VMS-1502 RTD Meter

General Description

The VMS-1502 is 6-channel RTD (Resistance Temperature Detector) meter. The RTD is based on material with accurate relationship between resistance and temperature as resistance is easy to measure. VMS-1502 continuously measures resistance on all channels and computes temperature according to selected sensor type. The VMS-1502 supports both platinum PT100 and PT1000 RTD sensors independently on each input channel. Measured resistance and temperature data can be read via RS-485 bus and Modbus RTU protocol.

VMS-1502 RTD Meter

Functions and Benefits

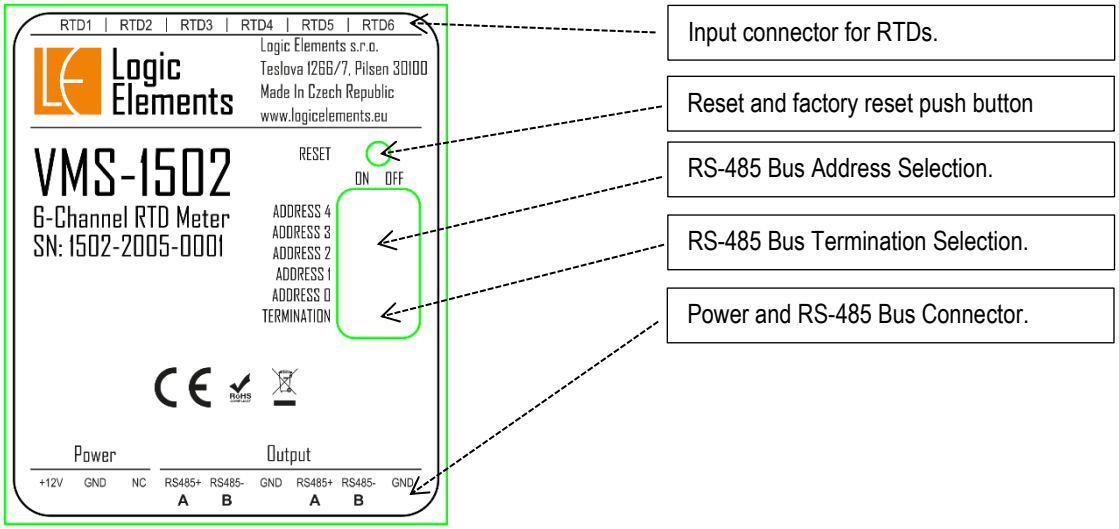
- 6 Analog RTD inputs (PT100 or PT1000)
- Wide temperature range
- High precision, each device is calibrated
- User-set lead resistance correction
- Programmable averaging
- Sensor fault detection
- 1 Digital output Modbus RTU with address switch
- Remote firmware update over Modbus

Parameters

Parameter	Value		
	Minimum	Typical	Maximum
Mounting	35/7.5 (DIN 46277, EN 50022)		
Width	3 modules		
Number of inputs	6		
Number of outputs	1		
Ambient temperature	-40 °C		85 °C
Temperature measuring range	-200 °C		600 °C
Temperature measuring accuracy PT100	+/- 0.5°C in full range		
Temperature measuring accuracy PT1000	+/- 0.25°C in full range		
Power supply voltage	4.5 V	12 V	25 V
Power supply consumption @ 12 V	22 mA	28 mA	35 mA
PT100 measuring current	1 mA		
PT1000 measuring current	250 uA		
Time to measure each channel	1 / 6 s		
Modbus communication	19200 baud/s, 8 data bits, Even parity, 1 stop bit		
Modbus address	0 + DIP value (minimum 1)		

