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Direct Logic 405

MODBUS SLAVE

F 4 – S L V - M B

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CHAPTER 1 : INTRODUCTION

This document describes the FACTS Engineering Modbus protocol support provided for the *AutomationDirect* 405 PLC using the F4-SLV-MB or the F4-SLV-MBR.

405 MODBUS SLAVES - FEATURE OVERVIEW

Module Part No.	RS-232, RS-422, RS-485	Modbus Modes	Leased Line / Radio Modem	Maximum Baud Rates
F4-SLV-MBR	Yes	RTU / ASCII	Yes	Radio Modem - 1200
F4-SLV-MB	Yes	RTU / ASCII	No	57600
D4-DCM	Yes	RTU	No	38400

Note: The Modbus protocol support is based on the Gould Modbus Protocol Document PI-MBUS-300 Rev B.

Normally an *AutomationDirect* Data Communication Module, D4-DCM, or a D4-450 CPU is used when a hardwired Modbus connection is required on the DL405. Applications which require radio communications or communication rates greater than 38400 bps may require the F4-SLV-MB.

FAST RESPONSE FEATURE

The DL405 Modbus Slave F4-SLV-MB, includes a fast response feature which in most applications, reduces the time required to poll a network. The Fast Response mode is automatic. No user programming is required.

The module automatically remembers the V-Memory locations read during the last valid read block poll, function codes 3 or 4. While other RTUs are being polled, the module continuously reads these V-Memory locations in the DL405 CPU. If another read block poll message is received by the module for the same V-Memory locations, then the module immediately sends this information back to the SCADA master. In the case where the same block of V-Memory is always read from the DL405 CPU, the module's response will have a turn-around delay time of 0.

F4-SLV-MB MODBUS RESPONSE TIME

DL405 Modbus Slave response time can be estimated using the following formula.

DB =	Data Bytes =	number of I/O points to R/W divided by 8 or number of registers to R/W times 2
ML =	Message length =	13 + DB
CT =	Communication Time (in seconds) =	10/baud rate x ML
AT =	Access Time (in seconds) =	PLC scan time
KT =	Keying Time (in seconds) =	RTS on-delay + RTS off-delay
CC =	CoProcessor Compilation Time	
RT =	Response Time =	KT x 2 + AT + CT + CC

Examples:

RS-422 network at 57600 baud, KT=0, 16 I/O R or W, 4 register R or W.

> For 15 msec scan time, RT = 15 + 1.7 + 5 = 22 msec

Radio network at 1200 baud, KT=.015, 16 I/O R or W, 4 register R or W.

> For 15 msec scan time, RT = .03 + 15 + 83 + 5 = 103 msec.

CHAPTER 2 : MODULE CONFIGURATION

STEPS FOR F4-SLV-MB CONFIGURATION

The following steps should be used as a guideline for installation of the F4-SLV-MB.

1. Set Port Configuration Jumpers

2. Install F4-SLV-MB in the CPU base and Note the Slot Number

3. Power Up PLC and connect DirectSoft

4. Intialize Slot Dependent V-Memory with RLL or DirectSoft Data View
   a. Determine where you want the Configuration Table to start
   b. Determine which features you need to configure in the Mode Word

5. Initialize Configuration Table V-Memory with RLL or DirectSoft Data View
   a. Configure Baud Rate
   b. Configure Address
   c. Configure Radio Keying Delays
   d. Configure Wait for Last Character Time-Out

6. Power Cycle PLC or do a PLC Program to Run transition

7. Build and connect communication cable

8. Verify F4-SLV-MB operation with Modbus Master

F4-SLV-MB JUMPER DESCRIPTIONS AND LOCATIONS
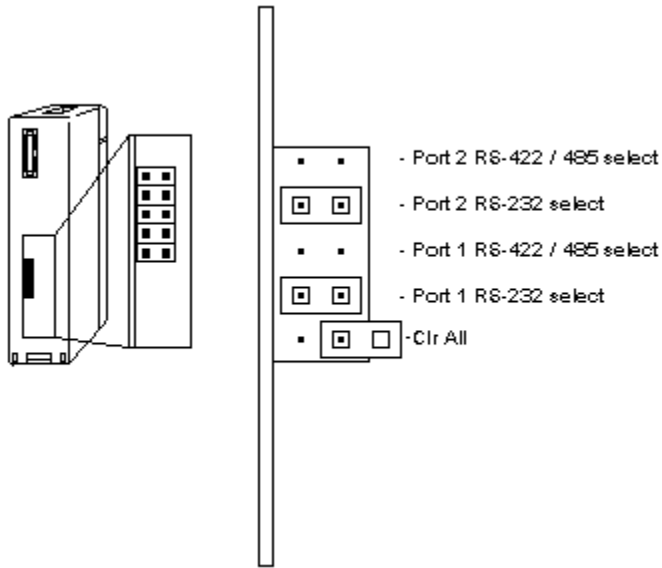
PORT 2

The communication interface type for port 2 is selected by placing a jumper on one of the port 2 options, either RS422 or RS232. The RS232 selection is the default factory setting.

