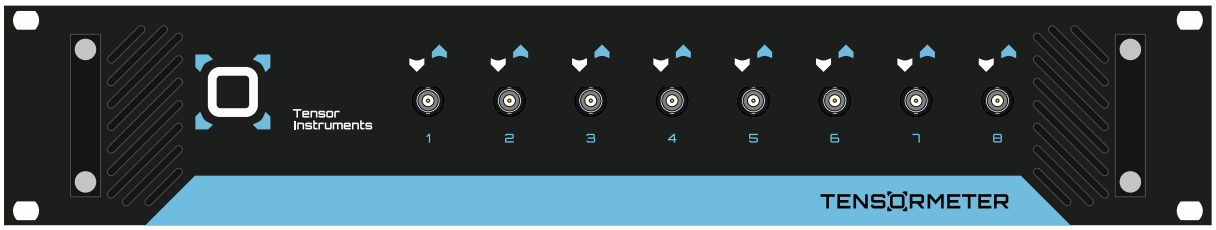
Data Sheet | Specifications

Tensormeter
Model RTM2



The Tensormeter is designed for automated precision measurements of resistances and voltages. The hallmark of the Tensormeter devices is their innovative flexible architecture based on an integrated matrix switch.

The switch matrix enables measurements that go beyond traditional 4-wire impedance measurements, such as Tensor measurements, van-der-Pauw, and allows the device to compensate its own drift, offset and noise, resulting in unparalleled stability. Tensormeter RTM2 enables the automated recording of the Resistance Tensor (longitudinal and transverse resistances) with one single device, even on unpattern thin films. It unites the benefits of Lock-in Amplifiers and Source/Measure Units with its excellent AC and DC performance. It covers the range from Nano-Ohm to Tera-Ohms with at least 8 digits of dynamic range.

Application fields

Materials research and characterization

- solid state physics
- semiconductor physics
- magnetism
- flexible electronics
- spintronics
- new functional electronic materials and devices

Industrial R&D and wafer/device testing

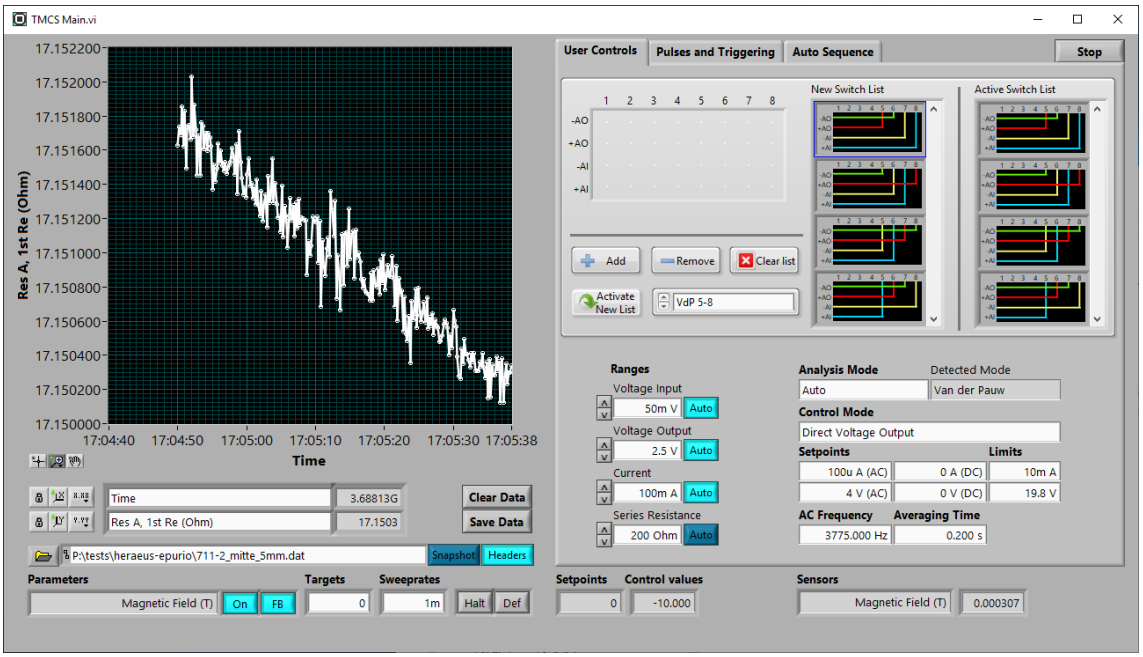
- microelectronic devices
- memory devices
- transistors, diodes
- LED/OLED
- solar cells
- displays, TCO
- sensors

Benefits:

- Replaces all standard devices for electrical characterization measurements (e.g. Lock-in Amplifier, SMU, DMM).
- Overcomes the limitations of stationary 4-point measurements by an integrated Matrix Switch.
- Offers presets for van-der-Pauw and Resistance Tensor measurements and allows for full user configurability.
- Makes complex sample preparation unnecessary (e.g. lithographic structuring).
- Allows for easy connectivity to many different measurement setups (e.g. probe stations, cryostats, vacuum systems).
- Saves measuring time and enhances sample throughput.

