Application Note

Substation Automation and Protection Division

MODBUS Plus Communication Between an ABB Protective Relay and a Modicon PLC

ABSTRACT: Modbus Plus Capable devices are continuously being introduced into the utility environment. This Application Note is intended to educate the user with the method to use the protective relay and PLC's Modbus Plus capabilities to allow for data access and control capabilities. A simple communication example is intended to give the reader a simple method to establish communication between devices using PLC Ladder Logic. This Application Note relies upon the reader's understanding of Ladder Logic programming of a Modicon PLC and Modbus Plus application.

MODBUS PLUS General Information

Modbus Plus is a communication protocol, which encompasses the physical layer, data link, transport and application link layer definition within the ISO model representation. The physical layer is a hybrid-defined interface, which allows up to 64 devices to be multi-dropped along a serial interconnection. The interface also allows devices to communicate to each other with a data rate (baud rate) of 1 megabaud. The combination of protocol implementation and baud rate selection make Modbus Plus an excellent high performance protocol desirable for the substation environment.

However, Modbus Plus has been given additional capabilities, which exceed the benefits of a fast baud rate. Modbus Plus is based upon a hybrid implementation of HDLC (High-level Data Link Control) protocol. This implementation allows multiple devices to communicate along a single cable interface. Modbus Plus allows up to 32 (or 64 with the addition of repeaters) devices to communicate along a network connection. Additionally, each device can be capable of transmitting/receiving data of a length of 32 data words, which can be seen by all nodes, attached to the network. Modbus Plus has the Modbus Protocol imbedded within its data transport structure..

Modbus Plus is a deterministic network in that the response time to a command can be reasonably calculated. The method of determinism employed is referred to as "Token Passing". Please refer to both ABB and Schneider Electric documentation referencing network throughput calculation. Each node attached to the network can read/write information in a calculated amount of time which is determined by data transferred along the network and the amount of nodes along the network receiving the token. The amount of time in which to transfer the token to each network is referred to as "Token Rotation Time".

MODBUS PLUS Communication Between Devices

Modicon Programmable Logic Controllers (PLC's) can communicate with Modbus Plus Capable devices using two methods: Method 1 is using Peer Cop,. Method 2 is using a Master Block.

Peer Cop is a capability used only to allow devices by Schneider Electric to communicate with each other. It enables one device to be configured to read or write from/to each other along a Modbus Plus connection path. It's throughput is dependent upon the Modbus Plus token rotation time.

A Master Block is the PLC's method of using an instruction, which is inserted within the PLC's Ladder Logic scan to access data from another Modbus Plus capable device. A Master Block performs the following data access tasks:

- Write 4X Data to other devices
- Read 4X Data from other devices
- Get Local Modbus Plus Network Statistics

- Clear Local Modbus Plus Network Statistics
- Write Global Database
- Read Global Database
- Get Remote Modbus Plus Network Statistics
- Clear Remote Modbus Plus Network Statistics
- Obtain Node Peer Cop Health Statistics

Data transfer (read or write) is explained later in this document. Network Statistics is a count of each of the node's good / bad transmission counts. If a bad transmission occurs, the nature of the failure is tallied on a table. Local statistics are those from nodes on the same Modbus Plus network, Remote Statistics are those gathered from nodes on other interconnected Modbus Plus networks.

An ABB protective relay has Modbus Plus "HOST" addressing implementation. An additional path entry is required for address assignment for devices which are designed with Modbus Plus "HOST" implementation An ABB protective relay has the following Modbus Plus features available:

- Place 32 Registers of Data in the Global Database for access by other devices.
- Reply to 4X Read Data Requests from a Host or PLC Device.
- Perform Operations when 4X Write Data Requests are sent by a Host Device.
- Respond to Local and Remote Network Statistics Requests.
- Respond to Clear Local and Remote Local Statistics Requests.

In summary, the ABB protective relay responds to commands from a Modicon PLC as well as place data into the Global Register buffer for retrieval from a host device.

MODBUS PLUS Node Addressing and Path Designation

Modbus Plus Node addressing for a Modicon PLC is determined by a thumbwheel switch or dipswitch configuration on the appropriate PLC. Please reference the appropriate Schneider Electric Product Manual for further information.

