User's Manual for the
HE150RTU100

Modbus Slave for the Hitachi™ H-252 Series

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PREFACE

This manual explains how to use the Horner APG Modbus (RTU) slave for the Hitachi H-252 Series.

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To obtain warranty service, return the product to your distributor with a description of the problem, proof of purchase, post paid, insured and in a suitable package.

ABOUT PROGRAMMING EXAMPLES

Any example programs and program segments in this manual or provided on accompanying diskettes are included solely for illustrative purposes. Due to the many variables and requirements associated with any particular installation, Horner APG cannot assume responsibility or liability for actual use based on the examples and diagrams. It is the sole responsibility of the system designer utilising the Modbus Slave Module to appropriately design the end system, to appropriately integrate the Modbus Slave Module and to make safety provisions for the end equipment as is usual and customary in industrial applications as defined in any codes or standards which apply.

Note: The programming examples shown in this manual are illustrative only. Proper machine operation is the sole responsibility of the system integrator.

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CHAPTER 1: INTRODUCITON

1.1 General

Congratulations on your purchase of the Horner Electric's Modbus Slave for the Hitachi H-252 series. The HE150RTU100 is a Modbus slave module that allows Modbus communications on either RS-232 or RS-485.

The HE150RTU100 allows a Modbus master to access H-252 series PLC reference data as though it were Modbus I/O. This data may be accessed using standard Modbus commands such as Read / Force Coils and Read / Preset Registers. The data accessible on the H-252 series PLC is the CPU Link data area. Data in the CPU Link area may be accessed from the PLC by either word or bit accesses. Likewise, when accessing that data though Modbus, an analogue command will reference the associated 'WL' word data and a discrete command will reference the associated 'L' bit data.

Read and Write packets of up to 2000 discrete or 125 analogue values are supported. Message reception LED's and Modbus Diagnostic and Exception commands are also supported to provide easy set-up and troubleshooting. Also provided to the PLC is a time-out indicator (DCS active) which indicates a break in communications with the Modbus master.

Configuration of the port operation and associated frame protocol parameters are easily accomplished by setting 6 Link words (WL0000 through WL0005) with an arithmetic block in the PLC. Baud rates of up to 115.2K are supported in either ASCII or RTU modes. Note that there are limitations in the number of stop bits and parity selections.

1.2 Specifications

Table 1.1 – HE150RTU100 Specifications

Mounting Requirement	One I/O slot in BSH rack
Power Requirements	170mA @ 5VDC
Operating Environment	0 to 60°C (32 to 140°F) 0 to 95% humidity (non-condensing)
User Memory	Dual-port 1,024 words (2,048 bytes)
Communications	One RS-232 port One RS-485 port
Protocol	MODBUS
Speed	300 to 115,200 Baud
Modes	RTU or ASCII

1.3 System Requirements

The HE150RTU100 Module requires:

a. One I/O slot in a BSH rack (follow directions in the PLC manual for module insertion and removal);
b. One H-252, H-252B or H-252C CPU;
c. Programming software for the PLC (Actsip-H, ActWin or other).

1.4 Physical Layout

Two important precautions should be observed while handling the module:

1. **Never** insert or remove the module into or out of the PLC unit while power is applied to the back-plane. If this practice is repeated, the module WILL eventually BE DAMAGED.
2. **Always** observe reasonable static discharge precautions while handling the module. Touch a grounded metal surface to discharge any static build-up before touching the module

