CZAKI THERMO-PRODUCT sp. z o.o.
ul. 19 Kwietnia 58
05-090 Raszyn-Rybie
tel. (22) 7202302
fax. (22) 7202305
www.czaki.pl
handlowy@czaki.pl

TEMPERATURE TRANSMITTER

for thermocouple sensors,
with Modbus-RTU communication protocol

TMD-21

User Manual

Table of Contents

1. Introduction

TMD-21 is a microprocessor-based measurement transmitter that enables temperature measurement using thermoelectric sensors (thermocouples): **T, J, K, N, S, R, B, E**.

The transmitter features an **RS-485** interface, allowing multiple transmitters to be connected to a shared bus. The transmitter's configuration and the reading of measurement results are done via the RS-485 interface. Communication uses the **Modbus-RTU** protocol, a typical protocol in industrial automation systems.

The signal from the temperature sensor is measured using a specialized analog-to-digital converter. The measurement results are then filtered, scaled, and linearized. The temperature of the sensor's 'cold junctions' is automatically compensated for. The entire process takes about 200ms.
The sensor's state is cyclically checked—sensor disconnection is indicated by the ST LED.
The transmitter provides galvanic isolation of measurement inputs from power and digital outputs.

The transmitter can be configured using the tmd-cfg program, available for free at www.czaki.pl.

The design of the TMD-21 transmitter enables the creation of distributed, scalable measurement systems.

2. Service mode

To configure the transmitter, it can be put into service mode by pressing the [FN] button.
Operation in this mode is indicated by the alternating blinking of the ST LED in green and red.
To exit the service mode, press the [FN] button again or send the 'reset' command.

In service mode, the transmitter operates with fixed settings:
- Transmitter address = 247
- Transmission speed = 19200
- Parity check = even

Service settings do not affect the configuration settings (registers), which can be set according to user needs.

2.1 Signaling

The TMD-21 transmitter has two LEDs:
- RS - yellow: indicates receipt/transmission of a modbus data
- ST - red: indicates the transmitter's status.
  - green: correct power and no processing errors
  - red: sensor errors (steady light) or service mode indication (blinking)

Sensor failure signaling
Sensor failure (short circuit or open circuit) is indicated by the red color of the **ST** LED diode.

2.2 Description of the transmitter terminals

7	A (D+)
8	GND
9	B (D-)
10	PWR (+24V DC)
12	GND

Fig. 2.1 Power and RS-485 interface connections

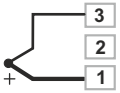


Fig. 2.2 Thermoelectric sensor (thermocouple) connections

2.3. RS-485 Interface

Recommended cable: shielded twisted pair 24AWG with Z >100Ohm.
The cable should be shielded. The shield must be grounded on one side.

Note - Ethernet cables of category 5 STP (as specified by EIA 568 standard) can be used. The maximum length of the bus on such cables is 600m.

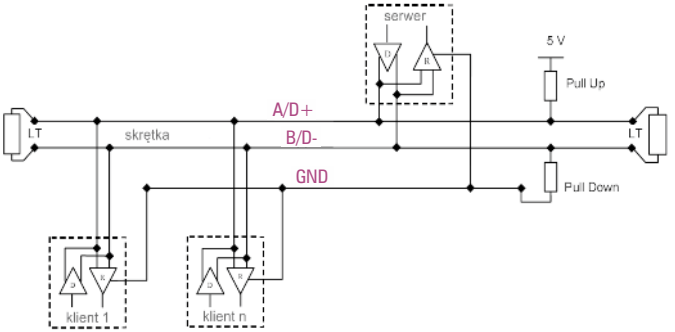


Fig. 2.4 Recommended RS-485 Modbus-RTU interface connection

Typical transmiter allow connection of up to 32 RS485 devices on a shared bus. The TMD21 transmitter circuit introduces a load of 1/8, allowing up to 247 transmitters to be connected on a single bus.

3. Modbus - description

The Modbus standard defines a communication protocol that allows collision-free communication of devices in a client/server mode.
The communication in the Modbus network is managed by the master device (server). Other devices are referred to as clients.
Data exchange in the Modbus network involves the transmission of messages between the server and individual clients, with the client sending a message only in response to the server's message.
Each client must have a unique number (from 1 to 247) assigned to it as its address in the network. The server communicates with the selected client by specifying its address in the message's content.
Besides the client's address, the message contains: command code, data, and CRC check.