Figure 1 illustrates the Modicon PLC's resident data paths. The PLC has four data slave paths resident in its device. An Additional Global Data Read Data Slave Path is available. It is through these paths that the PLC shall obtain the relay information.

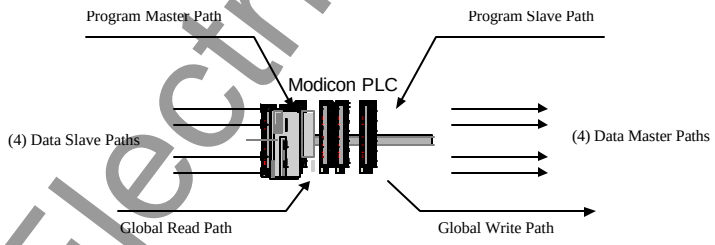

Figure 1 - Typical Modicon PLC Modbus Plus Path Definition.

The ABB Relay implementation host paths are shown in Figure 2 . A comparison of the data paths shows the similarities and differences between the PLC and ABB Relay implementation. The ABB Relay however, requires an additional path added to its base address to complete the full Modbus Plus address. As per the Figure 2 implementation, 8 data slave paths are incorporated within the relay. For a PLC to access the data within the relay, a base address of the node and one of the eight path addresses must be given for the address.

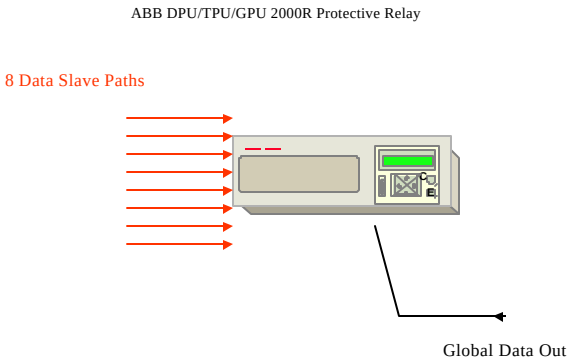

Figure 2 - ABB Protective Relay Path Implementation

Setting the address, of the ABB protective relay is accomplished via the front panel interface or via the ECP programming software accessible via the programming port. The address is in HEX encoding.

For example, if the PLC in Figure 1 was configured for address 1 and the ABB Protective Relay was configured for address 10 decimal (or configured as ADDRESS "A" hex through the front panel or ECP), the PLC would address the relay through one of any of the following addresses:

- 10.1.0.0.0 - Address 10 Path 1
- 10.2.0.0.0 - Address 10 Path 2
- 10.3.0.0.0 - Address 10 Path 3
- 10.4.0.0.0 - Address 10 Path 4
- 10.5.0.0.0 - Address 10 Path 5
- 10.6.0.0.0 - Address 10 Path 6
- 10.7.0.0.0 - Address 10 Path 7
- 10.8.0.0.0 - Address 10 Path 8

The Master Block Explained

The Modicon PLC allows for 4X data retrieval via Modbus Plus. The PLC scans ladder logic as such : Read PLC INPUTS -→ Execute LADDER LOGIC → Write PLC Outputs. The PLC scan is illustrated in Figure 3. The PLC reads the physical inputs wired into the unit, executes the program written in the PLC's native language (icon based Ladder Logic), and writes the status to the physical Output modules to control the hardwired components.

