# General Description

Resistor Temperature Detectors (RTD) are sensors used to measure temperature. The detector is based on material with accurate relationship between resistance and temperature as resistance is easy to measure.

This device is intended to serve as emulator of RTDs by allowing to set desired resistance or temperature on port. Such a device is very useful for testing of systems that measure temperature using RTD, for instance heating systems. Programmable and possibly very high temperature slew rate of this device allows for automatic boundary-condition and fault testing, emulation of which is otherwise very cumbersome.

# Functions and Benefits

* 1 channel isolated from power and RS-485
* Direct resistance settings
* Emulate NTC using coefficients and temperature
* Platinum sensors are supported
* Programmable temperature slew rate
* 1 Digital output Modbus RTU with address switch
* Remote firmware update over Modbus

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameter | Value | | | |
| **Minimum** | **Typical** | **Maximum** | |
| Mounting | 35/7.5 (DIN 46277, EN 50022) | | | |
| Size | 90 x 72 mm | | | |
| Number of inputs | 1 RS-485 bus | | | |
| Number of outputs | 1 RTD channel | | | |
| Ambient temperature | -30 °C |  | 200 °C | |
| Power supply voltage | 8 V | 12 V | 25 V | |
| Power supply consumption @ 12 V | 16 mA | 18 mA | 25 mA | |
| Nominal resistance of RTD port | 10 Ohm |  | 290000 Ohm | |
| Resistance step (LSB) | 1.2 Ohm | | | |
| Temperature accuracy (NTC 10k B3977) @ 25 °C | +- 0.1 °C | | | |
| Accuracy vs ambient temperature | -0.5 °C @ 60 °C |  | | +0.5 °C @ -20 °C |
| RTDx pins voltage to GND-ISO | 0 V |  | | 3.5 V |
| Current through RTDx port | -350 mA |  | | 350 mA |
| Modbus communication | 19200 baud/s, 8 data bits, Even parity, 1 stop bit | | | |
| Modbus address | 32 + DIP value | | | |

# Parameters

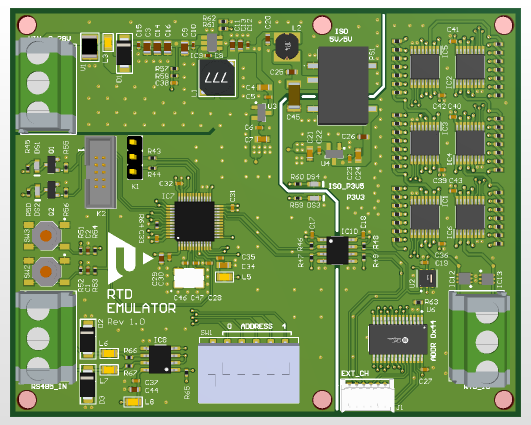
Obsah obrázku elektronika, obvod, Elektronická součástka, Elektronické inženýrství

Popis byl vytvořen automaticky

RTD Emulator

# Pin Description - TBD

## Pin Placing



Power connector

+12 V

GND

NC

Input connector

for emulated RTD

RTD   
RTD

GND-ISO

RS-485 bus connector

RS485+ A  
RS485- B

GND

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Reset and factory reset push button

Extension connector for external RTD modules

RS-485 bus address selection

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## 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 |
| RS485- B | RS-485 bus output | Negative RS-485 bus differential output |
| RTD |  | Port for RTD emulation. Both pins are interchangeable. Voltage at either pin must not exceed working range 0 – 3.5 V |
| GND-ISO | Ground of isolated RTDs | Ground of isolated part of RTD emulator. This ground must be tied to the ground of measuring device. |
| ADDRESS 0  –  ADDRESS 4 | Switch | Set Modbus RTU protocol address that will be added to **base value 32**. 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) + **32** = **63**. |