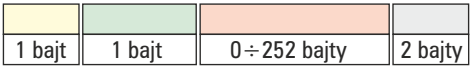
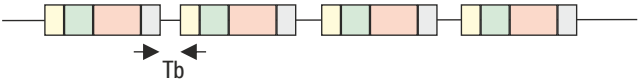


Fig. 3.1 Modbus-RTU communication frame

The command code informs the client of the action requested by the server. The recipient reads the message and performs the task (e.g., sending the measurement result) or returns an error if it cannot fulfill the command.

server: client: server: client:
command response command response



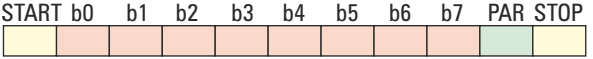
Tb - Bus access break: min 3.5 * single byte transmission time (11 bits)

Fig. 3.2 Communication over a serial bus

Each client device "supports" a list of commands, depending on the device type and functionality. The commands usually involve reading or writing registers or I/O lines of the device.
The list of supported commands and available registers is provided in the device documentation.

Frame CRC Checksum
Each Modbus message ends with a 16-bit CRC checksum.
In the TMD-10 transmitter, the initial value of the polynomial used to calculate the CRC is 0xA001 (hexadecimal).

Data format
In the Modbus protocol, registers are the basic "unit" of data.
A register is 2 bytes in size. Modbus messages are transmitted serially, byte by byte.
A byte is transmitted from the least significant bit to the most significant bit. Each byte of data is preceded by a start bit, followed by a parity bit (PAR) and a STOP bit:



Parity check.
The parity bit (PAR) is set depending on the chosen parity check mode:

EVEN	PAR = 0	PAR = 1
ODD	PAR = 1	PAR = 0
NO	PAR = 1	PAR = 1

Example:
For byte 0110 1010, we have PAR = 0 (EVEN) or PAR = 1 (ODD).

4. List of supported Modbus functions

03 (0x03)	Read input registers
04 (0x04)	Read registers
06 (0x06)	Write single register
08 (0x08)	Diagnostic functions
10 (0x10)	Write registers

Function 0x03 - (Read registers)
This function is used to read the device's internal registers (e.g., measurement values, parameter values, etc.)

Server command:

Function code	1B	0x03
Register address	2B	0x0000÷0xFFFF
Number of registers	2B	1÷125

Client response:

Function code	1B	0x03
Byte count	1B	2xN
Register values	2B x N	

Error report:

Error code	1B	0x83
Exception code	1B	
Address out of range		0x02
Data out of range		0x03

Function 0x04
This function is used to read read-only registers, such as measurement values, non-modifiable settings, etc.

Server command:

Function code	1B	0x04
Register address	2B	0x0000÷0xFFFF
Number of registers	2B	1÷125

Client response:

Function code	1B	0x04
Byte count	1B	2xN
Register values	2B x N	

Error report:

Error code	1B	0x84
Exception code	1B	
Address out of range		0x02
Data out of range		0x03

Function 0x06 (Write single register)
This function allows writing a single register to the device (e.g., the transmitter's network address).
Server command:

Function code	1B	0x06
Register address	2B	0x0000÷0xFFFF
Register value	2B	0x0000÷0xFFFF

Client response:

Function code	1B	0x06
Register address	2B	0x0000÷0xFFFF
Register value	2B	0x0000÷0xFFFF

Error report:

Error code 1B	0x84	
Exception code	1B	
Address out of range		0x02
Data out of range		0x03

Function 0x10 (Write registers)

This function allows writing several registers of the device (e.g., writing a real number or object description).

Server command:

Function code	1B	0x10
Address of the first register	2B	0x0000 ÷ 0xFFFF
Number of registers (N)	2B	0x0001 ÷ 0x0078
Byte count	1B	N * 2
Register values	N*2B	0x0001 ÷ 0x0078

Client response:

Function code	1B	0x10
Address of the first register	2B	0x0000 ÷ 0xFFFF
Number of registers (N)	2B	0x0001 ÷ 0x0078

Error report:

Error code	1B	0x90
Exception code	1B	
Write error		

Diagnostic Function 0x08
This function is used to perform diagnostics on the converter.
The subfunction code is provided as a parameter when invoked.