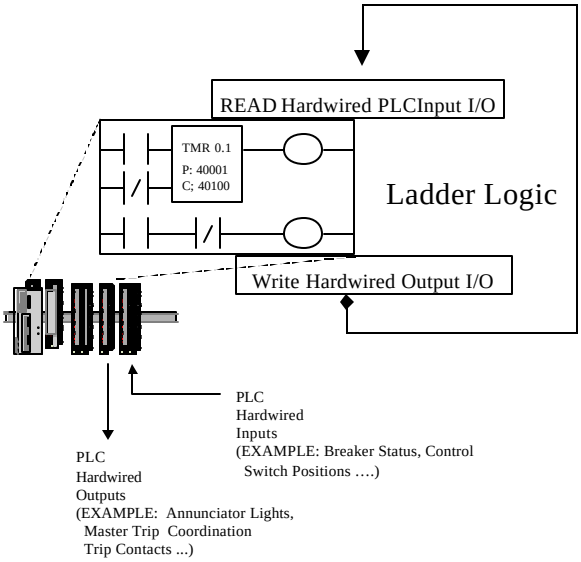

Figure 3 - Typical PLC Logic Execution

Within the PLC, a Master Instruction should be programmed within the unit which when scanned and executed, the PLC will transmit/receive data over the Modbus Plus Network. It may take more than one PLC scan to obtain the data over the network. The PLC scan is never stopped to wait for the data. The PLC will continue with its logic execution and upon a new ladder logic scan, a determination will be made by the instruction as to whether it received the information in the appropriate amount of time. The throughput of the data acquisition is determined by a variety of factors:

- Ladder Logic Execution Speed.
- Token Rotation Speed of Modbus Plus.
- Amount of data travelling over the network at the time of the request.
- Latency of the receiving device to respond to the request when received.

The MSTR (Master) Block is illustrated in Figure 4. A single PLC may have up to four Master Blocks active at any one time accessing data from the ABB protective relay. The amount of data, which may be requested by a PLC, is determined by the amount of free data paths available on the PLC. The ABB protective relay has up to 8 data paths, which may be accessed and busy at one time. The MSTR instruction block is parameterized via the PLC's Ladder Logic to perform the intended functions as illustrated via the function codes. If one was to obtain data from the GLOBAL data path, the amount of active MSTR instructions could be in a number greater than four.

The MSTR instruction is executed whenever the ENABLE instruction leg is energized. If the instruction is enabled, the ACTIVE output at the right side of the instruction shall energize. When the instruction has executed correctly, the COMPLETE instruction leg shall energize and the ACTIVE leg shall de-energize. If an error occurs within parameterization or timeout of the network without a response, the ERROR leg shall energize and the ACTIVE leg shall de-energize. The parameterization shall occur through configuration of the correct 4XXXX registers via the table provided for the instruction. If an error occurs, register 4XXXX +1 shall contain a number other than 0 indicating the failure. If a successful communication occurs, the data will be transferred into register block 4YYYY to 4YYYY + NNN (if a read operation or network statistics read operation) or data transferred from the PLC block 4YYY to 4YYYY + NNN if the MSTR operation is a write.

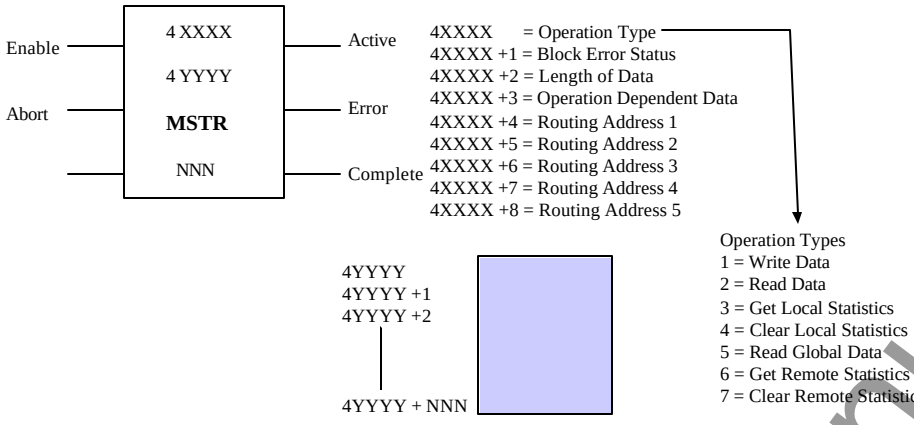

Figure 4 - Modbus Plus Master Instruction

METER DATA Access To a PLC Host From an ABB Relay.

Figure 5 illustrates a typical installation in which a PLC is to access data from an ABB DPU 2000R using a Master Instruction.