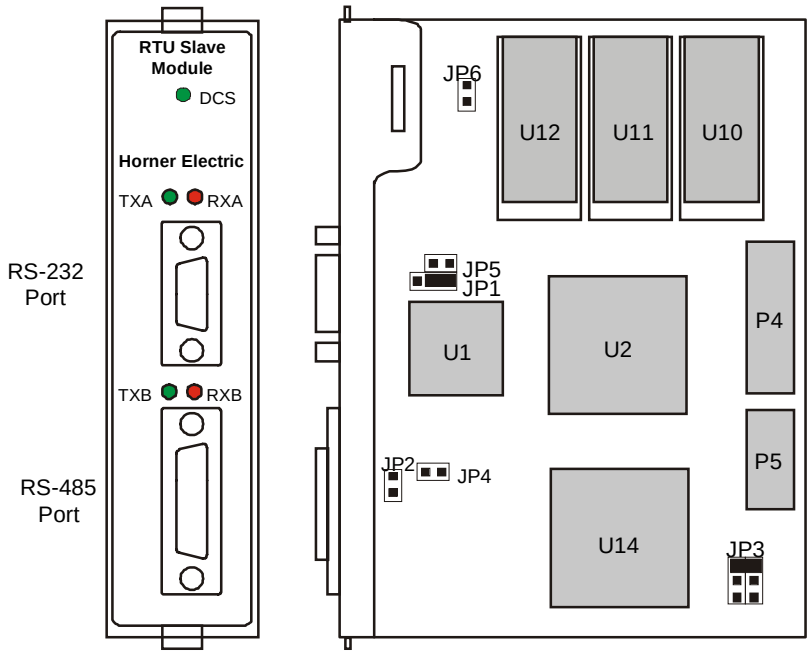

Figure 1.1 – HE150RTU100

1.5 Jumper Settings

The HE150RTU100 is equipped with several hardware jumpers. JP1, JP3, JP5 and JP6 are factory-configured jumpers. The user should not modify these jumpers! **Changing any of the pre-configured jumpers may cause the module to malfunction!**

Table 1.2

Jumper	Setting
JP1	Short pins 2 and 3 to enable watchdog (recommended) Short pins 1 and 2 to disable watchdog
JP2	Short to apply +5VDC to the RS-485 port
JP3	Hitachi module ID code. Short pins 3 and 4 for CPU Link module
JP4	NV-RAM density. Short pins 1 and 2 for 64k or 128k; open for 32k.
JP5	Short pins 1 and 2 to cause MPU port 1, bit 1 to read back as a 0.
JP6	Short pins 1 and 2 to allow the PLC to reset the module by asserting a back-plane reset signal. If open, the module is reset by power cycle or watchdog.

JP2 enables and disables the 5 VDC power supply on pin 5 of the 15 pin auxiliary port. If this jumper is installed, 5 VDC is supplied to pin 5.

STOP! Do not connect pin 5 of the auxiliary port to pin 5 on the PLC programming port with JP2 installed. If these pins are connected with this jumper installed, **DAMAGE WILL BE CAUSED TO BOTH THE PLC POWER SUPPLY AND THE ASCII BASIC MODULE!**

JP4 sets the RAM density. Short pins 1 and 2 for 64k or 128k; open for 32k. This jumper needs to be changed if additional memory is added.

CHAPTER 2: INSTALLATION AND CONFIGURATION

2.1 Basic Module Installation

1. Remove power to the CPU/Base.
2. Install the HE150RTU100 module in a free slot (see limitations below).
3. Configure the PLC CPU Link Parameter and I/O slot type as Link.
4. Insert a block in the PLC program to initialise the 6 configuration Link words (WL0 to WL5).
5. Connect the Modbus master to the appropriate port.
6. Start Modbus master application.

2.2 PLC Configuration for Module

The HE150RTU100 is a CPU Link type module (see Hitachi manuals for more information). Up to two-link type modules can be placed in a higher function base with a CPU module. Do not place the HE150RTU100 in an expansion base. Each installed link type module requires configuration information to be entered into the PLC though a programming device. This information contains the position and type of module in the base, and the link parameter, which defines the output area, used by the HE150RTU100.

Two data areas are reserved in the PLC for up to two CPU Link modules. Each area is dedicated to its associated CPU Link module and is 1,024 words wide. Each data area is also dividable (though PLC set-up) into an input and output section. The area designated as output is continuously transferred from the PLC to the HE150RTU100. The area designated as input is continuously transferred from the HE150RTU100 to the PLC. Therefore, the PLC program blocks must reference data elements in the area designated as output for sending data to the Master and reference the data elements in the area designated as inputs for receiving data from the Master. Likewise, the Modbus master must use offsets into the output area for reading data and offsets into the output area for writing data.

