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# MPU-32 AND FPU-32 TIA-485 NETWORK

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**PRELIMINARY**

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# 1. GENERAL

The TIA-485 network communications interface supports the Modbus RTU and the Allen-Bradley (A-B) DF1 half-duplex protocols. The communications system consists of a single master and up to thirty-two MPU-32 or FPU-32 slaves connected using a two-wire RS/EIA/TIA-485 network. If the master does not have an RS/EIA/TIA-485 port, a converter with send-data control is required. Send-data control does not require handshaking signals because the data signal from the RS-232 device is used to control the TIA-485 transmitter. The SE-485-DIN converter is recommended. For more information on converters, see TI 9.9

# 2. MODBUS PROTOCOL

Only the master can initiate a message transaction. Messages can be addressed to individual slaves or they can be broadcast messages (address 255). Broadcast messages are executed on the slaves but unlike individually addressed messages, the slaves do not generate a reply message.

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## 2.1 PROTOCOL SETUP

Setup options are available in the *Setup* │ *Hardware* │ *Network Comms* menu. Select *Network ID* and *Network Baud*; then select *Modbus RTU* from the *Network Type* menu. When network parameters need to be changed, first set the *Network Type* to *None*, make the parameter adjustments and then select *Modbus RTU* as the network type. A *Network ID* of 0 disables the slave. Valid slave addresses are 1 to 254.

## 2.2 MESSAGE SYNCHRONIZATION

Message synchronization is accomplished by detection of an idle communication line. The communication line is considered idle when no communication exists for an equivalent delay of 3.5 characters.

The first byte received after idle-line detection is interpreted as the address byte of the next message. Message bytes must be transmitted in a continuous stream until the complete message has been sent. If a delay of more than 3.5 characters exists within the message, the message is discarded.

Response messages from the slave are delayed by at least 3.5 character delays.

## 2.3 ERROR CHECKING

Modbus RTU uses a 16-bit cyclic redundancy check (CRC).

When a CRC error is detected, the message is discarded and there will be no response.

If the CRC check is correct but the internal data in the message is not correct, the slave will respond with an exception response code.

## 2.4 FUNCTION CODES SUPPORTED

The following function codes are supported:

- Read Holding Registers (Function Code 3)
- Read Input Registers (Function Code 4)
- Write Single Register (Function Code 6)
- Write Multiple Registers (Function Code 16)
- Command Instruction (Function Code 5)

Function Codes 3 and 4 perform the same function in the MPU-32 and FPU-32.

All MPU-32 and FPU-32 registers are mapped starting at Modbus address 40001. This corresponds to MPU-32 and FPU-32 register 0.

Where required, value representations use the "C" convention. For hexadecimal, 0x precedes the value.

### 2.4.1 READ INPUT/HOLDING REGISTERS (CODE 4/3)

The first byte of the read message is the slave address. The second byte is the function code. Bytes three and four indicate the starting register. The next two bytes specify the number of 16-bit registers to read. The last two bytes contain the CRC code for the message.

TABLE 2.1 READ REGISTERS (CODE 4/3)

| BYTE # | DESCRIPTION |
|---|---|
| Byte 1 | Slave Address |
| Byte 2 | Function Code |
| Byte 3 | MSB Register Address |
| Byte 4 | LSB Register Address |
| Byte 5 | MSB Number of Registers |
| Byte 6 | LSB Number of Registers |
| Byte 7 | LSB CRC |
| Byte 8 | MSB CRC |

The two-byte values of starting register and number of registers to read are transmitted with the high-order byte followed by the low-order byte.

The CRC value is sent with the LSB followed by the MSB.

The following message will obtain the value of register 1 (Modbus 40002) from slave 1. Note that Modbus registers are numbered from zero (40001 = zero, 40002 = one, etc.):

0x01 | 0x03 | 0x00 | 0x01 | 0x00 | 0x01 | 0xD5 | 0xCA

The addressed slave responds with its address and Function Code 3, followed by the information field. The information field contains an 8-bit byte count and the 16-bit data from the slave. The byte count specifies the number of bytes of data in the information field. The data in the information field consists of 16-bit data arranged so that the MSB is followed by the LSB.

