SIEMENS

APPLICATION DATA

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Procidia Control Solutions
RS485 Modbus Communication

Introduction

This paper discusses the use of the Modbus™ RS485 network interface included as a standard feature in all series 353[1] loop controllers. Various connection arrangements will be discussed and illustrated. The data that can be obtained from a loop controller using the Modbus protocol are listed in each controller user's manual (e.g. for the Model 353 Process Automation Controller, see UM353-1 or UM353-1B).

The Modbus protocol was developed by Gould Inc. for Modicon™ PLCs. Many companies have adopted this protocol and it has become an industry accepted standard. Detailed technical information can be found at the Modbus Internet site.

Background

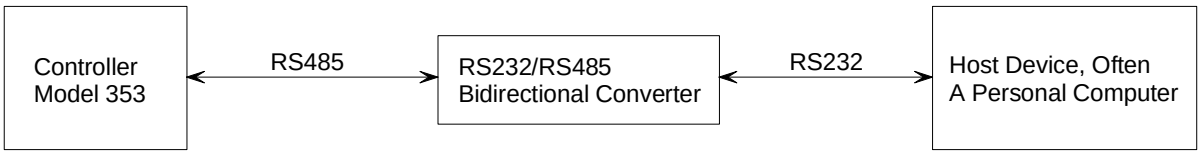
A host device, often a personal computer running HMI operator display software, communicates with a controller in a command/response format. A controller will respond to a command that contains its unique address that is issued from a single personal computer. A hardware block diagram is shown below.

Two terminals are included on each controller for connecting the 2-wire RS485 multi-drop network. However, most personal computers communicate through an RS232 communication port. This paper identifies several devices for converting an RS232 communication to RS485, and it shows the connections to the products used in these applications. Typical timing information is also provided so that the response time of an application can be evaluated. This is particularly important when multiple controller/loops are communicating with a single personal computer.

There are applications where multiple personal computers must communicate over a single network. The use of the Modicon BM85 Bridge/Multiplexer for this application is described later in this paper.

Controller Configuration

Certain parameters in the Station function block of the controller must be configured for proper operation of the RS485 communications. Each station ADDRESS on the RS485 network must be unique. The RP BAUD (rear port baud rate) must be set to match the baud rate of the



Modbus Communication Block Diagram

[1] Includes the Model 352Plus™ Single Loop Digital Controller

personal computer. The RP DELAY (rear port delay) should be set only if the 353 responds too quickly, which may occur when connected to a modem. The CT BIAS (cycle time bias) can be used to increase the cycle time of the controller. This may be necessary when frequent communication causes cycle time overrun errors. In this case, small increases should be made to the CT BIAS to eliminate or minimize the occurrence of these errors.

Modbus Funtion codes

The following Modbus functions are supported by the 353 controller.

- 01 Read Coil Statue *(a maximum of 48 can be requested)*
- 02 Read Input Status *(a maximum of 48 can be requested)*
- 03 Read Holding Registers *(a maximum of 60 can be requested)*
- 04 Read Input Registers *(a maximum of 60 can be requested)*
- 05 Force Single Coil
- 06 Preset Single Register
- 16 Preset Multiple Registers *(write floating point one variable at a time*)
- 17 Report Slave ID

Basic RS232/RS485 conversion

A bidirectional signal converter is used to perform the signal conversion between RS232 and RS485. Several considerations will affect the successful use of a converter.

RS232 uses separate lines for transmitted data (Tx) and received data (Rx). In addition, the personal computer may use some or all of the RS232 hardware handshaking lines. Since a controller communicates over a single wire pair, transmit and receive transceivers on the RS485 side are common in the converter and hardware handshaking is not used between the converter and the controller. When the converter receives data from the personal computer that is destined for a controller, the converter turns on its RS485 transmit transceiver and turns off its RS485 receive transceiver. It then reverses this action to receive the response from the controller and forward the response to the personal computer.