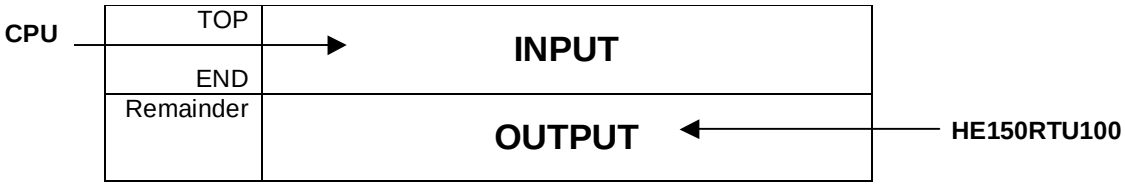

Figure 2.1 – **Hitachi Link Areas**

The data output area is defined with the programming device under PLC set-up / Link Parameters (1 & 2). Link Parameter 1 is for the leftmost CPU Link module in the base. Link Parameter 2 is for the rightmost additional CPU Link module in the base. Each Link Parameter has two separate values that are **Top** and **End**. Setting the **Top** and **End** Link Parameters sets the space in the Link data area that is designated output. The remainder of the 1,024 words is designated as input. See below for Link Parameters **Top** and **End** limitations.

NOTE: With the HE150RTU100 properly inserted and configured, the CPU when going to RUN mode may give a Self-Diagnostic-Error (WRF00) indication of [59] Special-Function-Module-Error. This is not a fatal error and can be ignored. If any other error is specified for the base location of the HE150RTU100, check in the CPU user's manual for more information.

2.3 Configuration Link Words (WL0000 to WL0005)

When configuring the PLC, the 'Link Parameters' entry for the associated HE150RTU100 must start at WL0000 (**Top**) and end at or above WL0005 (**End**). This 6-word area must be updated by the PLC with the port configuration parameters for the HE150RTU100. If additional "write" area is for the CPU, link area is continued immediately above the configuration link words by extending the **End** parameter. Furthermore, use care not to overwrite the configuration link words during operation.

The HE150RTU100 continuously monitors WL0000 to WL0005 for the initial configuration and any changes thereafter. The HE150RTU100 reconfigures the Modbus port any time the Valid-configuration-present-identifier word (WL0005) changes from a value not equal to A5A5H to a value equal to A5A5H.

Note: At start-up and when the identifier word is not equal to A5A5H the DCS light remains lit solid to indicate that the HE150RTU100 is not configured. Additionally, if the port was previously configured and the identifier word is changed from A5A5H, Modbus requests will return a Device Error.

The following specifies the format of the Configuration Link words:

Table 2.1 – Configuration Link Words

Link Word	Description	Options
WL0000	Slave Station ID	1 to 247
WL0001	Port Parameter	See Table 2.2
WL0002	Radio Modem Turn-Around-Time (ms)	0 to disable; 1 to 1000
WL0003	DCS Time-out (seconds)	0 to disable; 1 to 320
WL0004	DCS Status Bit (set if loss of communication with Master)	Any Link bit above END (i.e., L1000)
WL0005	Valid configuration present identifier	A5A5H for valid configuration Anything else for invalid configuration

Table 2.2 – Configuration Link Word WL0001

Link Bit	Description	Options		
0010	Stop Bits	0=1 Stop Bit, 1=2 Stop Bits		
0011	Use Parity Bit	0=No Parity Bit, 1=Parity Bit		
0012	Type of Parity	0=Odd Parity, 1=Even Parity		
0013	Port	0=RS-232, 1=RS-485		
0014	Modbus Transfer mode	0=ASCII Mode, 1=RTU Mode		
0015	Not Used	0		
0016	Not Used	0		
0017	Not Used	0		
0018	Port Handshaking	0=None, 1=Software, 2=Hardware,		
0019		3=Multi-drop, 4=Radio Modem		
001A	Not Used	0		
001B	Not Used	0		
001C	Port Baud Rate	0 = 300	4 = 4800	8 = 28,800
001D		1 = 600	5 = 9600	9 = 38,400
001E		2 = 1200	6 = 14,400	A = 57,600
001F		3 = 2400	7 = 19,200	B = 115,200