PORT 1

The communication interface type for port 1 is selected by placing a jumper on one of the port 1 options, either RS422 or RS232. The RS232 selection is the default factory setting.

CLR ALL

This jumper should always remain on one post (this is the factory setting).

CAUTION: Installing the CLR ALL jumper on both posts will prevent the module from operating correctly.

F4-SLV-MBR JUMPER DESCRIPTIONS AND LOCATIONS
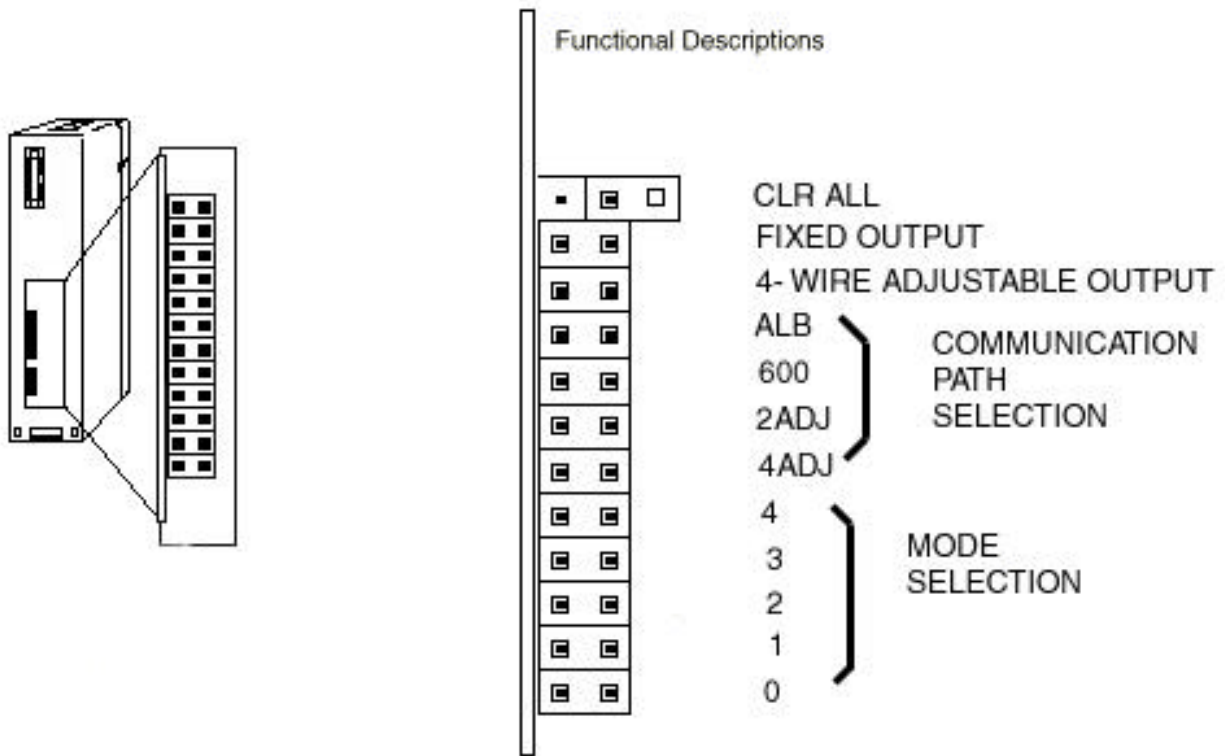
CLR ALL

This jumper should always remain on one post (this is factory setting).

CAUTION: Installing the CLR ALL jumper on both posts will prevent the module from operating correctly.

Transmit Level Adjustment Pot

Access to the transmit level adjustment pot is made via the small hole above the Port 2 DE-9 connector marked TXL. Turn the 25 turn pot clockwise to reduce the transmit level. Place a jumper on the Fixed Output posts to select the fixed -9 dBm transmit level. Place a jumper on the Four Wire Adjustable Output posts to enable transmit level adjustment.

