BENSHAW
ADVANCED CONTROLS & DRIVES

REMOTE RTD MODULE

The Leader In

Solid State Motor Control

Technology

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1. INTRODUCTION

1.1 How To Use This Manual

General

The Benshaw Remote RTD Module manual provides the following information;

- Product Description.
- Specifications.
- Installation.
- Use.

How To Use This Manual

The Benshaw Remote RTD Module manual is divided into 4 sections;

- Introduction.
- Technical Information.
- Installation.
- Operation.

1.2 Product Description

General

The Remote RTD Module is designed to monitor up to 8 RTDs and report their temperatures across a serial communications link.

Features

The RTD Module provides the following features;

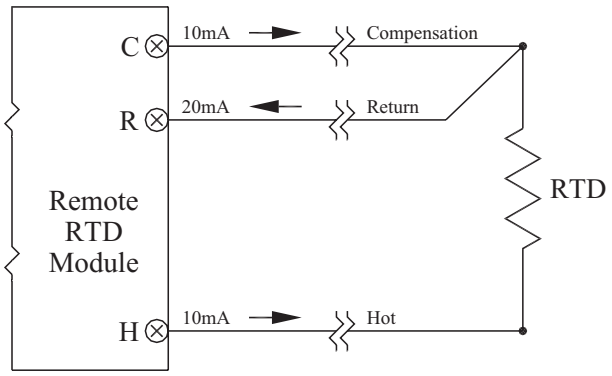
- Monitors up to 8 3-wire RTDs.
- Lead Resistance Compensation.
- RTD open detection.
- RTD shorted detection.
- Modbus communications over RS-485.

1.3 Theory of Operation

General

The Remote RTD Module makes a compensated measurement of a RTD (Resistive Temperature Device). This is accomplished by using three wires to connect the RTD to the module.

The Remote RTD module provides 10mA of current from H (Hot) and C (Compensation) terminals. The two currents add at the RTD and 20mA is returned to the R (Return) terminal. The following diagram illustrates this;



The connection wire from the Remote RTD Module to the RTD will typically have all three conductors the same size and length. This means that the resistance of each conductor will be the same. Call the resistance of each conductor R_{lead}.

From the above, the following equations can be seen;

$$V_{RH} = V_{R\ lead} + V_{RTD} + V_{H\ lead} = 20mA \times R_{lead} + 10mA \times R_{RTD} + 10mA \times R_{lead}$$
$$V_{CR} = V_{C\ lead} + V_{R\ lead} = 10mA \times R_{lead} + 20mA \times R_{lead}$$

Subtracting these two equations and subsituting R_{lead} for the different lead resistance provides the following;

$$V_{RH} - V_{CR} = \left(30mA \times R_{lead} + 10mA \times R_{RTD}\right) - \left(30mA \times R_{lead}\right)$$
$$V_{RH} - V_{CR} = 10mA \times R_{RTD}$$

This calculation gives the voltage across the RTD independant of the connection wire resistance. By performing this calculation, the Remote RTD Module compensates for the conductor resistance and gets the true value for the RTD resistance.

The Remote RTD Module then converts the measured voltage across the RTD to the temperature that the RTD is measuring. This is possible because the RTD conforms to a standard resistance vs temperature curve.