### 2.4.2 WRITE SINGLE REGISTER (CODE 6)

The function code format for writing a single register is shown in Table 2.2.

The message consists of the slave address followed by the Function Code 6 and two 16-bit values. The first 16-bit value specifies the register to be modified and the second value is the 16-bit data.

Provided no errors occurred, the slave will re-send the original message to the master. The response message is returned only after the command has been executed by the slave.

The following message will set register 3 to 300 in slave 5:

0x05 | 0x06 | 0x00 | 0x03 | 0x01 | 0x2C | 0x78 | 0x03

TABLE 2.2 WRITE SINGLE REGISTER (CODE 6)

| BYTE # | DESCRIPTION |
|---|---|
| Byte 1 | Slave Address |
| Byte 2 | Function Code |
| Byte 3 | MSB Register Address |
| Byte 4 | LSB Register Address |
| Byte 5 | MSB of Data |
| Byte 6 | LSB of Data |
| Byte 7 | LSB of CRC |
| Byte 8 | MSB of CRC |

### 2.4.3 WRITE MULTIPLE REGISTERS (CODE 16)

The function-code format in Table 2.3 can be used for writing single or multiple registers.

TABLE 2.3 WRITE MULTIPLE REGISTERS (CODE 16)

| BYTE # | DESCRIPTION |
|---|---|
| Byte 1 | Slave Address |
| Byte 2 | Function Code |
| Byte 3 | MSB Register Address |
| Byte 4 | LSB Register Address |
| Byte 5 | MSB of Quantity |
| Byte 6 | LSB of Quantity |
| Byte 7 | Byte Count |
| . | MSB of Data |
| . | LSB of Data |
| . | LSB of CRC |
| Byte n | MSB of CRC |

The slave will reply with the slave address, function code, register address, and the quantity followed by the CRC code for a total of 8 bytes.

### 2.4.4 COMMAND INSTRUCTION (CODE 5)

Modbus Function Code 5 (Force Single Coil) is used to issue commands to the slave. The format for the message is listed in Table 2.4 and the command code actions and corresponding coil number are listed in Table 2.5.

TABLE 2.4 COMMAND FORMAT (CODE 5)

| BYTE # | DESCRIPTION |
|---|---|
| Byte 1 | Slave Address |
| Byte 2 | Function Code |
| Byte 3 | MSB of Command Code |
| Byte 4 | LSB of Command Code |
| Byte 5 | Fixed at 0xff |
| Byte 6 | Fixed at 00 |
| Byte 7 | LSB of CRC |
| Byte 8 | MSB of CRC |

TABLE 2.5 SUPPORTED COMMANDS

| COMMAND CODE | COIL NUMBER | ACTION |
|---|---|---|
| 0x0003 | 4 | Reset Trips |
| 0x0004 | 5 | Set Real-Time Clock |
| 0x0005 | 6 | Clear Data-Logging Records |
| 0x0006 | 7 | Clear Trip Counters |
| 0x0008 | 9 | Clear Running Hours |
| 0x0009 | 10 | Emergency $I^2t$ and Trip Reset |
| 0x000C | 13[(1)] | Re-enable Temperature Protection |
| 0x000D | 14 | Remote/Net Trip Set |
| 0x000E | 15 | Remote/Net Trip Clear |
| 0x000F | 16 | Remote/Net Alarm Set |
| 0x0010 | 17 | Remote/Net Alarm Clear |
| 0x0011 | 18 | Run1 Set |
| 0x0012 | 19 | Run1 Clear |

[(1)] MPU-32 only.

Except for a broadcast address, the slave will return the original packet to the master.

### 2.4.5 COMMAND INSTRUCTIONS USING REGISTER WRITES

For PLC's not supporting Function Code 5, commands can be issued using Write Single Register (Code 6) and Write Multiple Register (Code 16).

Commands are written to MPU-32 or FPU-32 register 6 (Modbus register 40007). Supported commands are listed in the COMMAND CODE column in Table 2.5.

When using the Write Multiple Registers function code, the write should only write to register 6. If multiple registers are written starting at register 6, the first data element will be interpreted as the command code but no other registers will be written. If the command is successful, the slave will return a valid response message.