2.4 Configuration Example

The following configuration sets up the HE150RTU100 at slave station ID 12. The protocol properties are RS-232, 9600 baud, 2 stop bits, no parity and no handshaking. The modem TAT is disabled. DCS is enabled with a delay of 60s and L1000 is used as the DCS Status Bit. The CPU write-space is set to WL0000 to WL00FF. The HE150RTU100 is placed in slot 3 and can write from WL0100 to WL03FF.

Table 2.3 – Configuration Example

Setting		Link Word	Value
Slave Station ID = 12		WL0000	12 or 000AH
Port Parameter	2 Stop Bits	WL0001	20497 or 5011H
	No Parity		
	RS-232 Port		
	RTU Mode		
	No Handshaking		
	9600 Baud		
Radio Modem Turn-Around-Time = Disabled		WL0002	0
DCS Time-out = 60 seconds		WL0003	60 or 3CH
DCS Status Bit use L1000		WL0004	4096 or 1000H
Valid configuration present identifier		WL0005	42405 or A5A5H
CPU Settings – WL1		TOP	0000
		END	00FF

Setting WL0000 to WL0005 is generally accomplished using an arithmetic block as shown in Figure 2.2.

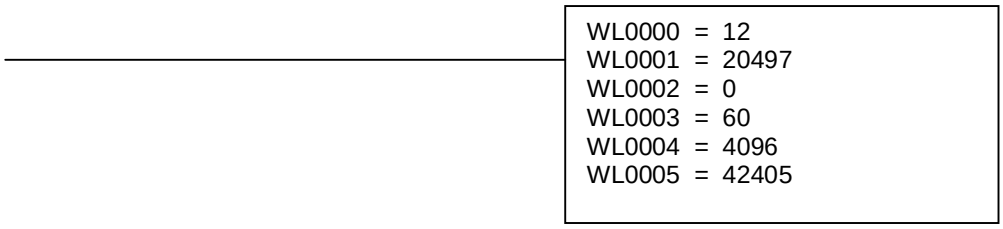

Figure 2.2 – Arithmetic Block Example

Note: WL0005 must be set not equal to A5A5H and then equal to A5A5H any time the configuration is changes for the new configuration to take effect.

CHAPTER 3: OPERATION

3.1 Modbus Protocol

Modbus is a master/slave protocol that supports on a common bus one master and up to 247 slaves. Note that when RS-485 is used for Modbus, it is typically limited to 32 units. As a Modbus slave, the HE150RTU100, must be assigned a unique address. Address 0 is reserved for broadcasting a message to all nodes. The HE150RTU100 processes broadcast messages but no response packet is returned.

The Modbus master issues a command to start the transaction. The command contains a unit address specifying the slave to respond. The slave processes the command and returns a single response. Message integrity is assured through use of checksums included in the messages. The slave ignores all messages that have invalid checksums and assumes the master has received any responses sent. It is the Master node's responsibility to provide time-out and retry provisions.

Before the HE150RTU100 responds appropriately to Modbus commands, it must be configured to the frame protocol used on the bus. This includes items such the media (RS-485, RS-232 or Modem), frame protocol such as (ASCII or RTU), baud rate, parity and stop bits, and finally optional handshaking.

3.2 Port Selection

Either RS-232 or RS-485 may be used for communications through the software configuration. The LED's on the front panel monitor activity on these ports. See Figure 1.1.