Pin Description

Pin Placing



Pinout Table

PIN	Type	Description
+12V	Power Supply Pin	Power supply pin for external power supply.
GND	Power Supply Pin	Power pin for supply ground.
NC	Not Connected	Not internally connected
RS485+ A	RS-485 Bus Output	Positive RS-485 bus differential output. There are 2 internally connected pins for easier wiring.
RS485- B	RS-485 Bus Output	Negative RS-485 bus differential output. There are 2 internally connected pins for easier wiring.
RTD1	RTD sensor terminals	Pair of terminals for RTD sensor (PT100 or PT1000). Both terminals are interchangeable. If sensor cable is shielded, shield must not be connected to either terminal. Instead, connect shield to earth ground by other means. This is also denoted as Channel 1 in hereafter.
RTD2 – RTD6	RTD sensor terminals	RTD sensor Channels 2 through 6
Termination	Switch	Turn on termination resistor 150 R on RS-485 bus in case the VMS-1502 is placed in the end of RS-485 bus.
ADDRESS 0 – ADDRESS 4	Switch	Set Modbus RTU protocol address. Individual address switches represent numerical values: ADDRESS 0: 1 ADDRESS 1: 2 ADDRESS 2: 4 ADDRESS 3: 8 ADDRESS 4: 16 If given switch is turned on, related numerical value is effective. RS-485 Modbus protocol address is determined as sum of all numerical values enabled by switches. If all switches are ON, address is equal to 31 (1 + 2 + 4 + 8 + 16). Note: If 0 address is selected, which is not allowed, VMS-1502 will use address 1.

Modbus RTU Protocol

The device implements Modbus RTU slave supporting the following function codes 3, 4, 16.

Modbus Registers Mapping – Input Registers

Address	Name	Format	Description
0	Temperature 1 (fixed)	INT	Measured temperature at input 1 in hundredths of centigrade *Minimum: -20000. Maximum: 32767.* Unit: 0.01 °C.
1	Temperature 2 (fixed)	INT	Measured temperature at input 2 in hundredths of centigrade *Minimum: -20000. Maximum: 32767.* Unit: 0.01 °C.
2	Temperature 3 (fixed)	INT	Measured temperature at input 3 in hundredths of centigrade *Minimum: -20000. Maximum: 32767.* Unit: 0.01 °C.
3	Temperature 4 (fixed)	INT	Measured temperature at input 4 in hundredths of centigrade *Minimum: -20000. Maximum: 32767.* Unit: 0.01 °C.
4	Temperature 5 (fixed)	INT	Measured temperature at input 5 in hundredths of centigrade *Minimum: -20000. Maximum: 32767.* Unit: 0.01 °C.
5	Temperature 6 (fixed)	INT	Measured temperature at input 6 in hundredths of centigrade *Minimum: -20000. Maximum: 32767.* Unit: 0.01 °C.
6, 7	Uptime	INT	Time since last power-up Unit: s.
8, 9	Number of conversions	INT	Number of conversions on all channels Unit: conversions.
10, 11	Status register	BIN	Binary map of different status flags Meaning of respective bits: Bit 0 - Generic error - Any error flag. Bit 4 - RTD 1 open - Open circuit at RTD input 1. Bit 5 - RTD 2 open - Open circuit at RTD input 2. Bit 6 - RTD 3 open - Open circuit at RTD input 3. Bit 7 - RTD 4 open - Open circuit at RTD input 4. Bit 8 - RTD 5 open - Open circuit at RTD input 5. Bit 9 - RTD 6 open - Open circuit at RTD input 6. Bit 10 - RTD 1 short - Short circuit at RTD input 1. Bit 11 - RTD 2 short - Short circuit at RTD input 2. Bit 12 - RTD 3 short - Short circuit at RTD input 3. Bit 13 - RTD 4 short - Short circuit at RTD input 4. Bit 14 - RTD 5 short - Short circuit at RTD input 5. Bit 15 - RTD 6 short - Short circuit at RTD input 6. Bit 16 - Configuration flash error - Error when working with configuration memory. Bit 17 - Low voltage - Detected low power supply voltage. Bit 18 - Modbus timeout - No modbus communication for timeout period. Bit 19 - Testing mode - Testing mode is enabled. *Minimum: 0. Maximum: 1048575.*
12	Input signals	INT	Set of input signals. Bits 0-4 - Modbus address offset Bits 5-8 - Bootstrap pins Bit 9 - Pushbutton *Minimum: 0. Maximum: 1023.*
13	Analog supply	INT	Measured analog reference voltage *Minimum: 2500. Maximum: 3500.* Unit: mV.
14	Power voltage	INT	Measured power supply voltage *Minimum: 5000. Maximum: 25000.* Unit: mV.
15, 16	Temperature 1 (float)	FLOAT32	Measured temperature at input 1 in hundredths of centigrade *Minimum: -200. Maximum: 600.* Unit: °C.
17, 18	Temperature 2 (float)	FLOAT32	Measured temperature at input 2 in hundredths of centigrade