2. TECHNICAL SPECIFICATIONS

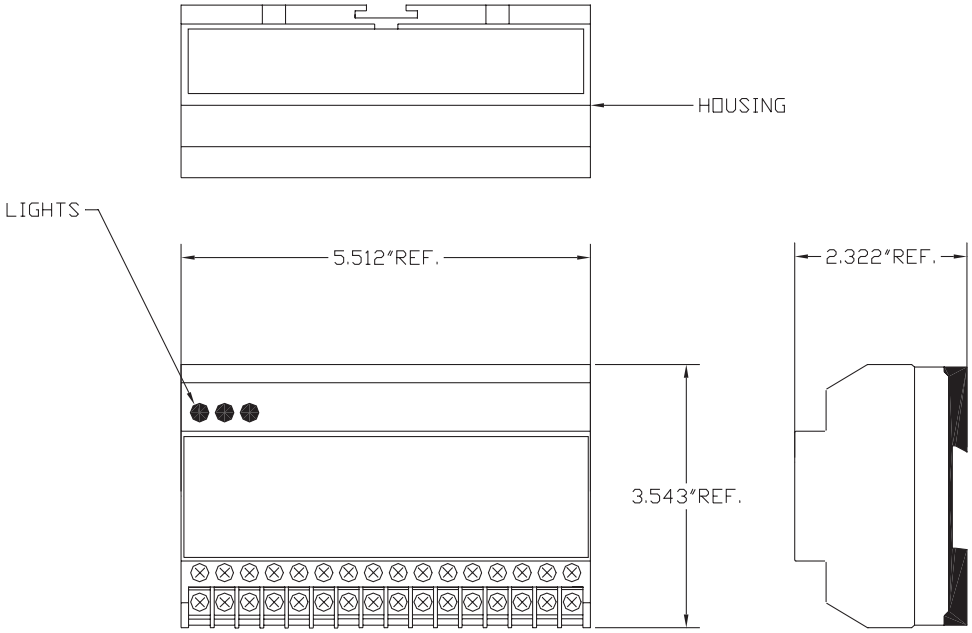
2.1 Specifications

General The following table lists the specifications for the RTD module.

Model Number	SPR-100P
RTD Type	100Ω Platinum, 3 lead
TCR (α)	0.00385 Ω/Ω/°C (DIN 43760)
Maximum Lead Resistance	25Ω per lead
Recommended Lead Resistance	Less than 16Ω per lead
Shorted Lead Detection	< 60Ω
Open Lead Detection	> 260Ω
RTD Sensing Current	10 mA DC
RTD Sensing Voltage	10V DC maximum
Range	0 to 200 °C (32 to 392 °F)
Resolution	1 °C (1.8 °F)
Accuracy	±1.0% full scale (±2 °C or ±3.6 °F)
Sampling Rate	1 RTD per second
Number of RTDs	8
Input Voltage	24 Volts DC ± 20%
Power Consumption	2.5 Watts
Inrush Current	15 Amps for .5 µ-seconds
Communication Type	RS-485
Communication Protocol	Modbus RTU
Modbus Addresses	16 to 23
Baud Rate	19200 bps
Operating Environment	-40 to 60 °C (-40 to 140 °F), up to 95% R.H., non-condensing
Storage Environment	Up to two years at -40 to 70 °C (-40 to 158 °F), up to 95% R.H., non-condensing
Terminal Strips	Accepts one or two stranded copper wires of the same size from 12 to 30 AWG
Dimensions	5 ½" W x 3 ½" H x 2 ¼" D
Dust/Moisture	IP20
Weight	12.5 ounces (356 grams)
Listing	c UL us LISTED

2.2 Physical

Construction The following diagram shows the physical construction of the Remote RTD Module;



3. INSTALLATION OF THE REMOTE RTD MODULE

3.1 Physical Installation

Location

The mounting location for the Remote RTD Module should be chosen to give easy access to the RTD wiring as well as providing a location to mount the power supply. The Remote RTD Module is specifically designed to be mounted close to the equipment it is monitoring. This eliminates long RTD wire lengths which save time and money on installation and wiring.

Site Requirements

The installation location must meet the following specifications;

- Temperature: -40°C to 60°C.
- Humidity: up to 95%, non-condensing.

Mounting

The Benshaw Remote RTD Module is designed to mount on industry standard 35mm wide by 7.5mm deep DIN rail. The Remote RTD Module should be mounted in a location that allows access to the control terminals and visual inspection of the indicator LEDs.

Modbus Address

Set the rotary switch on the top of the Remote RTD Module to the desired Modbus address.

3.2 Power Wire Connections

Power Connections

The 24VDC power source is connected to the following terminals.