### 2.5 ERROR RESPONSES

The following exception responses are supported::

- Boundry Error (1) - Applies to writes of 32-bit values. The high-order word must be written first followed by the write to the low-order word. If this sequence is not followed, a Boundry Error is returned and the value will not be stored. This does not apply on read requests.
- Address Error (2) - All accesses to communication registers must be within the specified address range or the Address Error code is returned.
- Command Error (3) - This error code is returned if the command code is not supported.
- Illegal Function Code (4) - The function code (Byte 2) is not supported.

The exception message consists of the slave address followed by a retransmission of the original function code. The function code will have the most-significant bit set to indicate an error. The 8-bit byte following the function code is the exception response code. The 16-bit CRC is at the end of the message.

### 2.6 REGISTER DATABASE

Appendix E in the MPU-32 and FPU-32 manual contains the Modbus Register Table. The table starts at register 0 (Modbus 40001) and each register is 16-bits wide. Types "long" and "float" are 32-bit values. For both long and float types, the low-order word is transmitted first followed by the high-order word. Word values have the high byte followed by the low byte. Float types as per IEEE 754 Floating-Point Standard. All bytes of long and float types must be written using one message or an error will result. This does not apply for read commands.

### 2.7 NETWORK STATUS AND INDICATION

Network status is viewed in the *Metering* | *Network Status* menu. “Type” should indicate Modbus slave and “Link” indicates the state as ON LINE or TIMED OUT.

Communication status LEDs are located on the rear panel of the slave. When Modbus RTU is selected, the green Module Status (MS) LED will be ON. The Network Status (NS) LED will indicate green when there is link activity and will flash red when the link is timed out. Both LED’s are OFF when the *Network Type* is set to *None.*

## 3 A-B DF1 PROTOCOL

The MPU-32 A-B® Protocol is based on the half-duplex master/slave Allen-Bradley (A-B) Data Highway Protocol (DF1) as described in Allen-Bradley Bulletin 1770-6.5.16. This publication is available from the A-B web site at www.ab.com. A DF1 master is required. Consult the A-B documentation for devices with master capabilities.

A-B® is a registered trademark of Rockwell International Corporation.

The DF1 commands shown in Table 3.1 are supported. Each PLC has limitations when using a particular command. Determine the best command to use for the application.

TABLE 3.1 DF1 COMMANDS

| COMMAND | CMD | FNC |
|---|---|---|
| Unprotected Read | 01 | - |
| Unprotected Write | 08 | - |
| Typed Read | 0F | 68 |
| Typed Write | 0F | 67 |
| Typed Logical Read | 0F | A2 |
| Typed Logical Write | 0F | AA |

The PLC-5 and SLC 5/04 support reading and writing to integer files (Type N) and float files (Type F). Since MPU-32 and FPU-32 meter values are float types, these will typically be stored in a PLC Type-F file. It is also possible to read float types as two integers; however, further processing is required to obtain the float value.

The PLC requires two communication ports—a PLC programming port and a DF1 master communications port. Typically, a DH+ port will be used for PLC programming and the RS-232 will be used for DF1 communications via an SE-485-DIN converter.

### 3.1 PLC-5 / SLC5/04 CHANNEL-0 SETUP

The RS-232 Channel-0 port is set up for a DF1 half-duplex master. Set the Channel-0 baud rate and CRC to match the MPU-32 or FPU-32 settings. The parity bit is not supported on the MPU-32 and FPU-32.

Additional recommended PLC settings:

DF1 Retries = 3
RTS Send Delay = 1 (20 ms)
RTS Off Delay = 0
Ack timeout = 5 (100 ms)
Reply msg wait = 3 (60 ms)

For the polling mode, select MESSAGE BASED (DO NOT ALLOW SLAVE TO INITIATE MESSAGES) or STANDARD (MULTIPLE MESSAGE-TRANSFER PER NODE SCAN). The MPU-32 or FPU-32 can buffer up to 4 messages. The selection MESSAGE BASED (DO NOT ALLOW SLAVE TO INITIATE MESSAGES) is recommended.