Features:

- Reconfigurable device architecture based on an integrated switching matrix
- 8 user-defined channels (BNC connectors), whose function (input or output) can be freely determined
- Conventional AC and DC 4-wire measurements with fixed connections (Kelvin/ Hall geometry)
- AC and DC measurements with alternating connections (van-der-Pauw geometry) with one device
- Simultaneous measurement of exactly separated absolute values for longitudinal and transverse resistances without lithographic patterning
- Software presets for common measurement modes, but any user-specific switching sequences can be specified
- TCP-based communication, easy integration in any environment (e.g. Labview, C, Python)



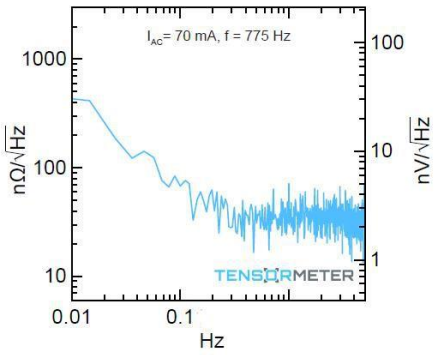
Graphical user interface of proprietary Tensormeter control software

Typical measurement examples:

- Ultra-low noise and high stability AC & DC 4-wire measurements in standard geometries (Kelvin and Hall layouts)
- Van-der-Pauw switched connection 4-wire measurements on irregular, unstructured thin-film samples
- Zero-Offset Hall 4-wire measurements (exact separation of longitudinal and transverse resistance even with unstructured samples)
- Sub-ppm relative resistance change measurements
- Ratiometric resistance measurements to eliminate sample and device drifts
- High drive harmonic distortion measurements, pulse & measure routines

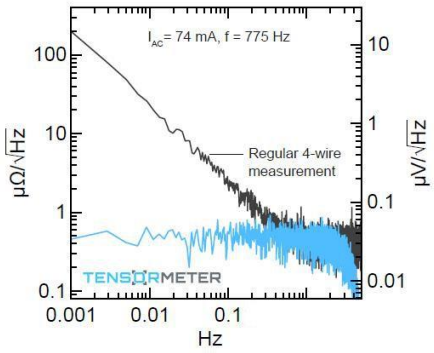
Low Resistive Sensors and Specimen

Differential Input Noise Spectrum of a resistive sensor. Ultra-low wideband & 1/f noise AC measurements allow accurate sensor characterization and operation.

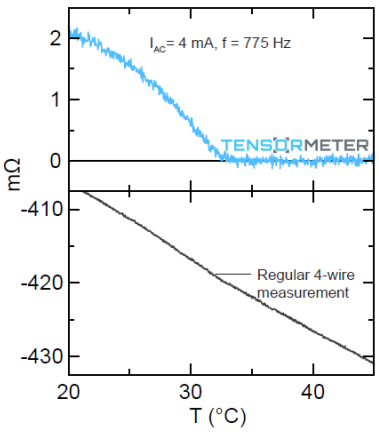


Zero-Offset Hall: Eliminate Drift and Parasitics

Differential Input Noise Spectrum of a Hall measurement on a thin film sample. The Zero-Offset Hall preset of the Tensormeter eliminates thermal drift and allows long integration and orders of magnitude improved sensitivity compared to regular 4-wire Hall measurements.



Spintronics: Loss of magnetic order during warmup of an anti-ferromagnetic sample monitored in Hall Resistance. The Zero-Offset Hall preset (top) clearly shows the loss of signal. On the contrary, parasitic signal contributions overshadow the useful magnetization signal in a regular 4-wire Hall measurement of the same sample (bottom).



Electrical Specifications (typ.)

Outputs

- Symmetrical Output: DC to 60 kHz, ±20 V, ±100 mA
- Output noise: -150 dBFS
- Integral Nonlinearity: 5 ppm
- Pulse / arbitrary function output with 2 µs resolution

Switch Matrix

- Fully controllable integrated 8x4 switching matrix
- Maximum switching frequency: 2000 Hz
- LEDs indicate the switch configuration (can be switched off)
- Switch Resistance: DRV: 2.5 Ω, SNS: 5.0 Ω
- Floating column impedance: 0.5 TΩ || 5 pF