Table 3.1 –Port 1, RS-232

Pin #	Signal Name	Direction
1	(DCD) Always High	Output
2	(TXD) Transmit Data	Output
3	(RXD) Receive Data	Input
4	No Connection	N/A
5	(GND) Signal Ground	N/A
6	(DSR) Always High	Output
7	(CTS) Clear To Send	Input
8	(RTS) Request To Send	Output
9	(RI) Always High	Output

Table 3.2 –Port 2, RS-485

Pin #	Signal Name	Direction
1	Not Used	
2	Not Used	
3	Not Used	
4	Not Used	
5	(PWR) 5 VDC Power	N/A
6	(RTS-) Request To Send	Output
7	(GND) Signal and Power Ground	N/A
8	(CTS+) Clear To Send	Input
9	(TERM) Termination	Input
10	(RXD-) Receive Data	Input
11	(RXD+) Receive Data	Input
12	(TXD-) Transmit Data	Output
13	(TXD+) Transmit Data	Output
14	(RTS+) Request To Send	Output
15	(CTS-)Clear To Send	Input

3.3 Frame Protocol

RTU mode sends each byte of information in binary form thus requiring 8-bits of transmitted data. ASCII mode divides a byte of information into two nibbles (of 4-bits each) and then transmits each nibble as a 7-bit hexadecimal character. Therefore, ASCII mode uses twice as many transmitted characters; however, debugging with printable ASCII characters can be much easier. Therefore, setting the mode to either ASCII or RTU indirectly sets whether the data size to 7 or 8 bits.

In addition to the mode, the baud rate, parity and the number of stop bits must be set to that used the bus. All these parameters are changeable with software configuration.

Note: The following frame protocol combinations are NOT valid for the HE150RTU100 and should NOT be used as the bus frame protocol.

"**ASCII mode, 1 Stop Bits and No Parity**. This combination requires 2 stop bits before the HE150RTU100 accepts any characters and thus is invalid.

RTU mode, 2 Stop Bits and either Even or Odd Parity. This combination generates only 1 stop bit, which may or may not, effect the application's reception of characters and thus is invalid

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3.4 Handshaking

The HE150RTU100 provides five (5) different handshaking modes to provide for multi-drop configurations or to limit data flow back to masters with hardware/software limitations.

Table 3.3 - Handshaking

Handshaking	Description
No	No hardware handshaking is provided. If the slave returns data at a rate and value the master is unable to handle, data is lost. If the RS-485 is used, the transmit driver is enabled continuously.
Software	The HE150RTU100 module suspends sending data on the reception of a XOFF character. Transfer continues on the reception of a XON character. **Note**: This mode should not be used with RTU mode.
Hardware	The HE150RTU100 asserts CTS continuously to sender. RTS is monitored during HE150RTU100 transmissions. If the master drops the RTS line low, the HE150RTU100 suspends the transfer. Transfer continues when the master raises the RTS line.
Multi-drop	Multi-drop handshaking is required for RS-485 multiple node (either single or half-duplex) or single node half-duplex configurations. The transmit driver is only enabled when the HE150RTU100 is transmitting. For RS-232, this mode controls the CTS signal for compatibility with RS232-to-RS485 converters that are operated in a half-duplex mode. **Note**: When multi-drop handshaking is enabled, no other handshaking is available.
Radio Modem	This mode is similar to hardware handshaking with the exception that CTS is only asserted when the HE150RTU100 has data to send. Thereafter, the HE150RTU100 sends or suspends data transfer based on the RTS line. The radio modem mode also provides an optional modem turn-around-timer (TAT). If the modem does not respond to the CTS line within a specified period, the transmit buffer is flushed; CTS is dropped and the frame is lost. See section 2.3 to set the modem TAT.

3.5 DCS Active Detection

The HE150RTU100 provides the capability to optionally monitor the activity from the Modbus master. Should that activity drop-off, a bit is set in both the *DCS Status Bit* (as specified in WL0004) and the Modbus exception status byte; furthermore, the DCS LED begins to flash at a 1 second intervals. This provides a method for the CPU, maintenance operator to determine if the master is functioning properly. The *DCS Status Bit* and the DCS LED is reset immediately when communications with the master is restored. The bit in the Exception status byte remains set until after the Modbus Read Exception command is received.

To enable this feature, set the *DCS Time-out* (WL0003) with the amount of time the HE150RTU100 waits after the last communication with the master before setting the *DCS Status Bit* and flashing the DCS LED Time-out value must be between 1 to 320 seconds. Setting *DCS Time-out* to 0 disables this feature.

