User Guide
Tensormeter Model RTM1

The Tensormeter Model RTM1 is the first of a new kind of electronic precision measurement devices. Its unique construction combines advantages found in several different device classes such as multimeters, sourcemeters and lock-in amplifiers and delivers excellent or even unparalleled performance across a huge range of measurement tasks. Building on an integrated analog switch matrix, it is possible to conduct measurements that go beyond traditional scalar 4-wire resistance measurements and into the territory of multi-component resistance tensor measurements. The device is targeted at applications in science and in automated test environments.

1. Installation and Infrastructure

Strictly adhere to the specifications in this Section. Otherwise, warranty will be void. Stresses beyond those stated under Absolute Maximum Ratings can lead to permanent damage to the device.

Operation of the RTM1 requires it to be installed indoors at an ambient temperature between 0°C and 50°C and non-condensing humidity. For ultimate performance, limit air circulation and temperature changes, position the device as far away as possible from strong sources of fast-changing magnetic fields and use the power connector that is delivered together with the device.

❗	Do not attempt to open the device chassis or to make alterations to the device. Always contact your supplier or the manufacturer if your measurement situation demands changes to the device.

1.1. Absolute Maximum Ratings

❗	Do not exceed the given value ranges during operation of the RTM1. It may cause damage to the device.

Operation temperature	-20°C – 70°C, non-condensing humidity
Power supply voltage to GND	-0.3 … 28 V
Port 1-8 voltage to GND	-36 V … 36 V
Port 1-8 output current	-100 mA … 100 mA
Port 1-8 input current	-1 mA … 1 mA
Reference port voltage to GND	-36 V … 36 V
Reference port output current	-20 mA … 20 mA
Reference port input current	-10 mA … 10 mA
Trigger port voltage to GND	-30 V … 30 V
Trigger port current	-2 mA … 2 mA

1.2. Hardware Specifications

Installation specifications

Size	19" rack-mountable device, 3 height units, 25 cm depth
Power demand	< 30 W, 24 VDC supplied via AC mains connector
Operation range	0°C – 50°C, non-condensing humidity
Vibrations	<10 G
Front connectors	BNC, 50 Ω type, grounded shield
Communication connector	USB Type B, grounded shield
Cooling	Free convection (can be closed at expense of warmup time)
Front LED indicators	Power, Channel selection, all dimmable and disengagable

Electrical specificaions

Analog output	
Symmetrical output	DC – 20 kHz, ±20 V, ±100 mA
Output noise floor	< -140 dBFS
Max. pulse amplitude	±40 V, ±100 mA (AC-coupled)
Time resolution	10 µs
Differential Analog input	
input noise (superbeta)	3 nV/√Hz , 0.5 pA/√Hz
input bias current (superbeta)	1 nA
input noise (bipolar)	1.5 nV/√Hz , 2.4 pA/√Hz
input bias current (bipolar)	150 nA
input noise (FET)	4.3 nV/√Hz , 0.02 pA/√Hz
input bias current (FET)	0.2 nA
Frequency Demodulation	Simultaneous, multi-frequency, up to 20 kHz
Sensing precision	<0.1 ppm
Continuous dynamic range	>8 digits
Gain TC	100 ppm/K, <1 ppm/K (ratiometric)
DC offset voltage TC	1 µV/K, <0.01 µV/K (differential)
Switch Matrix	32 switches, <8 Ω each, 5 ms actuation time
Reference input/output	single-ended ±10 V, arbitrary function input
Trigger input/output	single-ended 5V TTL

1.3. Software

The RTM1 device exclusively communicates via its USB2.0 Interface to the RTM_Server software running on a Windows PC. User Interaction is always with the RTM_Server, and not with the device. While RTM_Server is restricted to Windows, the user software can run on any operating system as well as on remote computers. The communication between the Server and its Clients uses platform independent TCP. For an extensive explanation of the TCP commands and syntax, refer to the Tensormeter Command Reference.