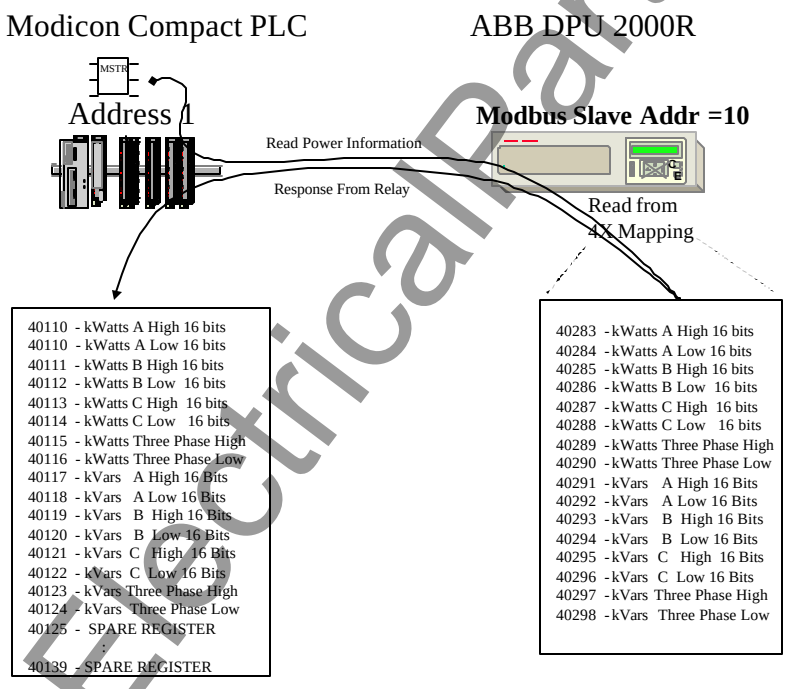

Figure 5 - Modbus Plus Network Topology MSTR Read Instruction Example

A sample Ladder Logic Instruction network is given in Figure 6. The ladder logic is included for instruction purposes only. The MSTR instruction is energized by internal coil 00107. If the instruction is active, coil 00102 energizes to request the information from the ABB protective relay. If the block is parameterized incorrectly, coil 00103 will energize and register 400101 will contain a non-zero number indicating the fault type. If the Ladder Logic instruction obtains the information from the relay, output coil 00104 shall

energize indicating completion of the network access. Also within this network example, an counter will increment each time a successful network communication occurs. This count, contained in the PLC memory 400109 can serve as a heartbeat counter to monitor continuous and successful communications.

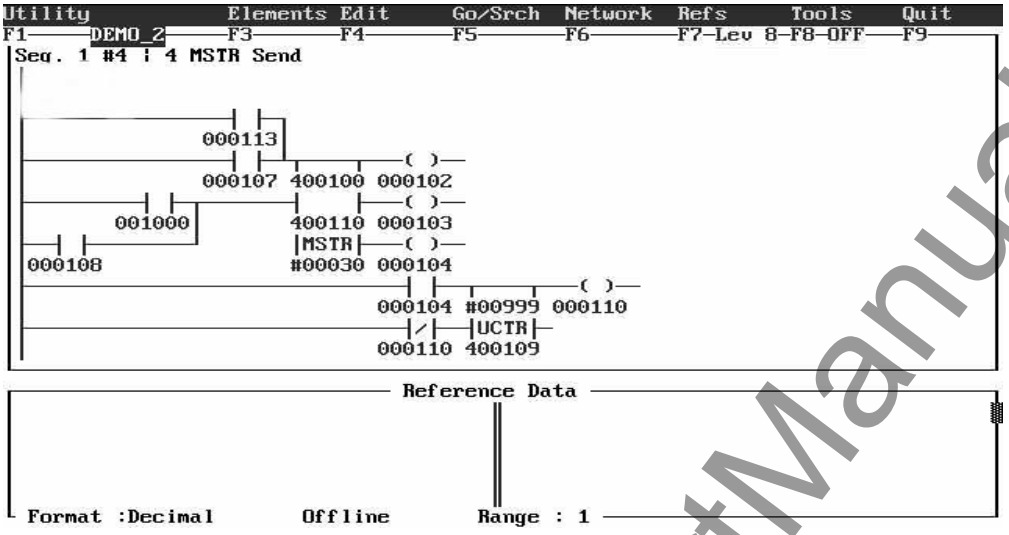

Figure 6 - MSTR Ladder Logic Network Example

The MSTR is intended to access data from the ABB Protective relay. Figure 7 illustrates the registers 400100 through 400108 which must be parameterized in order to obtain relay data. Figure 7 shows the MSTR configuration screen containing the parameters required for the Ladder Logic to operate correctly.