Note: When setting *DCS Time-out*, the *DCS Status Bit* (WL0004) must also be set. If specified L register in WL0004 is invalid (i.e., above 3FFF or in the CPU write area between TOP and END, the *DCS Time-out* function is disabled.

3.6 Front Panel Diagnostic LED's

Referring to Figure 1.1, RXA and TXA flicker when there is activity on the RS-232 port. Similarly, RXB and TXB flicker when there is activity on the RS-485 port.

On power-up or if the valid configuration parameter ID is not set, the DCS light is solidly lit. Once the configuration is properly set the DCS light goes out. Thereafter, if the DCS timer has not timed out or is not enabled, the DCS LED momentarily lights when a valid Modbus message has been received and is being processed HE150RTU100. If RX light is flashing and the DCS is not, this generally indicates that the frame protocol is incorrect. If DCS is enabled and timed out, this LED flashes every 1-second.

3.7 Supported Modbus Commands

The following Modbus commands are supported:

Table 3.4 – Supported Modbus Commands

Code	Meaning	I/O	Unit	Min	Max	Duplicates
01	Read Coil Status	I	Bit	1	2000	
02	Read Input Status	I	Bit	1	2000	[01]*
03	Read Holding Registers	I	Word	1	125	
04	Read Input Registers	I	Word	1	125	[03]*
05	Force single coil	O	Bit	1	1	
06	Preset Single Register	O	Word	1	1	
07	Read Exception Status	I	Bit	8	8	
08	Loopback Diagnostic Test	....				
15	Force Multiple Coils	O	Bit	1	2000	
16	Preset Multiple Registers	O	Word	1	125	

* Indicates that this command duplicates that function code listed. The reference accessed is instead determined by the specified reference (Address).

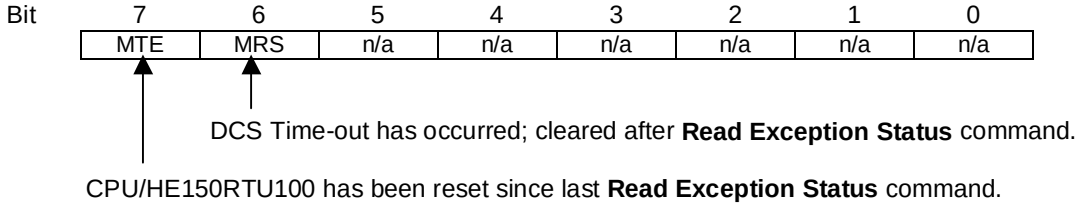
3.7.1 Modbus command descriptions

It is not in the scope of this document to describe each command in detail. For more specific information on the standard Function Codes, Sub-function Codes and exception responses, refer to the "Gould Modbus Protocol Reference Guide" (PI-MBUS-300 Rev. B) published by Gould Inc.

HE150RTU100 specific information is described below for the **Read Exception Status** and the **Loopback Diagnostic Test**.

3.7.2 Read Exception Status command (HE150RTU100 specifics)

The Modbus **Read Exception Status** command returns a byte value that indicates the status of the HE150RTU100. The following defines each bit in the status byte.



3.7.3 Loopback Diagnostics Test command (HE150RTU100 specifics)

The HE150RTU100 supports the following standard Diagnostic Codes for the **Loopback Diagnostics Test** command:

Table 3.5 – Supported Loopback Diagnostic Test Commands

Code	Meaning
00	Return 2-byte Data Field (loopback test)
01*	Reset HE150RTU100
02*	Return 16-bit HE150RTU100 diagnostic register (always zero)
04	Force Slave into listen only mode
10	Clear counters and diagnostics register
11	Return 16-bit bus message count
12	Return 16-bit bus invalid error check count
13	Return 16-bit Slave message count
14	Return 16-bit Slave no response count
*HE150RTU100 specific Diagnostic Codes [01 and 02]:	