If the RTM1 has been acquired together with a relay PC, this will have the RTM_Server already pre-installed and configured. Otherwise, the most recent version of the RTM_Server is available as a Windows installation package on the website **www.tensormeter.de**. The download archive also contains working Client programs for LabVIEW and code examples for individual functions for LabVIEW and Python. If you want to setup a Client program in another programing environment, contact your supplier or the manufacturer for support.

The configuration file used by RTM_Server contains a number of advanced settings that are specific to each individual device. These files are included in your delivery and should be stored carefully. In case of a loss of configuration, please contact your supplier or the manufacturer for support.

2. Operation

2.1. Starting operation

The RTM1 can be switched on and off with a power switch located next to its power inlet on the rear side of the device. As a device aimed at long term measurements and high precision, it is advantageous to leave the device always switched on. Although switching the RTM1 off does no harm, the equilibration time after power-up can be noticeable for minutes in very demanding measurement tasks.

Once powered up, make sure that the device is properly connected via USB to the PC with RTM_Server. The RTM_Server software will automatically connect with the device when it is launched and will open a TCP port (typically 6340) on the Server PC that Clients can use for connections.

2.2. Initiating Client connection

When a client connects to the opened port, the RTM_Server will send a message containing all presently set parameters and will send updates, whenever a setting is changed on the server side. This behavior can be disabled in the menu of the RTM_Server, by setting the TCP Auto Update to Off. The same menu also allows to set the TCP numerical communication format to be either fixed length binary numbers or variable length clear text ASCII numbers. For a comprehensive documentation of the Server-to-Client communication protocol, refer to the **Tensormeter Command Reference**.

2.3. Setting up parameters

The Tensormeter has a range of electrical parameters that define the way how measurements are performed. The general steps in setting up a measurement are:

1) Define the switch matrix to make connections to the ports needed in the measurement.
2) Adjust the excitation voltage and series resistor values to provide a strong signal but be not harmful to the sample at the same time

For a much more detailed recap of the above steps, with a lot of additional information, please refer to the **RTM Operation Parameter Guide**.

2.4. Continuous and Finite Measurements

Setting the Remaining Measurements count to -1, will put the device into a continuous measurement mode, which is the preferred mode for maximum precision. The continuous measurements keep the sample always agitated and thus avoid a short warm-up spike as it would occur during the beginning of a measurement after a pause. The continuously measured data points are timestamped and stored in an internal buffer. Once a Client asks for data, all previously measured data that is stored in the buffer will be transmitted.

Setting the Remaining Measurements to a positive number will initiate the accumulation of the stated amount of measurement points and the device will acquire no more data points when the desired number has been recorded. These points will be stored in the internal buffer in the same way as in the continuous measurement mode. They will only be sent to the Client, once the Client asks for them. The finite measurements mode can be useful if the Tensormeter is used in context with other devices and the measurements have to happen at a specific time.

A more advanced version of the finite measurement mode, is hardware or software triggering of measurements, the details of which are explained in the **Tensormeter Command Reference**.

2.5. Data Format

Data is always sent as a 2D array of double precision floating-point numbers. The number of lines in the data array is variable from zero to many and corresponds to the number of measurement points contained in the sent data package. The number of columns is 41 when all columns are selected for transmission (default after Client connection) but can be set to any number of columns in any order using the Select Channels Client command, which is described in the **Tensormeter Command Reference**.

3. Maintenance

The Tensormeter RTM1 requires no maintenance to function normally.

In some scenarios, a regular device calibration can improve the measurement results, especially in cases where a high level of absolute accuracy is required. For tasks requiring a high level of absolute accuracy, it is generally recommended to use the differential and ratiometric measurement modes. If this is not an option in the target application, the base accuracy of the RTM1 determines the accuracy of the measurement results.

To carry out a calibration, connect a resistor with a known resistance to the ports 1-4 of the RTM1. Ports 1 and 4 should be connected to one end of the resistor and Ports 2 and 3 should be connected to the opposite end, creating a 4-wire resistance measurement configuration. Next, enter the advanced menu in the RTM_Server (top left icon), enter the known resistance value of the calibration resistor in Ohms and press the Calibration button. Calibration takes several minutes to complete. Do not disturb the measurement or touch the device or connections during calibration.