### 3.2 TYPED-READ MESSAGES

The Typed-Read message (CMD=0F, FNC=68) requires a Control Block where the message configuration is stored. In the SLC, this is normally N7:0 but could be any other file that supports the control-block data. Use the following MSG settings:

| | |
|---|---|
| Read/Write: | Read |
| Target Device: | PLC5 |
| Local/Remote: | Local |
| Control Block: | N7:0 |

**NOTE:** For the PLC-5, the message block must be of type MG so that the channel number can be set in the message setup screen.

The Setup screen is used to specify file information. In the PLC's *Controller* section, *Data Table Address* is the destination in the PLC where data is to be stored. This can be a float (Fx:x) file or an integer (Nx:x) file. *Element Size* must be set to the number of elements to transfer. This is a decimal value and this value is limited in some controllers. In the SLC 5/04, the maximum value for integers is 100 and for floats it is 50.

In the PLC's *Target Device* setting, set *Data Table Address* to the A-B File address listed in the MPU-32 or FPU-32 manual, Appendix E. The A-B File column in Appendix E is listed as FILE:ELEMENT. To read or write the elements as floats, the PLC-5 address would be <F><FILE>:<ELEMENT> (Example F4:56). To read or write the elements as integers, add 20 to the file number and preceed with N, <N><FILE+20>:<ELEMENT> (Example N24:56). *Local Address* is the slave address.

Example settings for reading 25 registers as float type (25 meter readings):

Data Table Address: ..... F8:0 (in PLC)
Element Size:................ 25
Target Device Data
Table Address:.......... F6:0 (in slave)
Local Address:.............. 9 (Must match slave ID)

**NOTE:** To read float values, both data table addresses must be specified as float (F) type.

Example settings for reading a block of 100 registers (16-bit integer):

This could be a mix of float and integer values since floats can be transferred as two integers.

Data Table Address: ..... N9:0 (in PLC)
Element Size:................ 100
Target Device Data
Table Address:.......... N23:8 (Start of Overload)
Local Address:.............. 9 (Must match slave ID)

If a float has been read into the PLC as two integers and stored in an N-type file, the float can be recovered by using two copy commands. Assume that the two integers are stored in N9:0 and N9:1. The first copy command is used to swap the two words so they are in the correct order; copy N9:0 to N9:11, and copy N9:1 to N9:10. The second copy command will copy the two integers to the F-type file; copy N9:10 to F8:0 with a size of 1. The two integers are now combined correctly as a single 4-byte float located in F8:0.

### 3.3 TYPED-WRITE MESSAGES

The Typed-Write message (CMD=0F, FNC=67) is used to write data to the MPU-32 or FPU-32.

| | |
|---|---|
| Read/Write: | Write |
| Target Device: | PLC5 |
| Local/Remote: | Local |
| Control Block: | N7:0 |

The PLC's Setup screen is used to specify file information. In the *This Controller* section, *Data Table Address* is the source file in the SLC. This can be a float (Fx:x) file or an integer (Nx:x) file. *Element Size* must be set to the number of elements to transfer. For the MPU-32, the maximum element size is 100 for integers and 50 for floats.

In *Target Device*, set *Data Table Address* to the A-B File address listed in the MPU-32 or FPU-32 manual, Appendix E. Both integer and float values sent from the SLC are in the correct byte order and interpreted correctly by the MPU-32 or the FPU-32.

*Local Address* is the slave ID.

Example settings for writing a single float value to slave register 13.

Data-Table Address: .....F8:0 (Location of float value)
Element Size: ................1
Target-Device Data-
Table Address: ..........F3:13
Local Address: ..............9 (Must match slave ID)

Reset commands to the MPU-32 or FPU-32 are issued by writing an integer command code to register 6 (N23:6) in the MPU-32 or the FPU-32.

A command message should only be issued when the command is required. Supported commands are listed in the COMMAND CODE column in Table 2.5.

Example settings for writing a reset command.