			Minimum: -200. Maximum: 600. Unit: °C.
19, 20	Temperature 3 (float)	FLOAT32	Measured temperature at input 3 in hundredths of centigrade *Minimum: -200. Maximum: 600.* Unit: °C.
21, 22	Temperature 4 (float)	FLOAT32	Measured temperature at input 4 in hundredths of centigrade *Minimum: -200. Maximum: 600.* Unit: °C.
23, 24	Temperature 5 (float)	FLOAT32	Measured temperature at input 5 in hundredths of centigrade *Minimum: -200. Maximum: 600.* Unit: °C.
25, 26	Temperature 6 (float)	FLOAT32	Measured temperature at input 6 in hundredths of centigrade *Minimum: -200. Maximum: 600.* Unit: °C.
27, 28	Resistance 1	FLOAT32	Measured resistance (after lead wire compensation) at input 1 *Minimum: 0. Maximum: 3200.* Unit: Ohm.
29, 30	Resistance 2	FLOAT32	Measured resistance (after lead wire compensation) at input 2 *Minimum: 0. Maximum: 3200.* Unit: Ohm.
31, 32	Resistance 3	FLOAT32	Measured resistance (after lead wire compensation) at input 3 *Minimum: 0. Maximum: 3200.* Unit: Ohm.
33, 34	Resistance 4	FLOAT32	Measured resistance (after lead wire compensation) at input 4 *Minimum: 0. Maximum: 3200.* Unit: Ohm.
35, 36	Resistance 5	FLOAT32	Measured resistance (after lead wire compensation) at input 5 *Minimum: 0. Maximum: 3200.* Unit: Ohm.
37, 38	Resistance 6	FLOAT32	Measured resistance (after lead wire compensation) at input 6 *Minimum: 0. Maximum: 3200.* Unit: Ohm.
39, 40	Serial number	INT	Serial number of product with common device ID in format xxyyzzzz. xx - year of production yy - month of production zzzz - serial incremental number of the product *Minimum: 20050001. Maximum: 20080099.*
41, 42	Product number	INT	Product family identification. *Minimum: 1502. Maximum: 1502.*
43, 44	Hardware version	INT	Hardware revision of the device defined as 0xAAAABBBB: AAAA - major part BBBB - minor part *Minimum: 65539. Maximum: 327695.*
45, 46	Bootloader version	INT	Firmware revision of the bootloader as number 0xAAAABBBB: AAAA - major version BBBB - minor version *Minimum: 262145. Maximum: 327695.*
47, 48	Firmware version	INT	Firmware revision of the current application image as an incremental number. See list of FW revision or release notes for respective features. *Minimum: 1. Maximum: 150.*
49, 50	Assembly date	INT	Assembly information of the current application in format xxxxyyzz: xxxx - year of FW build yy - month of FW build zz - day of FW build *Minimum: 20200413. Maximum: 20221231.*
51, 52	CRC checksum	INT	CRC checksum of the current application
53, 54	Firmware size	INT	Firmware size of the current application in bytes *Minimum: 10000. Maximum: 28000.*
55, 56	Configuration writes	INT	Number of writes into internal configuration flash (size 4kB, entry 128 B, total endurance 10000 * 4096 / 128 = 320000) *Minimum: 0. Maximum: 1000000.* Unit: writes.