- 24VDC – - Negative connection to 24VDC power supply
- 24VDC + - Positive connection to 24VDC power supply
- ⏚ - Chassis ground connection

3.3 RS-485 Wiring

RS-485 Communications

The RS-485 communications wiring should use shielded twisted pair cable. The shield should only be terminated at one end. The connections are as follows;

- A (–) - RS485 negative communications connection.
- B (+) - RS485 positive communications connection.
- Com - RS485 common connection.

RS-485 Cable Specification

The RS-485 communications cable should conform to the following specification;

- Conductors - 2 twisted pair (one pair signal plus one for signal common).
- Gauge - 16 to 24 AWG stranded, tinned copper.
- Impedance - 100 to 120 Ohms.
- Capacitance - 15.5pF/ft. or less.
- Shield - Overall Shield.

RS-485 Topology

The RS-485 network should be wired in a daisy-chain configuration. Avoid using star or stub configurations.

RS-485 Shielding

The RS-485 shield should be terminated at only one point in the network, preferably at the master device. Do not connect the RS-485 shield to the RTD shield terminals.

RS-485 Termination

A 120Ω resistor may optionally be installed between the A(-) and B(+) terminals if the Remote RTD Module is the end device on the RS-485 network. The terminating resistor may be necessary if the RS-485 cable is extremely long. Do not install a terminating resistor if the Remote RTD Module is not the end device on the network. There should never be more than two terminating resistors on the network.

3.4 RTD Wire Connections

RTD Connections

Each Remote RTD Module has connections for up to 8 RTDs. The terminals for the RTD wires are as follows;

- R - RTD return wire.
- C - RTD compensation wire.
- H - RTD hot wire.

Each RTD is connected to the three terminals with the common number. For example, RTD number 5 connects to the terminals numbered 5R, 5C, and 5H.

RTD Cable Specification

Benshaw recommends using 3-wire twisted (triad) shielded cable to connect the RTDs to the RTD module. It is important to keep the three wires of the same length and type for accurate lead resistance compensation.

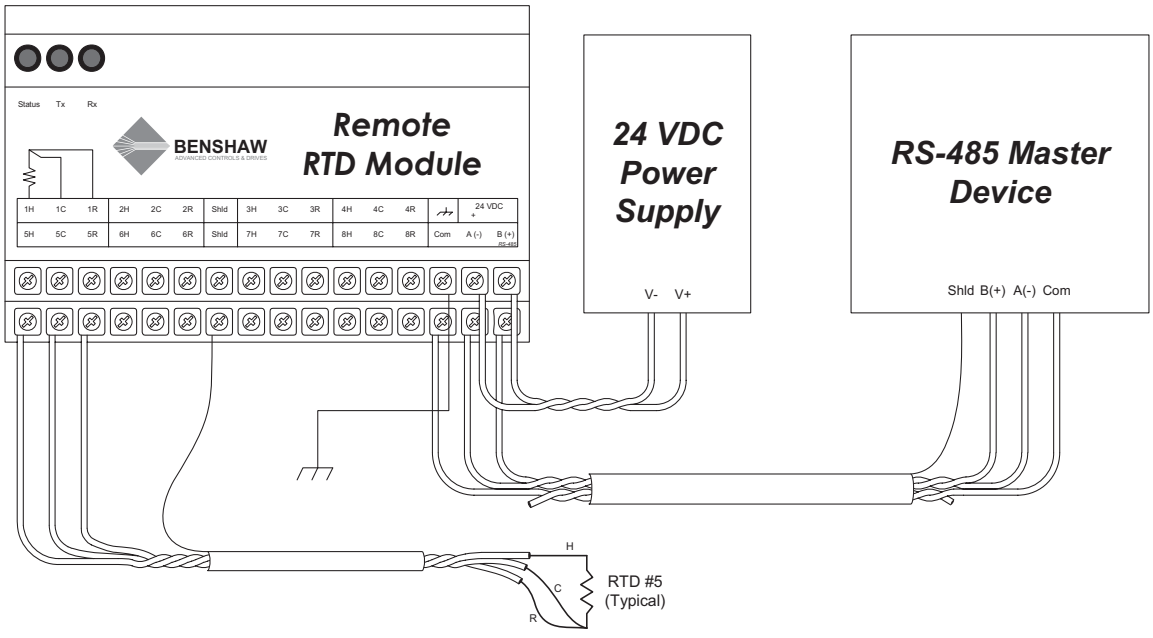
RTD Cable Shielding

The RTD cable shield should be terminated at either of the shield terminals. For a simpler installation, a cable containing multiple triads with an overall shield can be used to connect a group of RTDs to the module with a single cable.