3.8 Modbus Responses

Modbus commands and responses consist of "message frames" that contain the following information:

a. Slave Address
b. Function Code
c. Data
d. Error Check Code

If the address in a Modbus command matches a slave address and the received data is validated by the slave with the Error Check Code, then that slave executes the indicated function. The slave then issues a response based on that function.. Alternately, if an address of 0 (broadcast) in the Modbus command, all Modbus slaves execute the command; however, in this case no slave issues a response. Note that only

Function Codes of 5, 6,15,16, 72 and some sub-functions of Function 8 may be “broadcast.” A normal response contains the same slave address and function code as the request; however, the individual data field(s) may vary according to the function.

If the Modbus slave detects an error either internally or in the command parameters, the command is not executed and an Exception Response is returned. An exception response is indicated by setting the high bit in the returned function code and returned data byte describing the exception.

The HE150RTU100 supports the standard Exception codes listed below:

Table 3.6 – Exception Codes

Code	Name	Description
01	Illegal function	Invalid command function was sent
02	Illegal data address	Invalid reference, or size exceeded table bounds
03	Illegal data value	Not valid data for a particular reference
04	Failure in device	Valid configuration identifier <> A5A5H

CHAPTER 4: WIRING

4.1 RS-232 Connections

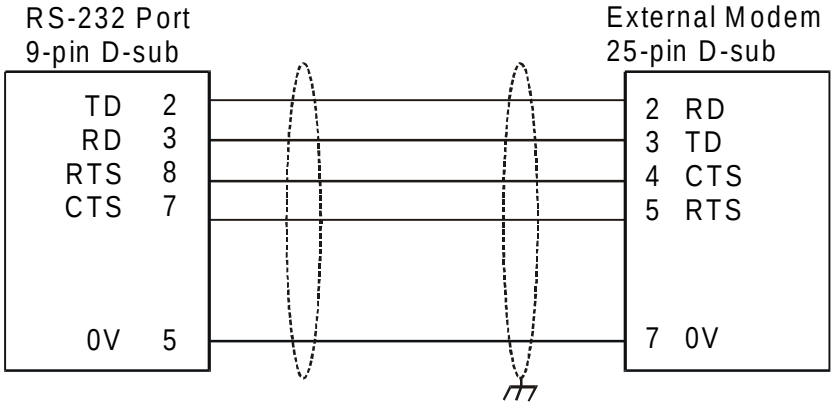


Figure 4.1 – RS-232 to Telephone Modem

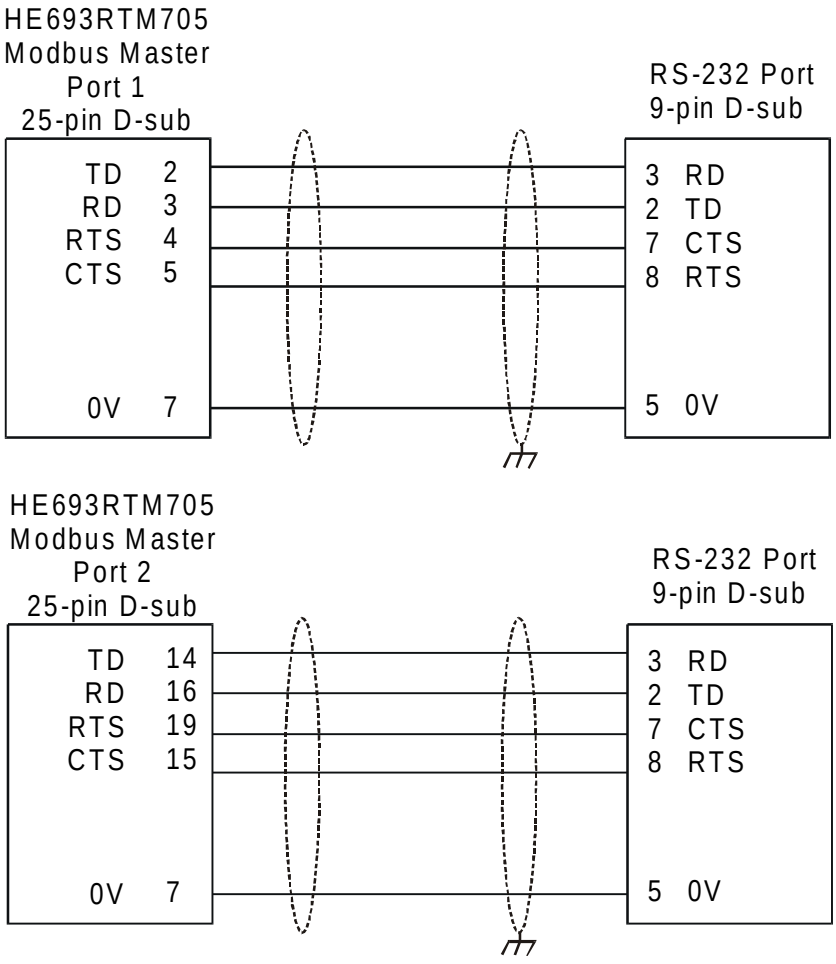


Figure 4.2 – HE150ETN150 to HE693RTM705 Modbus Master (Port 1)

4.2 RS-485 Connections

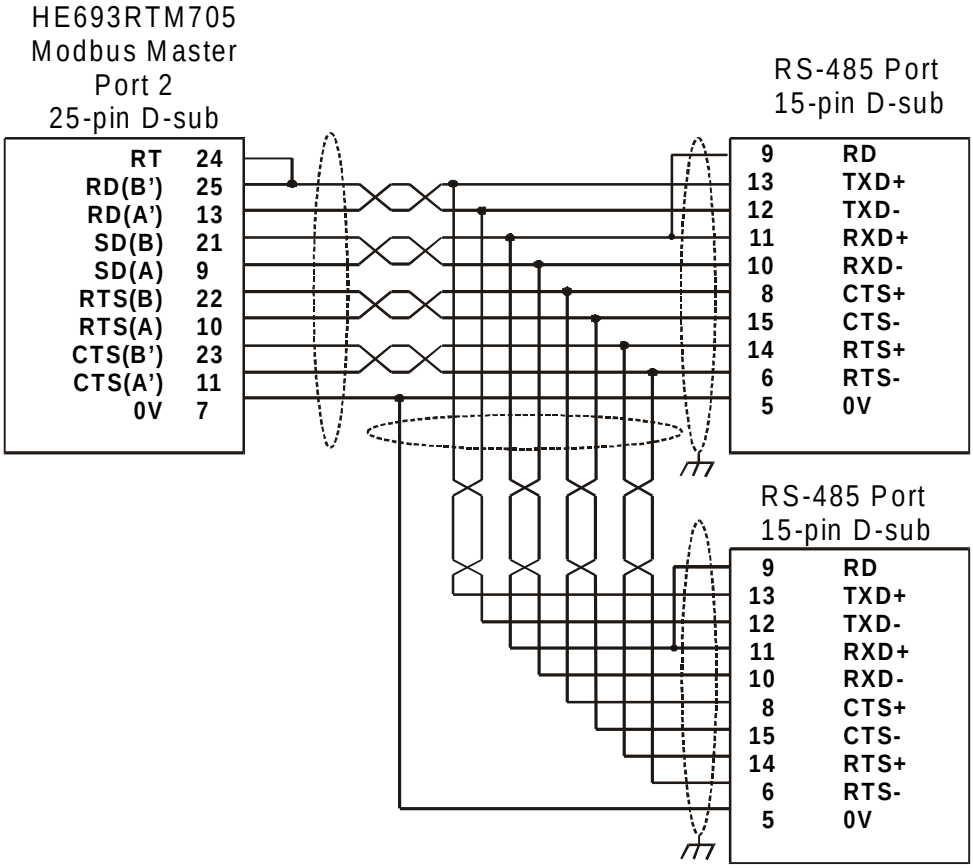


Figure 4.2 – HE150ETN150 to HE693RTM705 Modbus Master (Port 1)