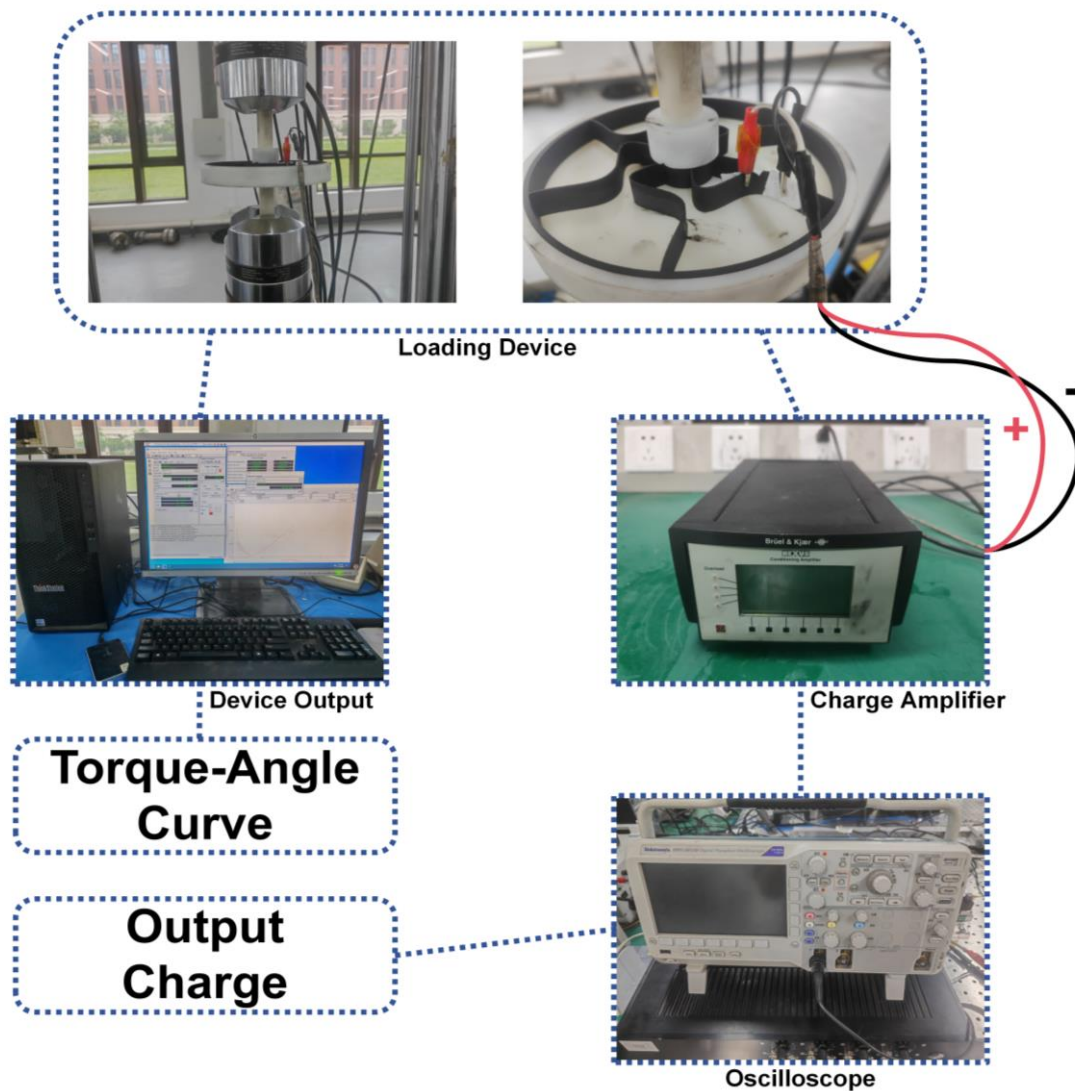
Tool/Software	Model/Version	Manufacturer	Details
Simulation Software	ABAQUS 2024	Dassault Systèmes	Static analysis with large deformation settings enabled
Experimental Loading Platform	MTS858	MTS Systems	Rotational loading system with torque-angle sensor.
Charge Amplifier	2692A	Brüel & Kjær (B&K)	Charge-to-voltage conversion ratio of 1pC to 1mV.