3.5 Wiring Diagram

General

The following is the wiring diagram detailing the connections of the RTD module. Only the wiring for RTD #5 is shown as the typical connection, but all the other RTDs connect similarly.



4. COMMUNICATING WITH THE REMOTE RTD MODULE

4.1 Modbus Communications

General

The Remote RTD Module uses an industry standard RS-485 port, communicating as a Modbus RTU slave. The Remote RTD Module has the following communications features;

- RS-485 port.
- 19200 bits per second communications rate.
- 8 data bits, 1 stop bit, no parity.
- Modbus RTU slave, addresses 16 to 23.

4.2 Modbus Input Registers

General

The Benshaw Remote RTD Module has a number of Modbus input registers. These registers are used to read the temperatures measured by the eight RTDs.

Registers

The following table lists the Modbus input registers;

Register	Description	Values
30001	RTD 1	0 to 200 - Temperature in degrees Celsius
30002	RTD 2	0 to 200 - Temperature in degrees Celsius
30003	RTD 3	0 to 200 - Temperature in degrees Celsius
30004	RTD 4	0 to 200 - Temperature in degrees Celsius
30005	RTD 5	0 to 200 - Temperature in degrees Celsius
30006	RTD 6	0 to 200 - Temperature in degrees Celsius
30007	RTD 7	0 to 200 - Temperature in degrees Celsius
30008	RTD 8	0 to 200 - Temperature in degrees Celsius
30009	Shorted RTD	A bit is set if an RTD has a shorted lead. Otherwise, it is clear. The set bit is as follows; Bit 0: RTD 1 shorted. Bit 1: RTD 2 shorted. Bit 2: RTD 3 shorted. Bit 3: RTD 4 shorted. Bit 4: RTD 5 shorted. Bit 5: RTD 6 shorted. Bit 6: RTD 7 shorted. Bit 7: RTD 8 shorted. Bits 8-15: unused.
30010	Open RTD	A bit is set if an RTD has an open lead. Otherwise, it is clear. The set bit is as follows; Bit 0: RTD 1 open. Bit 1: RTD 2 open. Bit 2: RTD 3 open. Bit 3: RTD 4 open. Bit 4: RTD 5 open. Bit 5: RTD 6 open. Bit 6: RTD 7 open. Bit 7: RTD 8 open. Bits 8-15: unused.

4.3 Modbus Holding Registers

General

The Benshaw Remote RTD Module has a single Modbus holding register. This register is used to set the operating mode of the module. In normal mode, the RTD module scans all eight RTDs at an update rate of 1 RTD per second. In test mode, it continually monitors the chosen RTD. The default mode at power-up is normal mode.

Holding Register

The following table list the Remote RTD Module holding register values;

Register	Description	Values
40001	Operation Mode	0 = Normal mode 1 = Test mode, RTD# 1 2 = Test mode, RTD# 2 3 = Test mode, RTD# 3 4 = Test mode, RTD# 4 5 = Test mode, RTD# 5 6 = Test mode, RTD# 6 7 = Test mode, RTD# 7 8 = Test mode, RTD# 8

4.4 Modbus Commands

General

The Remote RTD Module supports the following Modbus commands;

- Read input registers (function code 04h).
- Read holding registers (function code 03h).
- Preset single register (function code 06h).