Modbus Registers Mapping – Holding Registers

The table below contains a description of all Holding registers and its function description.

Address	Name	Format	Description
0	Function	INT	Function command register. Following commands are supported: Value 9901 - Reset Value 8801 - Factory reset Value 7701 - Testing mode Value 66xx - Invoke error Value 5501 - Invoke watchdog reset Vaue 2 - Restart Value 1 - Run **Default: 1.** *Minimum: 0. Maximum: 9901.*
1	Average samples	INT	Number of temperature samples to average to get result. **Non-volatile, default: 1.** *Minimum: 1. Maximum: 128.*
2	Modbus baud rate	ENUM	Modbus RTU serial port baud rate Allowed values: Value 0 - Default 19200 - Default 19200 baud/s. Value 1 - 300 - 300 baud/s. Value 2 - 600 - 600 baud/s. Value 3 - 1200 - 1200 baud/s. Value 4 - 2400 - 2400 baud/s. Value 5 - 4800 - 4800 baud/s. Value 6 - 9600 - 9600 baud/s. Value 7 - 19200 - 19200 baud/s. Value 8 - 38400 - 38400 baud/s. Value 9 - 57600 - 57600 baud/s. Value 10 - 115200 - 115200 baud/s. **Non-volatile, default: 7.** *Minimum: 0. Maximum: 10.*
3	Modbus settings	ENUM	Modbus RTU serial port parity Allowed values: Value 0 - 8-N-1 - 1 stop bit, none parity. Value 1 - 8-E-1 - 1 stop bit, even parity. Value 2 - 8-O-1 - 1 stop bit, odd parity. Value 3 - 8-N-2 - 2 stop bits, none parity. Value 4 - 8-E-2 - 2 stop bits, even parity. Value 5 - 8-O-2 - 2 stop bits, odd parity. **Non-volatile, default: 1.** *Minimum: 0. Maximum: 5.*
4	Sensor type 1	ENUM	Sensor type settings at input 1 Allowed values: Value 0 - PT100 - PT100 is used. Value 1 - PT1000 - PT1000 is used. **Non-volatile, default: 0.** *Minimum: 0. Maximum: 1.*
5	Sensor type 2	ENUM	Sensor type settings at input 2 Allowed values: Value 0 - PT100 - PT100 is used. Value 1 - PT1000 - PT1000 is used. **Non-volatile, default: 0.** *Minimum: 0. Maximum: 1.*
6	Sensor type 3	ENUM	Sensor type settings at input 3 Allowed values: Value 0 - PT100 - PT100 is used. Value 1 - PT1000 - PT1000 is used. **Non-volatile, default: 0.** *Minimum: 0. Maximum: 1.*
7	Sensor type 4	ENUM	Sensor type settings at input 4 Allowed values: Value 0 - PT100 - PT100 is used.