Data-Table Address: .....N9:0 (Reset code = 3)
Element Size: ................1
Target-Device Data-
Table Address: ..........N23:6 (Command Register location)
Local Address: ..............9 (Must match slave ID)

### 3.4 Unprotected Read/Write Messages

For PLC-2 and PLC-3 processors not supporting Typed Read/Write messages, Unprotected Read/Write messages can be used. For these messages, the data address is the Octal value of the register numbers listed in column one of the MPU-32 or FPU-32 manual, Appendix E. The size is the number of registers. The maximum number of registers that can be transferred in a single message is 100.

### 3.5 Typed Logical Read/Write

The Typed Logical Read (CMD = 0F, FNC = A2) and Typical Logical Write (CDM = 0F, FNC = AA) messages are supported by the full line of SLC500 processors and Prosoft MVIxx-DFCM communication interfaces.

Both float (F) and interger (N) types are supported. Unlike the typed commands in Section 3.2 and 3.3, a file offset is not required for integer values. Use the A-B file address as listed in Appendix E and precede the address with F for float values and N for integer values.

The maximum number of integers and floats that can be read is 100 and 50 respectively.

Reset commands to the MPU-32 or FPU-32 are issued by writing one of the COMMAND CODES listed in Table 2.5 to register 6 (N3:6).

### 3.6 Network Status and Indication

Network status is viewed in the *Metering* | *Network Status* menu. Type should indicate A-B DF1 slave and Link indicates the state as ON LINE or TIMED OUT.

Communication status LED's are located on the rear panel of the MPU-32 or FPU-32. When A-B DF1 is selected, the green Module Status (MS) LED will be ON. The Network Status (NS) LED will indicate green when there is link activity and will flash red when the link is timed out. Both LED's are OFF when the *Network Type* is set to *None.*

## 4 Data Records

Event record information is located starting at MPU-32 and the FPU-32 register 973.

Only one event record can be read at a time. Record data is for the record indicated by the Record Selector. To select a record, write the record number to Record Selector with the first message and then read the values in the record with a second message. Record Head points to the next available record. The last event record captured is at Record Head minus one.

The Record Selector must be in the range of 0 to 99. Values outside this range will select record 0.

## 5 Network Timeout

The MPU-32 and FPU-32 can be configured to trip or alarm on a network timeout using the *Setup* | *Hardware* | *Network Comms* menu. The *Net Trip Action* and *Net Alarm Action* set points set the actions to be taken when a timeout occurs. To prevent a timeout, a valid message, addressed to the slave, must be received at time intervals less than five seconds.

## 6 User Defined Registers

User-Defined Registers are used to assemble data in groups in order to minimize the amount of message requests. User-Defined Register values are entered using the *Setup* | *Hardware* | *Network Comms* | *User Register* menu, by using SE-Comm-RIS, or by using network communication messages.

The values entered are the MPU-32 or FPU-32 register numbers corresponding to the required parameter. User Register values are accessible from the menu or via communications starting at MPU-32 or FPU-32 register 1400 (Modbus 41401 or A-B file 9:190).

The data corresponding to these register values is retrieved by reading the values starting at registers 1432 (Modbus 41433, A-B file 9:222). The format of the data is a function of the associated register type.

Typically, for PLC communications it is desirable to define data assemblies that are grouped by data type (float or integer). A single read can then access all required float values while another read can access the integer values.

For example, to access the three phase currents, enter 860, 861, 862, 863, 864, and 865, in User Register 0 to 5. The values are read by reading three float values starting at Modbus 41433 or A-B file 9:222. In a similar manner, the status and trip bits 0 to 32 can be read by entering 1096, 1097, 1104, 1105 in the next available register locations starting at User Register 6. These can be read starting at register 1438 (Modbus 41439, A-B file 9:228).

The A-B File column in the MPU-32 and FPU-32 manual Appendix E is listed as FILE:ELEMENT. To read the elements as floats, the PLC-5/SLC500 address would be <F><FILE>:<ELEMENT> (Example F9:222). To read the elements as integers using the PLC's "Typed" commands, add 20 to the file number and preceed with N, <N><FILE+20>:<ELEMENT> (Example N29:222). For SLC500 "Typed Logical" commands, the offset of 20 is not required (Example N9:222). See Section 3.5 for details.