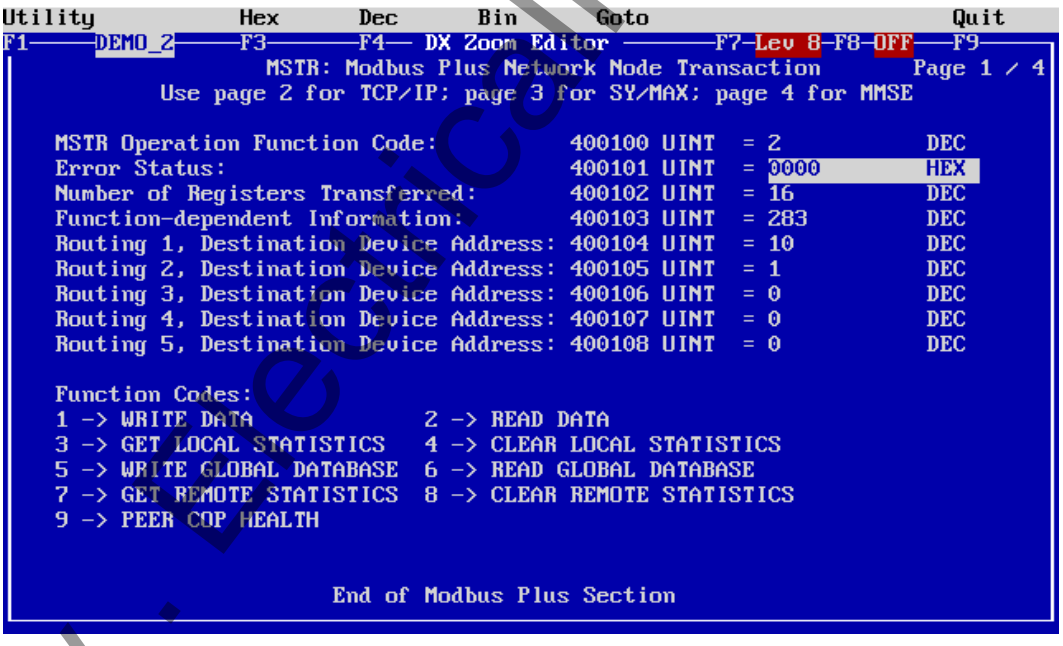

Figure 7 - MSTR Configuration Parameters

This example illustrates the configuration of Reading (PLC Register 400100 = 2) sixteen registers (PLC Register 400102 = 16) representing KW phase A,B,C, Total KW, KVARS phase A,B,C, and Total KVARS (Function Dependent Information from ABB DPU 2000R Modbus Address 40283), at Node number 10 (DPU 2000R = Node 10 [Address = 00A HEX]). Note the RELAY address is specified as the configured address via the relay front panel (Register 400104 = 10) and the Modbus Plus Data Slave path (in this case Data Slave Path 1 as designated in Register 400105 = 1).

Each time the MSTR instruction is executed, the data as designated in the parameterization block of 400100 to 400108 shall be transferred from the DPU 2000R's address to the PLC's data buffer which in this case resides in addresses 400110 through 400139 (as designated by the length of 30 at the bottom of the MSTR instruction). As illustrated in Figure 5, the data is transferred from the ABB DPU 2000R's register map to the PLC's registers as illustrated.

Ladder logic may be written to change the parameters within the MSTR block so additional values may be obtained from the ABB DPU 2000R. A sample ladder logic construct is included in Figure 8 which energizes the MSTR instruction when its operation has terminated.