Oscilloscope

DPO2012B

Tektronix

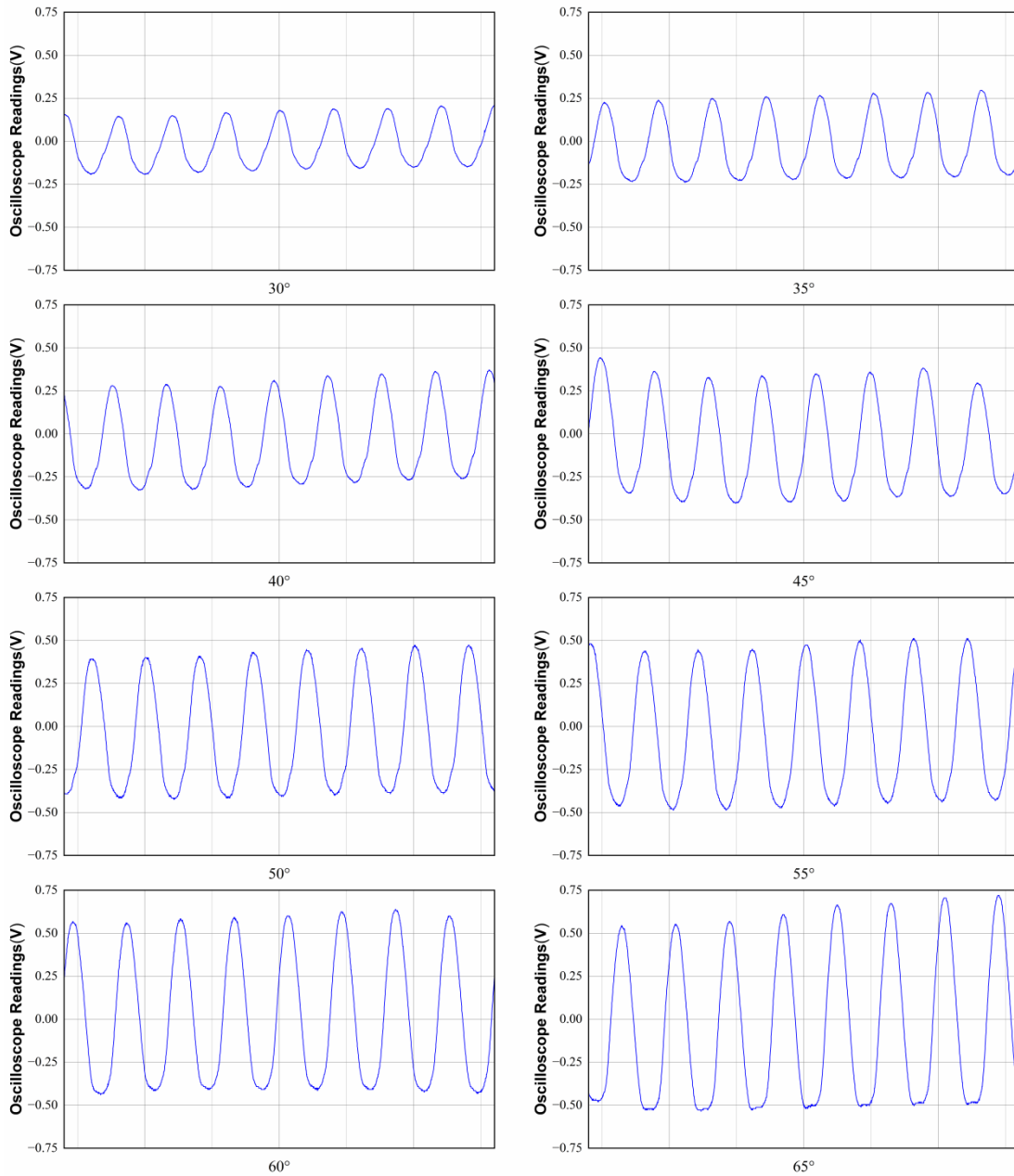
Vertical sensitivity auto,
time base 1ms/div, auto
trigger mode.



Supplementary Figure 1. This figure shows the diagram of the experimental setup and the flowchart.

Among them, the top left figure shows the MTS loading device, responsible for applying periodic torsional angle loads, with its built-in system outputting the corresponding torque data. The top right figure shows the connection method for charge measurement. Two metal clamps are attached to the same bending beam, insulated from both sides and from the metal clamps by insulating strips, ensuring that the flexoelectric charge measurement comes from both sides of the beam. The middle right figure shows the charge amplifier, which is connected to the clamps according to positive and negative

polarity, respectively, with the structure. The obtained signal is output to the oscilloscope shown in the bottom right figure, providing the output charge data.



Supplementary Figure 2. Oscilloscope raw images at selected angles under the full angular displacement loading range of 0 to 80°.