Measurements

- BJT input (compound of SNS+ and SNS-): 1.5 nV/$\sqrt{\text{Hz}}$, 2500 fA/$\sqrt{\text{Hz}}$
- FET input noise (compound of SNS+ and SNS-): 8 nV/$\sqrt{\text{Hz}}$, 2 fA/$\sqrt{\text{Hz}}$
- FET input load: < 1 pA, 0.1 pA/V, 8 pF
- Resistance measurement noise floor: 10 nΩ/$\sqrt{\text{Hz}}$ (direct BJT input)
- Resistance measurement noise floor: < 1 nΩ/$\sqrt{\text{Hz}}$ (Transformer-coupled FET input)
- Gain change with temperature: 100 ppm/K
- Gain change with temperature in ratiometric mode: < 1 ppm/K
- Gain stability total in ratiometric mode with thermalized reference: 1 ppb
- DC offset voltage change with temperature: ±1 µV/K, ±3 ppm/K
- DC offset voltage change with temperature in differential mode: <0.1 ppm/K

Ranges

- 4 Series Resistors from 100 Ω to 20 MΩ
- 4 Output Voltage Measurement Ranges from 2 V to 20 V
- 8 Input Voltage Measurement Ranges from 100 mV to 20 V
- 4 Current Measurement Ranges per Series Resistor from 100 nA to 200 mA
- All Ranges User/Auto Selectable
- Base Precision within Range: <1 ppm of full range for Output Voltage and Current
- Base Precision within Range: <0.1 ppm of full range for Input Voltage
- Continuous dynamic range within one Range: > 8 digits

DRV Frequency Reference

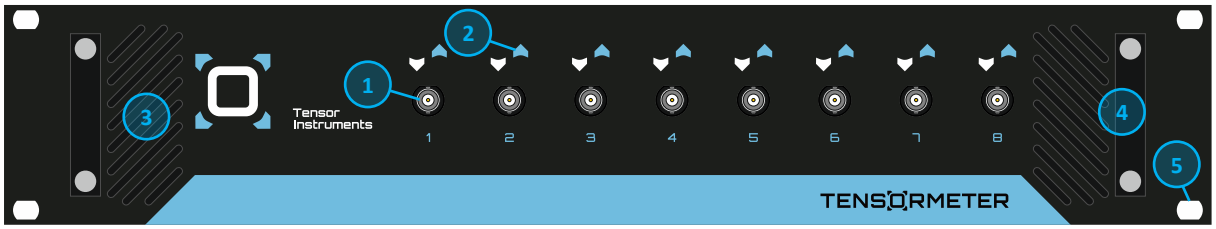
- Any of the 8 ports or 4 port functions can be used as Reference Input or Output

Digital In/Out

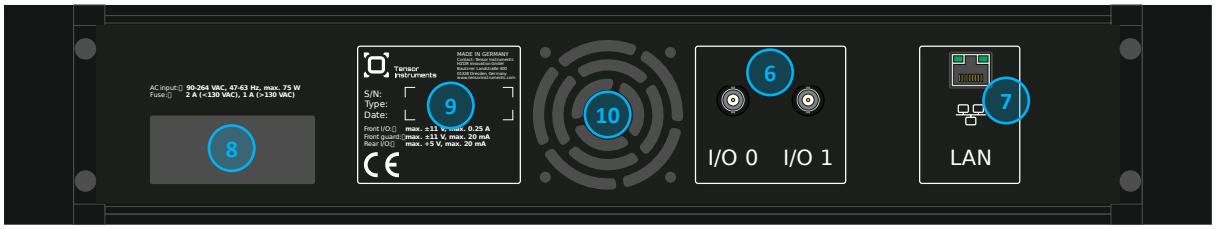
- 2 BNC ports
- Signal level: single-ended 3.3V CMOS logic
- Bandwidth: 10 MHz
- For Trigger input/output
- Auxiliary analog PWM output

Hardware/software specifications

- 19” rack-mountable device, 2 height units, 32 cm depth
- TCP-based user connection over Ethernet (USB-Ethernet adapter possible)
- Client communication examples for LabView and Python (more on request)
- Power demand < 75 W, Universal AC single phase AC input, C14 connector
- BNC connectors, 50 Ω coaxial type
- Factory calibration



Device front panel with (1) 8 BNC ports for multiple analog functions: drive, sense, reference phase-locking, (2) LED indicators for the port function: input (white arrow) or output (blue arrow), (3) cooling air flow inlet (do not obstruct), (4) handles for easy transport and rack installation, (5) 19” rack mounting holes.



Device rear panel with (6) 2 BNC ports for multiple digital functions: triggering, threshold-checking, PWM, (7) Ethernet connector for the main TCP communication, (8) fused and switched mains power inlet, (9) device information, (10) cooling air flow outlet (do not obstruct).

Scope of delivery

- Tensormeter RTM2 19” rack-mountable device
- Software package with client code examples for LabVIEW and Python (no driver needed)
- Tensormeter RTM2 User Guide incl. TCP Commands, Operation Parameter Guidelines
- Mains cable with Type F connector (others on request)
- Ethernet Cable

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