# 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, 1 | Uptime | INT | Elapsed seconds from device startup Unit: s. |
| 2, 3 | Register map version | INT | Version of register map in format xxxyyy. Xxx - major version of register map. Yyy - minor version of register map. Major version defines compatibility of different register maps. If major version of register map changes, the values previously stored in the flash memory are discarded and factory values are used *Minimum: 1001. Maximum: 5050.* |
| 4, 5 | Status register | BIN | Binary map of different status flags Meaning of respective bits:  Bit 0 - Generic error - Error in the device. Bit 1 - Testing mode - Testing mode is enabled. Bit 2 - Calibrated successfully - Calibration data read successfully. Bit 3 - Modbus timeout - No modbus communication for timeout period. Bit 16 - Configuration flash error - Error when working with configuration memory. Bit 17 - Reset by IWDG - Last reset was caused by Independent watchdog. |
| 6 | Input signals | INT | Set of input signals.  Bits 0-4 - Modbus address offset Bits 5-8 - Bootstrap Bit 9 - Pushbutton *Minimum: 0. Maximum: 1023.* |
| 7, 8 | 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 |
| 9, 10 | Product number | INT | Unique device ID *Minimum: 9153. Maximum: 9153.* |
| 11, 12 | Hardware version | INT | Hardware revision of the device defined as xxxyyy: xxx - major revision (letter) yyy - minor revision (number) *Minimum: 1001. Maximum: 5099.* |
| 13, 14 | Bootloader version | INT | Firmware revision of the bootloader as number xxxyyy: xxx - major version of bootloader yyy - minor version of bootloader *Minimum: 1001. Maximum: 5099.* |
| 15, 16 | Firmware revision | 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: 999.* |
| 17, 18 | 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: 20231100. Maximum: 20250330.* |
| 19, 20 | CRC checksum | INT | CRC checksum of the current application |
| 21, 22 | Firmware size | INT | Firmware size of the current application in bytes *Minimum: 10000. Maximum: 32000.* |
| 23, 24 | Configuration writes | INT | Number of writes into internal configuration flash memory (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, 1 | Command | INT | Following commands are supported: Value 9901 - Reset Value 8801 - Factory reset Value 7701 - Testing mode Value 66xx - Invoke error Value 5501 - Invoke watchdog reset **Default: 0.** *Minimum: 0. Maximum: 9901.* |
| 2, 3 | Testing register | INT | Generic system testing register |
| 4 | Modbus baud rate | ENUM | Modbus RTU serial port baud rate Allowed values:  Value 0 - 9600 - 9600 baud/s. Value 1 - 19200 - 19200 baud/s. Value 2 - 38400 - 38400 baud/s. Value 3 - 57600 - 57600 baud/s. Value 4 - 115200 - 115200 baud/s. **Non-volatile, default: 1.** *Minimum: 0. Maximum: 4.* |
| 5 | Modbus parity | ENUM | Modbus RTU serial port parity Allowed values:  Value 0 - NONE - NONE parity. Value 1 - EVEN - EVEN parity. Value 2 - ODD - ODD parity. **Non-volatile, default: 1.** *Minimum: 0. Maximum: 2.* |
| 6 | Modbus stop bits | ENUM | Modbus RTU serial port - number of stop bits Allowed values:  Value 0 - 1 stop bit - 1 stop bit. Value 1 - 2 stop bits - 2 stop bits. **Non-volatile, default: 0.** *Minimum: 0. Maximum: 1.* |
| 7 | Apply modbus parameters | INT | Apply new modbus communication parameters. Value 1 - Apply new settings **Default: 0.** *Minimum: 0. Maximum: 1.* |
| 8 | Modbus timeout | INT | Longer silent period implies connection lost. Zero value disables timeout indication. **Non-volatile, default: 10.** *Minimum: 0. Maximum: 7200.* Unit: s. |
| 100 | Emulation mode | ENUM | Set mode of RTD emulation.  Allowed values:  Value 0 - Direct resistance - Set resistance is directly applied to RTD ports. Value 1 - NTC thermistor - Set temperature is used for NTC resistance computation. Value 2 - Platinum RTD - Set temperature is used for PT1000 resistance computation. **Default: 0.** *Minimum: 0. Maximum: 2.* |
| 101 | Temperature correction | ENUM | Temperature correction mode. Recalculates decade resistance values ​​based on current temperature. Allowed values:  Value 0 – Temperature calibration off  Value 1 - Temperature calibration on **Default: 0.** *Minimum: 0. Maximum: 1.* |
| 102 | NTC beta | INT | NTC beta coefficient for computation **Default: 3977.** *Minimum: 3000. Maximum: 5500.* |
| 103 | NTC stock resistance | INT | NTC stock resistance at 25 °C (10000 for common 10k NTC) **Default: 10000.** *Minimum: 1000. Maximum: 10000.* Unit: Ohm. |
| 104 | Platinum stock resistance | INT | Platinum stock resistance at 0 °C  Allowed values: Value 100 - PT100 Value 500 - PT500 Value 1000 - PT1000 **Default: 1000.** *Minimum: 100. Maximum: 1000.* Unit: Ohm. |
| 105, 106 | Set resistance | INT | Resistance that should be set at RTD port 1 **Default: 10000.** *Minimum: 10. Maximum: 290000.* Unit: Ohm. |
| 107, 108 | Set temperature | FLOAT32 | Set temperature for RTD port **Default: 25.** *Minimum: -30. Maximum: 200.* Unit: °C. |
| 109 | Temp slew rate mode | ENUM | Temperature slew rate mode.  Allowed values:  Value 0 – Slew rate mode off - disables this feature Value 1 - Slew rate mode on **Default: 0.** *Minimum: 0. Maximum: 1* |
| 110 | Temperature slew rate | FLOAT | Slew rate of temperature change in temperature emulation mode. The Temperature changes continuously according to the step used. **Default: 5.** *Minimum: 0. Maximum: 100.* Unit: °C/s. |
| 111 | Maximum of slew rate range | INT | Slew rate range. The value from which the temperature starts to rise.  Set maximum of temperature range in slew rate mode. **Default: 50.** *Minimum: -30. Maximum: 200.* Unit: °C. |
| 112 | Minimum of slew rate range | INT | Slew rate range. The value at which the temperature ends after reaching it.  Set minimum of temperature range in slew rate mode- **Default: 15.** *Minimum: -30. Maximum: 200.* Unit: °C. |