Format

All Modbus messages have the following format;

Address	Function code	Data	CRC-16
1 byte	1 byte	n-bytes	2 bytes

Read Input Registers

Function code 04h is used to read one or more consecutive input registers. The first register read is 30001 plus the offset. For example, to read the temperature of RTD #4 (input register 30004), send the command;

Address	Function Code	Register Offset	Number of Registers	CRC-16
10h	04h	00 03h	00 01h	C2 8Bh

If the temperature being read by RTD#1 was 123^{o}C, the Remote RTD Module will respond with the Modbus holding register in the following format;

Address	Function Code	Byte Count	Register Data	CRC-16
10h	04h	02h	00 7Bh	05 10h

Read Holding Registers

Function code 03h is used to read the contents of the single Remote RTD Module holding register. Since there is only one register available to read, using the register offset of 00 00h will read the contents of register 40001. For example, to check the mode of the Remote RTD Module, send the command;

Address	Function Code	Register Offset	Number of Registers	CRC-16
10h	03h	00 00h	00 01h	87 4Bh

If the Remote RTD Module is in the test mode for RTD#4, it will respond with the following;

Address	Function Code	Byte Count	Register Data	CRC-16
10h	03h	02h	00 04h	45 84h

Preset Single Register

Function Code 06h allows the Modbus master to write to the holding register in the Remote RTD Module. This command allows the mode of the Remote RTD Module to be set. For example, to set the Remote RTD Module to test mode so that it only monitors the temperature of RTD#7, send the command;

Address	Function Code	Register Offset	Register Data	CRC-16
10h	06h	00 00h	00 07h	CB 49h

The Remote RTD Module will respond with this echo of the command;

Address	Function Code	Starting Register	Number of Registers	CRC-16
10h	06h	00 00h	00 07h	CB 49h

4.5 Modbus Exception Responses

General

There are four different communications errors the Remote RTD Module will recognize and respond to. They are;

- CRC Error
- Illegal Function (exception code 01)
- Illegal Data address (exception code 02)
- Illegal Data Value (exception code 03)

CRC Error

If the Remote RTD Module receives a message that contains a CRC error, the received message is ignored. No response is sent.

Illegal Function

If the Remote RTD Module receives a message that is anything other than read holding registers, read input registers, or preset single register (functions 03, 04, 06), it will respond with and illegal function exception response. This response will be in the form;

- Byte 1: RTD Module Address.
- Byte 2: The requested function code with the MSB set to 1 to indicate an exception.
- Byte 3: Exception code 01h indicating an illegal function code.
- Byte 4: LSB of CRC code.
- Byte 5: MSB of CRC code.

For example, if a read coil status function (function code 01) is sent to the Remote RTD Module, the following would be the response;

Address	Function Code	Exception Code	CRC code
10h	81h	01h	D1 95h

Illegal Data Address

If the Remote RTD Module receives a supported command that refers to unsupported registers, it will respond with an illegal data address exception response. This response will be in the form;

- Byte 1: RTD module address.
- Byte 2: Function code with the most significant bit set to 1 to indicate an exception.
- Byte 3: Exception code 02h indicating an illegal data address exception.
- Byte 4: LSB of CRC code.
- Byte 5: MSB of CRC code.

For example, if an attempt is made to read a holding register that does not have a valid address, the Remote RTD Module will respond with the following;

Address	Function Code	Exception Code	CRC code
10h	83h	02h	90 F4h

Illegal Data Value

If the Remote RTD Module receives a preset single register command that contains an illegal value, it will respond with and illegal data value exception response. The response will be in the form;

- Byte 1: RTD module address.
- Byte 2: Function code with most significant bit set to 1 indicating an exception.
- Byte 3: Exception code 03h indicating an illegal value exception.
- Byte 4: LSB of CRC code.
- Byte 5: MSB of CRC code.

For example, the Remote RTD Module will respond with the following if it receives an invalid preset single register command;

Address	Function Code	Exception Code	CRC code
10h	86h	03h	52 64h

4.6 Indicating LEDs

Description

There are three indicating LEDs. They perform the following functions;

- TX - On when the Remote RTD Module is transmitting data.
- RX - On when the Remote RTD Module is receiving data.
- Status - Blinks once per second in normal mode. Each flash corresponds to the temperature measurement of one of the RTD inputs.

Revision History;

Revision	Date	ECO#
00	16/11/99	
01	23/02/00	
02	24/02/00	
03	31/03/00	
04	28/04/00	088

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