			Value 1 - PT1000 - PT1000 is used. **Non-volatile, default: 0.** *Minimum: 0. Maximum: 1.*
8	Sensor type 5	ENUM	Sensor type settings at input 5 Allowed values: Value 0 - PT100 - PT100 is used. Value 1 - PT1000 - PT1000 is used. **Non-volatile, default: 0.** *Minimum: 0. Maximum: 1.*
9	Sensor type 6	ENUM	Sensor type settings at input 6 Allowed values: Value 0 - PT100 - PT100 is used. Value 1 - PT1000 - PT1000 is used. **Non-volatile, default: 0.** *Minimum: 0. Maximum: 1.*
10, 11	Test register	INT	Internal testing purpose
12, 13	Lead resistance 1	FLOAT32	Resistance of lead wires for input 1 **Non-volatile, default: 0.** *Minimum: -2000. Maximum: 2000.* Unit: Ohm.
14, 15	Lead resistance 2	FLOAT32	Resistance of lead wires for input 2 **Non-volatile, default: 0.** *Minimum: -2000. Maximum: 2000.* Unit: Ohm.
16, 17	Lead resistance 3	FLOAT32	Resistance of lead wires for input 3 **Non-volatile, default: 0.** *Minimum: -2000. Maximum: 2000.* Unit: Ohm.
18, 19	Lead resistance 4	FLOAT32	Resistance of lead wires for input 4 **Non-volatile, default: 0.** *Minimum: -2000. Maximum: 2000.* Unit: Ohm.
20, 21	Lead resistance 5	FLOAT32	Resistance of lead wires for input 5 **Non-volatile, default: 0.** *Minimum: -2000. Maximum: 2000.* Unit: Ohm.
22, 23	Lead resistance 6	FLOAT32	Resistance of lead wires for input 6 **Non-volatile, default: 0.** *Minimum: -2000. Maximum: 2000.* Unit: Ohm.
24	Calibration mode	INT	Writing 1111 stores the current calibration into one-time programmable memory **Default: 0.** *Minimum: 0. Maximum: 1111.*
25	Reserved	INT	Reserved for future use
26, 27	PT100 gain calibration	FLOAT32	Gain calibration for PT100 sensors **One-time prog., default: 1.** *Minimum: 0.9. Maximum: 1.1.*
28, 29	PT100 zero calibration	FLOAT32	Zero calibration for PT100 sensors **One-time prog., default: 0.** *Minimum: -1. Maximum: 1.* Unit: Ohm.
30, 31	PT1000 gain calibration	FLOAT32	Gain calibration for PT1000 sensors **One-time prog., default: 1.** *Minimum: 0.9. Maximum: 1.1.*
32, 33	PT1000 zero calibration	FLOAT32	Zero calibration for PT1000 sensors **One-time prog., default: 0.** *Minimum: -1. Maximum: 1.* Unit: Ohm.

Register Notes

- Registers spanning more than one modbus register are little endian (least significant portion are located at lower address).
- Registers use one from the following number formats:
  - INT – Integer value (signedness may differ among registers depending on the usage)
  - BIN – Integer unsigned value where each bit has dedicated meaning
  - ENUM – Enumerated value from given list
  - FLOAT – Simplified floating point number represented as 10 times the original number
  - FLOAT32 – Single precision floating point number in IEEE-754 format.
- The content of registers denoted as **Non-volatile** is stored in the internal non-volatile Flash memory, so the most recently written value is used after device power up. The values of these registers should not change more than 320000 times according to minimal endurance of the memory. Number of write operations can be obtained from input register "Configuration writes"
- **Default** value is used out-of-box or when user resets the configuration by pressing push button for more than 5 seconds. If default value is not mentioned, holding register will be set to 0. Holding registers may have some factory default value that is not stated in the table (e.g., identification such as serial number, firmware revision etc.).
- **One-time prog.** stands for registers that are written during manufacturing process. It can be temporarily changed by write command, though the value will be lost at power down.

RS-485 Communication Settings

RS-485 settings can be changed through Modbus Holding registers. The new settings are applied **only** after writing the Modbus Coding register. It is a good practice to write both Modbus registers at once. The default configuration is as follows.

Parameter	Value
Baud rate	19 200 Baud/s
Word length	8 bits
Parity	Even
Stop bits	1

Led Indication

For simple behavior indication, the VMS-1502 is equipped with Red and Green LED diode inside the housing next to the Termination DIP switch.

LED state	Meaning
Green – blinking	Operational state, all sensors within measuring range, active communication.
Red – solid	Malfunction, device is not operating.
Red – blinking	Warning state. Either sensor is outside measuring range, or undervoltage.
Red + Green concurrent blinking	Modbus communication timeout.
Red + Green alternate blinking	Bootloader is working. Either at power on or after remote firmware upgrade.