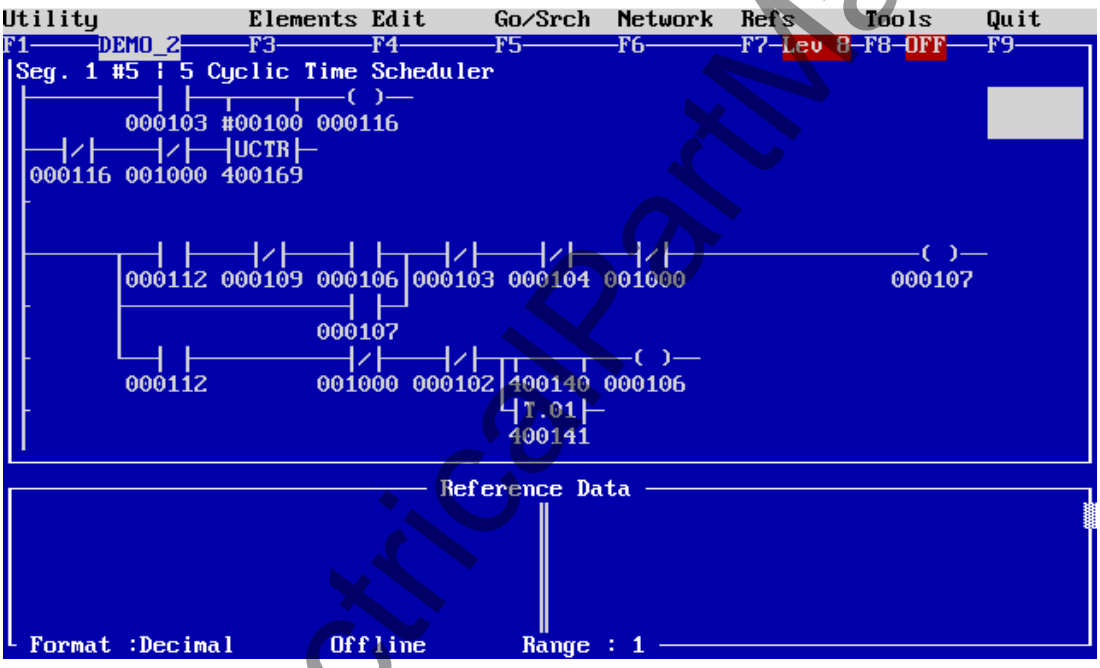

Figure 8 - MSTR Cyclic Timer Ladder Logic

Figure 8 ladder constructs are as such:

01000 is a system reset contact which when energized resets the MSTR and counters.
00112 is a system start contact which when energized allows the MSTR to read network data over Modbus Plus.
If the network MSTR is idle (coil 00102 is de-energized or at a state of 0) then the timer energizes for the time indicated in Register 400140. Upon timeout, 00106 energizes and latches in 00107 which starts the MSTR instruction. Coil 00107 will be reset (or unlatched) when the MSTR terminates operation normally or through error. Upon reset, the MSTR instruction will not execute. The timer shall reset and when it times out, the entire sequence shall begin again.

The UCTR instruction contained in this logic counts the amount of Modbus Plus errors encountered when communicating to the relay. Its count is kept in register 400169.

Additional ladder logic can be written to transfer different pointers to obtain additional information from the DPU 2000R. The data would have to be transferred to registers 400100 to 400108. The logic is relatively straightforward.

Conclusion

The ABB series of Protective relays have been designed and certified to operate seamlessly with Modicon Programmable Logic Controllers. The Ladder Logic is straightforward and easily implemented. Metering data, element status, fault/operation records, device settings, and other important and time-critical information is easily obtained from the relay using a programmable logic controller with Modbus Plus capability.

REFERENCE TEXT

DPU/DPU 2000R Modbus/Modbus Plus Implementation and Protocol Guide, Revision 1.5 August 18. 1998. ABB Company.

INSTRUCTIONS – DPU 2000R Distribution Protection Unit 1MRA5877219-MIB (IB 7.11.1.7-4), REF 544, Issue B, October 1997, ABB Company.

MODICON LADDER LOGIC BLOCK LIBRARY USERS GUIDE 840 USE 101 00, Version 1.1, July 1995, AEG Schneider Automation

MODICON MODSOFT Programmer Software User Guide, 840 USE 115 00, Version 1.1 June 1996, AEG Schneider Automation

MODBUS PLUS and SUBSTATION AUTOMATION, 8000BR9606R11/97, REV C, Groupe Schnieder

Contributed by:
John Popiak
Revision 0, 11/99

ABB, Inc.
7036 Snowdrift Road
Allentown, PA 18106
800-634-6005 Fax 610-395-1055
Email: powerful.ideas@us.abb.com
Web: www.abb.com/substationautomation