Server command:

Function code:	1B	0x08
Subfunction code:	2B	0x0000, 0x0003, 0x0002
Data:	N * 2B	

Client response *(see the subfunction description 0x0004)*:

Function code:	1B	0x03
Subfunction code:	2B	0x0001
Data:	2B	0x0000

Diagnostic Subfunctions:
Echo

Subfunction code:	2B	0x0000
Data:	N * 2B	

The converter repeats the received data—the message sent by the server will be identical to the message sent in response.

Reset Communication Interface

Subfunction code:	2B	0x0001
Data:	2B	0x0000

The converter's serial port is reset and reinitialized. If the converter was in listening mode, it will not send a response and will exit the listening mode. If the converter was not in listening mode, it will send a response to the command, similar to the echo subfunction.

Changing communication parameter settings (transmission speed, parity check) and changing the network address will be executed after the communication interface reset!

4.1 List of Registers for the TMD-21 Converter

Register Address	Description	Value
200/40201	Device address	1 ÷ 247
201/40202	Transmission speed	= 0 for 9600 b/s = 1 for 19200 b/s = 2 for 19200 b/s = 3 for 38400 b/s = 4 for 57600 b/s = 5 for 115200 b/s
202/40203	Parity check	= 0 none parity bit = 1 for 'ODD' = 2 for 'EVEN' = 3 for 'NO' (2 STOP bits)
203/40204	Sensor type	= 0 thermocouple B = 1 thermocouple E = 2 thermocouple J = 3 thermocouple K = 4 thermocouple N = 5 thermocouple R = 6 thermocouple S = 7 thermocouple T
204/40205	Averaging mode	= 0: for no averaging = 1: for 2 measurements = 2: for 4 measurements = 3: for 8 measurements = 4: for 16 measurements
0/30001	Converter status	= 0x00: for correct result = 0x01: for sensor disconnection = 0x02: for TC voltage error = 0x80: for CJC error

1/30002	Measured temperature •10.0 (integer)
2/30003	Cold Junction Temperature (CJC)•10.0 (integer)
3/30004	Measured temperature - (floating-point number - LE)
4/30006	Cold Junction Temperature (CJC) (floating-point number - LE)
100/30101	Converter serial number
101/30102	Converter type designation
102/30103	Firmware version

Data size is given as a multiple of the size of a single register (2 bytes).

4.2 Configuration Program

You can use the tmd-cfg program for converter configuration, available at:

https://www.czaki.pl/content-dir/uploads/tmd-cfg_v5-2.zip

5.Technical Data

Sensor type, measurement range, and linearization error

TC-T	(Cu-CuNi)	-200 ... 400°C	/ ±0.10°C
TC-E	(NiCr -CuNi)	-200 ... 1000°C	/ ±0.15°C
TC-J	(Fe - CuNi)	-210 ... 1200°C	/ ±0.11°C
TC-K	(NiCr-Ni)	-200 ... 1372°C	/ ±0.13°C
TC-N	(NiCrSi - NiSi)	-200 ... 1300°C	/ ±0.10°C
TC-S	(Pt10%Rh - Pt)	-50 ... 1768°C	/ ±0.20°C
TC-R	(Pt13%Rh - Pt)	-50 ... 1768°C	/ ±0.20°C
TC-B	(Pt 30%Rh - Pt 6%Rh)	+95 ... 1798°C	/ ±0.25°C

5.Technical Data (cont.)

Temperature drift:	< 0.01% of the reading per °C
Relative measurement error:	< 0.15%
Cold junction temperature compensation error: 1.0°C	
Response time:	< 20ms
Measurement time:	200ms
Communication:	RS-485
Communication protocol:	MODBUS-RTU
Network address:	1 ... 247
Transmission speed:	9600, 19200, 38400, 57600, 115200 bit/s
Transmission parameters:	8E1, 8O1, 8N1, 8N2
Galvanic isolation:	500V AC
Power supply:	12 ... 36 V DC / 0.2 W
Operating temperature:	0 ... +60°C
Humidity:	< 90% non-condensing
Dimensions (height x width x depth):	98 x 17.5 x 56.4mm
Weight	~50g

5.1 Factory Settings

Network address:	247
Transmission speed:	19200 bit/s
Transmission parameters:	8E1
Measurement configuration:	TC-K

6. Package Contents

TMD-21 converter