In a typical application, a personal computer will send a command and then wait for a pre-configured time-out period for a response to be returned. In the RS232/RS485 applications discussed in this paper, the converter uses the data command from the personal computer to control its RS485 transceivers. Some converters can use the RS232 handshaking lines from the personal computer but some software applications may control these lines differently, which could result in improper operation.

Controllers are usually located some distance from the personal computer. Since the RS232 cable is limited to less than 50 feet, the converter should be located near the personal computer with the converter connected to the same power ground as the personal computer. The controller will usually be connected to a different power ground so use of an isolated converter is recommended to isolate the power and the communication lines.

Timing Considerations

When a command is sent from a personal computer, the controller receives the request and sends back a response. Although the time for this exchange is usually very short, the personal computer must send out multiple requests in each scan cycle to obtain all the data needed for display or historical archiving. If the personal computer device is a HMI (Human Machine Interface) used for plant operation, certain data is requested only when displayed on the screen. Other data, such as alarm status and data, which will be logged in a trend file will usually be requested on each scan cycle.

Several benchmarks and examples follow. These can be used to approximate the overall scan cycle of the personal computer. The baud rate selected was 19.2K which is suitable for most applications. Increasing the baud rate to 38.4K will not improve the performance significantly due to the turn-around time in the personal computer and the controller.

Coil Requests:
In most HMI applications, coil requests will be made to every loop on every scan cycle since the loop status and the alarm status information are contained in coil data. Therefore, this becomes a fixed time for each scan cycle. The response time to obtain loop coil data is approximately 150 msec.[2]

> Example: Assume a Modbus network with 5 controllers and 4 loops per controller. The worse case scan time to retrieve all coil data using 20 separate requests is approximately 3 seconds.

Integer Requests:
Process, Setpoint, and Valve information is available in scaled form as integer data in a Modbus register. Up to 60 registers can be requested using a single command. Most integer data is located in the same area so that multiple loops can be requested at the same time.[3] A typical response time to acquire a single integer is 70 msec. To acquire 10 integer values in a single request requires approximately 150 msec.

> Example: Assume a 5 loop group from 5 different controllers is displayed. This requires 5 individual requests. Using the 150 msec response as worse case per controller yields a total of 0.75 seconds to retrieve the P, S, & V from all 5 controllers.

REAL (Floating Point) Requests:
Floating Point data is available in two consecutive registers. Most of the range scaling and controller tuning, is contained in this format and is usually requested only when viewed on a screen. A typical response time to acquire a single REAL is approximately 100 msec. The time to acquire 10 REAL values in a single request is approximately 180 msec.

> Example: Assume a loop detail screen is displayed which uses 4 integer values and 20 REAL values. Since some REAL values are accessed at different locations in the Modbus mapping, 4 separate requests will be needed. Approximately 600 msec. is needed to retrieve all this data.

From the above example of 5 controllers and 4 loops per controller, the scan time will typically be 4 seconds. If the HMI is also scanning for trend data, it could add an additional 1-2 seconds to the scan time. In many cases this is satisfactory for a HMI application. However, if the number of stations is doubled, the scan time will also double, which would be unsatisfactory for most applications.

An alternative when multiple controllers/loops are connected to an HMI is to use multiple COM ports on the personal computer. Most HMI scanners can multi-task the COM port scanning. Although there will be some overhead in the computer, it will be insignificant compared to the response times of the controllers. Serial communication cards that plug into a computer provide multiple RS485 connections. This also eliminates the need for an external RS232/RS485 converter. Companies such as Cyber Research (www.cyberresearch.com) provide these products. Most software scanners (OPC Servers) support multiple COM ports.

When controllers are used in remote monitoring applications where loops are monitored periodically, rather than a plant operator application where constant scanning for alarm status and data for trending is required, the maximum number of stations is 32, the physical limitation of an RS485 network. In this type of application the command/response timing still applies but usually only a few loops at a time are monitored on the personal computer and updates are normally in the order of a few seconds.

Several RS232/RS485 converters are discussed below, and a wiring diagram is shown for each converter.