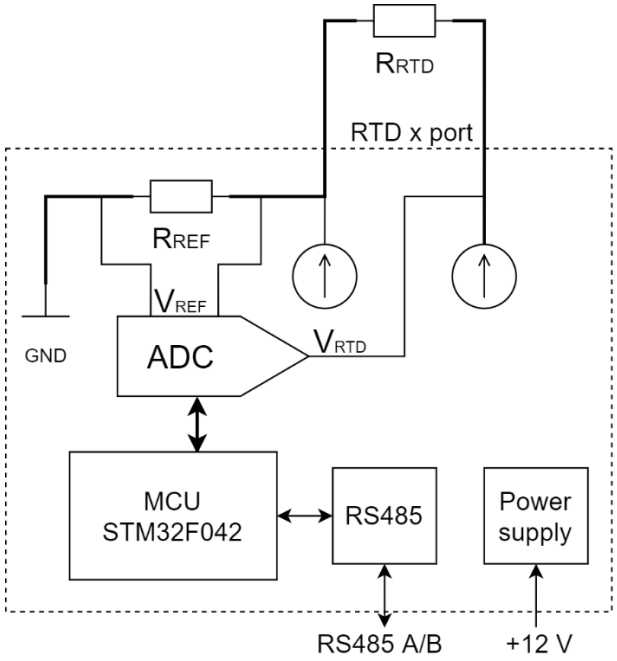
Push Button

Push button can be used to restart device and to reset it to the factory default settings

Push time [s]	Action
Less than 0.5 s	Nothing (debouncing and false push prevention feature)
Between 0.5 s and 5 s	Device restart
More than 5 s	Reset to factory default settings. Device will restart as well.

Functional Description

The VMS-1502 uses a ratiometric principle to measure unknown resistance of RTD as a ratio to the precise reference resistor. There are 2 current sources that drives current through RTD and reference resistor. The voltage across RTD is sampled by ADC using voltage across reference resistor as reference voltage. The measured voltage ratio is equal to resistance ratio.



Each channel is continuously sampled for period of 166 ms, the complete round of 6 input RTDs takes approximately 1 second. The input is sampled at modulator frequency of 32 kHz. Samples are than decimated and FIR filtered to final sample rate of 20 samples per second. Such very-low-pass filter has advantage of very good 50-Hz and 60-Hz rejection (less than -80 dB).

Wiring and Power-up

Recommended powering-up sequence is as follows:

1. Power up VMS-1502 emulator
2. Connect VMS-1502 to RS485 bus
3. Connect RTD sensors to RTD ports. Note that both pins of each RTD port are interchangeable.

Note that both pairs of RS485 terminals (A + B) are identical and internally connected. Their purpose is to ease device chaining. When connecting to VMS-1401, RS485+A should be connected to pin labelled A485+ and RS485-B to pin A485-.

Temperature Monitoring Use Case

Typical application of VMS-1502 is monitoring of multiple temperatures. One should proceed in the following steps:

1. Verify that values of “Average samples”, “Sensor type 1-6” and “Lead resistance 1-6” match our application and intended use.
2. If values do not match, write them. Note that it is not recommended to write them too often because of flash memory endurance consideration.
3. Read “Temperature 1-6 (float)” or “Temperature 1-6 (fixed)” to obtain measured temperature
4. Monitor sensor faults by either reading “Status register” and evaluating respective bits or by obtained temperature value. Fault states are represented by boundary temperature values, such as Temperature 1-6 (float)=-200 or Temperature 1-6 (fixed) = 32767.

Device limitations

Common GND / Galvanic Isolation

All 6 RTD inputs are referenced to the common ground (GND). Neither pin of RTD port is directly connected to ground.

Bias Voltage on RTD

Due to constant current sources, both pins of every RTD port are biased by voltage between 1 and 2.3 V depending on sensor type and resistance value. Neither pin can be directly tied to Common GND.

Norm Compliance

This product was developed and manufactured with the compliance of following European norms (EN):

- EN 61000-4
- EN 55032
- EN 50581:2013

Document revisions

Revision number	Date	Remarks
Rev 01.0	09/2017	Document release
Rev 02.0	08/2020	Update to new device hardware and feature revision. Relevant for SN 1502-2005-0001 and newer