## RS-485 Communication Settings

RS-485 settings can be changed through Modbus Holding registers. The new settings are applied **only** after writing the “Apply modbus parameters” register. The default configuration is as follows.

|  |  |
| --- | --- |
| Parameter | Value |
| Baud rate | 19200 Baud/s |
| Word length | 8 bits |
| Parity | Even |
| Stop bits | 1 |

# Led Indication

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

|  |  |
| --- | --- |
| LED state | Meaning |
| Green – blinking | Operational state with active communication. |
| Red – solid | Malfunction, device is not operating. |
| Red – blinking | Warning state. Some internal error, requested resistance is out of 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

Obsah obrázku text, diagram, Plán, Technický výkres

Popis byl vytvořen automaticky

The RTD Emulator is composed of two galvanically isolated parts. The Controller part contains RS485 transceiver, power supply stabilizer and microcontroller. The RTD part is isolated by I2C isolator and DC-to-DC power supply. RTD channel is galvanically referenced to common isolated ground (GND-ISO). In most applications, this GND-ISO must be connected to the ground of device that measures the emulated resistance.

The RTD channel is composed of a resistive decade that can be switched into the desired combination using analog switches. The resistor decade is composed of six rows of fixed resistors, each row containing seven resistors and one direct connection.

# Wiring and Power Up

Recommended powering-up sequence is as follows:

1. Power up RTD emulator

2. Connect RTD emulator to RS485 bus

3. Connect GND-ISO to measuring device

4. Connect RTD port

# NTC Emulation Use Case

1. Write “Value 1 - NTC thermistor” to register “Emulation mode”.
2. Set slew rate range to register “Minimum of slew rate range”, “Maximum of slew rate range” and slew rate value to register “Temperature slew rate” if needed

3. Write “NTC stock resistance” constant as expected by the measuring device

4. Write “NTC beta” constants as expected by the measuring device

5. Write temperature to register “Set temperature” for standard operating

6. Write “Value 1 – Slew rate on” to register “Temperature slew rate mode” if you want to use this feature

# PT1000 Emulation Use Case

1. Write “Value 2 - Platinum RTD” to register “Emulation mode”
2. Set slew rate range to register “Minimum of slew rate range”, “Maximum of slew rate range” and slew rate value to register “Temperature slew rate” if needed
3. Write value 1000 to register “Platinum stock resistance”
4. Write temperature to register “Set temperature” for standard operating
5. Write “Value 1 – Slew rate on” to register “Temperature slew rate mode” if you want to use this feature

# Device Limitations

**GND-ISO**

his ground should be connected to ground of measuring system that evaluates resistance of emulator.

**RTD Ports Voltage**

The voltage connected to the RTD port must not exceed 3.5V. Otherwise, the port may be destroyed.

**Resistance Resolution**

The resistance of the resistive decade has a step of 1.2 ohm.

**Minimal Resistance Value**

The minimum adjustable value of the RTD port is 10 ohms. This limit is given by the internal resistance of the analog sensors in the decade.

# 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 |  | Document release |
|  |  |  |