[2] Only one loop at a time can be requested since the maximum number of coils that can be requested with a single command is 48.
[3] See the controller user's manual for more details.

Telebyte Converter

The Telebyte Model 245 Isolated Converter meets the requirements described above. Figure 1 shows typical connections between a single personal computer and 1-32 controllers at a plant location that has a single-point system ground.

The Telebyte converter has DB25 connectors for both RS232 and RS485 connections. A cable assembly that provides wire terminations corresponding to pins 2 and 14 must be constructed to connect the Telebyte to the controller.[4] Switch settings should be as shown in the figure.

All controllers are wired together in a bus configuration and a 120Ω network terminating resistor is installed on the last station.

Entrelec Converter

The Entrelec® 084.233.11 Isolated Converter (Siemens PN 16055-395) can also be used in the above application. Figure 2 shows a typical connection between a single personal computer and a controller (or up to the maximum of 32) at a plant location with a single-point system ground. This figure shows the 3-wire hookup between the converter and the controller that is recommended by Entrelec. Other devices such as an APACS® ACM serial port will require that the Transmit and Receive connections be reversed.

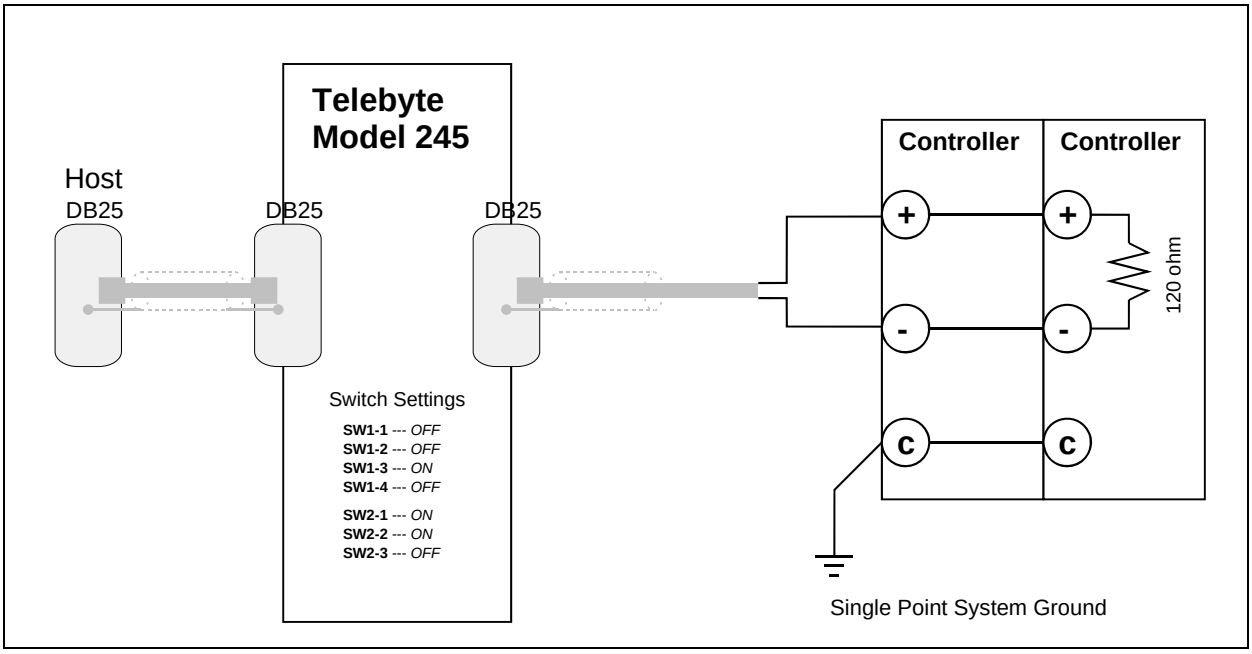


Figure 1

[4] Refer to the Telebyte literature supplied with the converter for current information.