## 7 TIA-485 NETWORK CONNECTION

The TIA-485 uses the three-terminal connector marked +, -, and SH located on the rear panel of the MPU-32 and FPU-32. See Fig. 1. The + and – terminals are for the TIA-485 communication lines and the SH terminal is for the cable shield. The SH terminal is connected through a parallel R-C to ground and allows the cable shield to be daisy chained as shown in Fig. 2. The cable shield must be connected to ground at one end only.

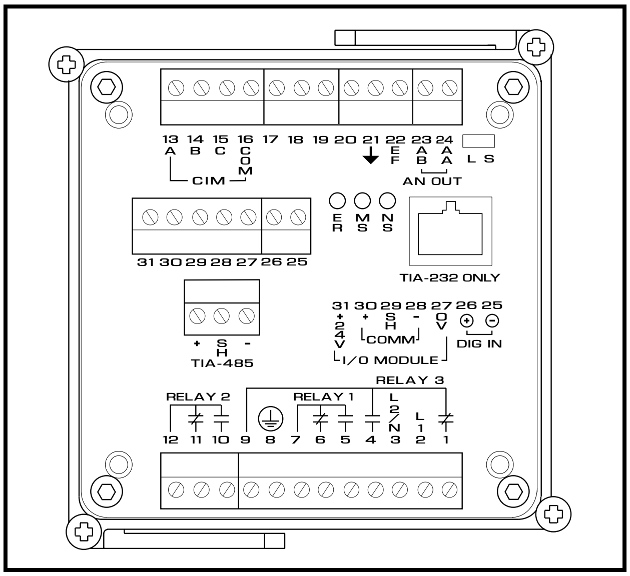


FIGURE 1. MPU-32 Rear View

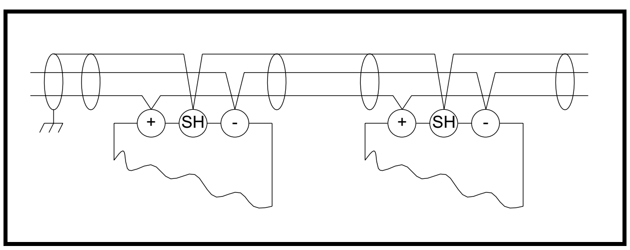


FIGURE 2. Cable Shield Using SH Terminal.

An alternate shielding method is shown in Fig. 3. In this method, the cable shield is grounded in sections and the SH terminal is not used.

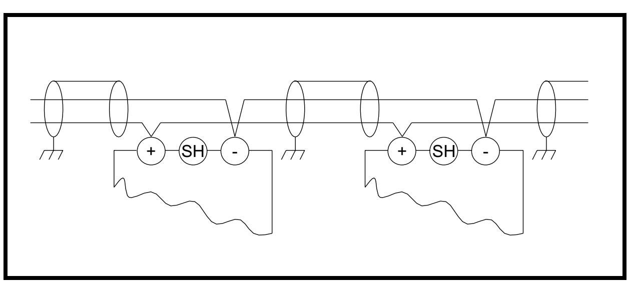


FIGURE 3. Cable Shield Grounded in Sections.

## 8 SPECIFICATIONS

| | |
|---|---|
| Interface | Isolated RS/EIA/TIA-485, 2 wire, multi-drop, half duplex. |
| Protocol | Modbus RTU, A-B DF1 |
| Baud Rate | 9.6 to 38.4 kB. |
| Bit Format | 8 bits, no parity, one stop bit(1) |
| Number of MPU-32's Connected | Maximum of 32 units. |
| Bus length | 1200 meters (4000 ft) total.(2) |

(1) Terminal "-" is negative with respect to terminal "+" for a binary 1 (MARK or OFF) state.
Terminal "-" is positive with respect to terminal "+" for a binary 0 (SPACE or ON) state.

(2) For line lengths exceeding 10 meters (30 ft), 150-Ω terminations are required at the cable ends.

**NOTE:** TIA-485 communications have priority over TIA-232 communications. Simultaneous operation requires the TIA-232 baud rate to be set to 9600 to minimize TIA-232 data errors. No data errors occur on the TIA-485 network regardless of the baud rate setting. During simultaneous operation, requests are processed in the order received.