The Entrelec converter has screw terminals for both the RS485 and RS232 connections. The default jumper settings are satisfactory but should be verified with the figure. All controllers are wired together in a bus configuration and a 120Ω network terminating resistor is installed on the last station.

The converter provides external supply voltages and terminal connections for polarizing the RS485 lines. These must be connected as shown in the figure where 0V is connected to P- and 5V to P+.

RS485 Repeaters

When two groups of controllers are mounted in separate plant locations that may have different system grounds, an isolated repeater will isolate the two system grounds. Additional repeaters can then be installed to extend the controller network

Entrelec Repeater

The Entrelec 084.12.14 Isolated Repeater meets the requirements described. Figure 3 illustrates a typical isolated controller network with the system ground for a group of PAC353 controllers at location A isolated from the system ground for a group at location B.

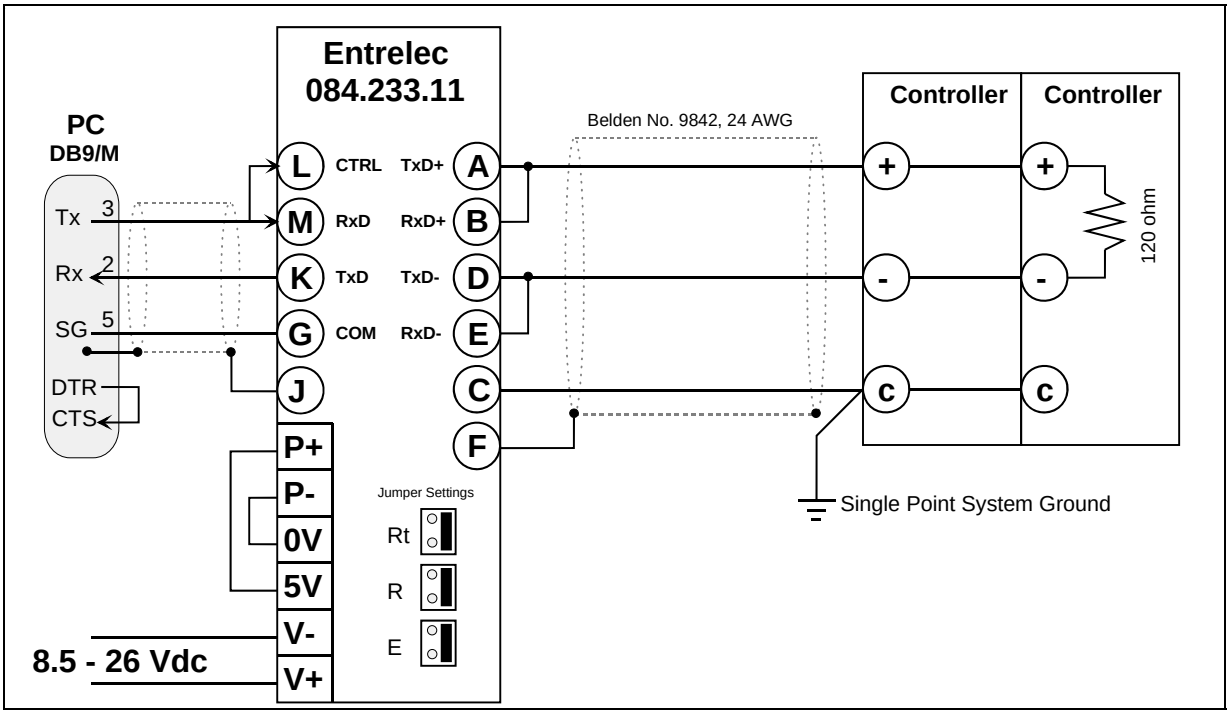


Figure 2

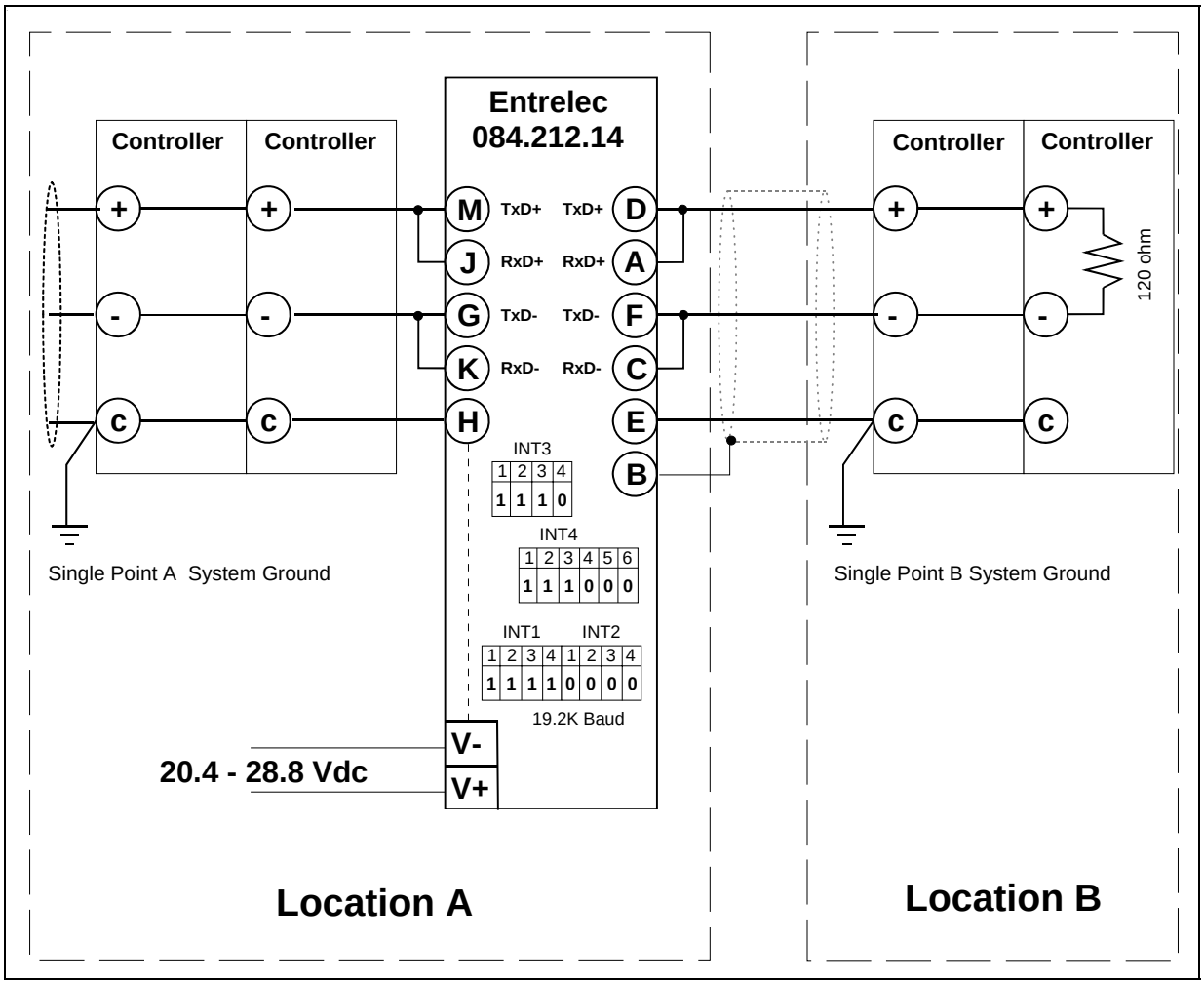


Figure 3

Multiple Modbus Masters

Where multiple personal computer devices are to communicate with a network of controllers, the following standard products are available.

Modicon BM85 Bridge/Multiplexer

This device, shown in Figure 4, can be used to enable up to 3 personal computers or other host devices to simultaneously communicate with controllers on a network. This device also has a Modbus Plus port that can be used to extend the BM85 to other Modbus Plus devices.

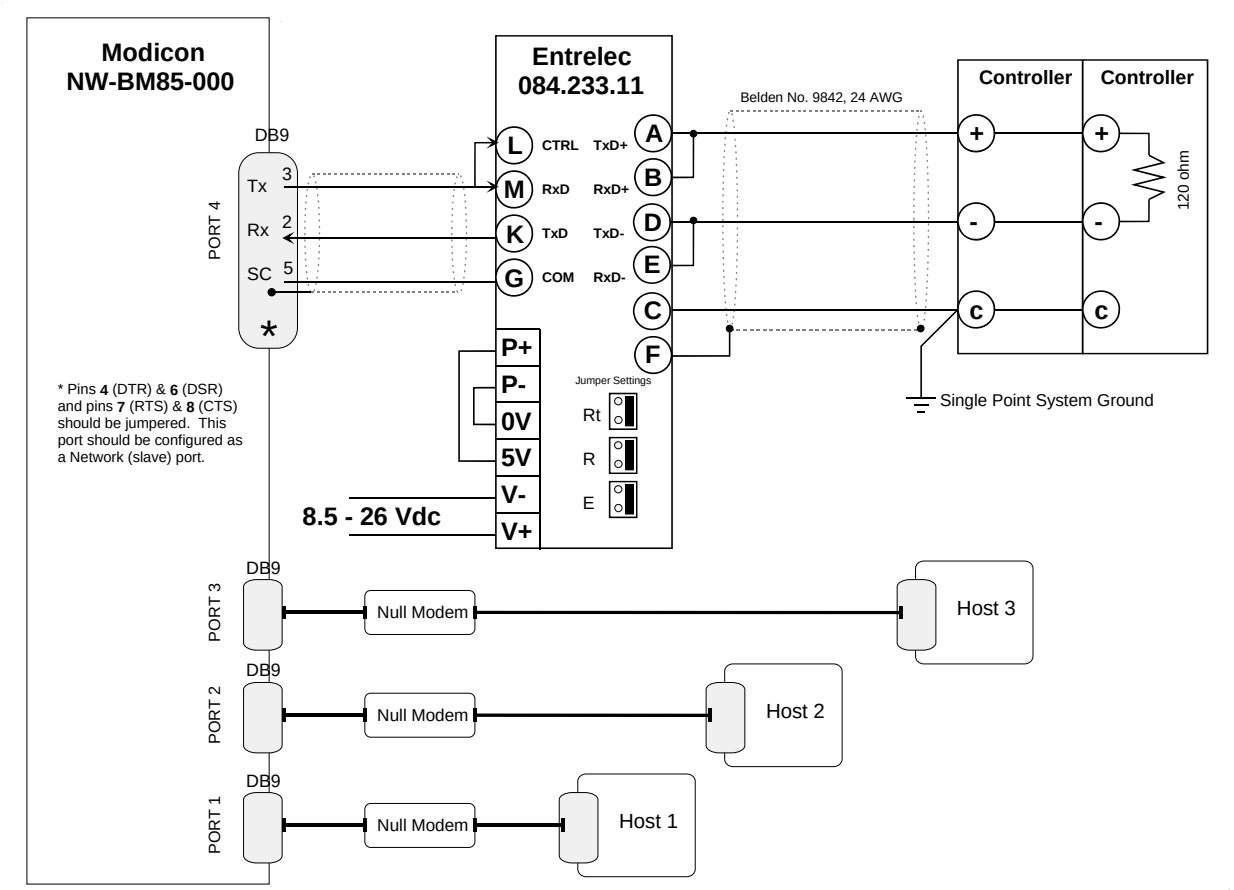


Figure 4

Application Support

User manuals for controllers and transmitters, addresses of Siemens sales representatives, and more application data sheets can be found at www.usa.siemens.com/ia. To reach the process controller page, click **Process Instrumentation** and then **Process Controllers and Recorders**. To select the type of assistance desired, click **Support** (in the right-hand column).

See AD353-138 for a list of Application Data sheets.