Receive Sensitivity Adjustment Pot

Access to the receive sensitivity pot is made via the small hole above the Port 1 DE-9 connector marked SENS. Turn the 25 turn pot counter-clockwise to attenuate (decrease) the receive sensitivity. To disable the pot place a jumper on the "600" pins. To enable 2-wire or 4-wire sensitivity adjustment, position a jumper on the pins labeled "2ADJ" or "4ADJ" respectively.

Communication Path Selection

Install a single jumper in one of the four sets of pins labeled ALB, 600, 2ADJ, OR 4ADJ in the diagram below. This selects the signal path as shown in the table below.

Communication Path	ALB	600	2ADJ	4ADJ
Data TXD to RXD (analog loop back)	■	□	□	□
4-Wire w / no RXD sensitivity adjustment	□	■	□	□
2-Wire w / RXD sensitivity adjustment	□	□	■	□
4- Wire w / RXD sensitivity adjustment	□	□	□	■

Mode Selection

Modem operating mode selection is made by positioning jumpers on the last 5 pairs of pins labeled "4" to "0" as shown in the following tables. A "□ " in the following tables indicates that the jumper should be removed whereas a "■" indicates that it should be installed.

300 BAUD

Modem Operating Mode Description	4	3	2	1	0
Bell 103 orig., 300bps, full-duplex, 2-wire	■	■	■	■	■
Bell 103 orig., 300bps, full-duplex, 4-wire (Receive = Transmit frequency, 1070 / 1270 Hz)	□	■	■	■	■
Bell 103 answer, 300 bps, full-duplex, 2-wire	■	■	■	■	□
Bell 103 answer, 300 bps, full-duples, 4-wire (Receive = Transmit frequency, 2025 / 2225 Hz)	□	■	■	■	□

600 BAUD

Modem Operating Mode Description	4	3	2	1	0
CCITT V.23 mode 1, 600 bps, half-duplex, 2-wire	■	□	■	■	■
CCITT V.23 mode 1, 600 bps, full-duplex, 4-wire	□	□	■	■	■
CCITT V.23 mode 1, 600 bps, half-duplex, 2-wire w/ soft turn off	■	□	□	■	■

1200 BAUD

Modem Operating Mode Description	4	3	2	1	0
Bell 202, 1200 bps, half-duplex, 2-wire	■	■	■	□	■
Bell 202, 1200 bps, full-duplex, 4-wire	□	■	■	□	■
Bell 202 w / equalization, 1200 bps, half-duplex, 2-wire	■	■	■	□	□
Bell 202 w / equalization, 1200 bps, full-duplex, 4-wire	□	■	■	□	□
CCITT V.23 mode 2, 1200 bps, half-duplex, 2-wire	■	■	□	□	■
CCITT V.23 mode 2, 1200 bps, full-duplex, 4-wire	□	■	□	□	■
CCITT V.23 mode 2, 1200 bps, half-duplex, 2-wire w/soft turn off	■	□	□	□	■
CCITT V.23 mode 2 w / equalization, 1200 bps, half-duplex	■	■	□	□	□
CCITT V.23 mode 2 w / equalization, 1200 bps, full-duplex	□	■	□	□	□
CCITT V.23 mode 2 w / equalization, 1200 bps, half-duplex, 2-wire w/soft turn off	■	□	□	□	□

SLOT DEPENDENT V-MEMORY

There are three configuration V-Memory locations associated with each slot of a DL405 CPU base. These three locations are the Configuration Pointer, Mode Word, and Module Revision. This configuration information is read at power up and when the PLC CPU is mode is changed from program to run. When a configuration change is required, write the new information to the appropriate V-memory location, then power cycle the base or transition the PLC CPU from program to run mode. The program revision is updated when a new configuration is read. The following table shows the slot dependent configuration V-Memory locations.

Slot Dependent V-Memory Map

Slot Number	Configuration Pointer	Mode Word	Module Revision
0	V7350	V7351	V7352
1	V7353	V7354	V7355
2	V7356	V7357	V7360
3	V7361	V7362	V7363
4	V7364	V7365	V7366
5	V7367	V7370	V7371
6	V7372	V7373	V7374
7	V7375	V7376	V7377

CONFIGURATION POINTER

The Configuration Pointer specifies where in V-Memory configuration information such as station address, baud rate, radio keying times, and wait for last character time-out values are located. This value is in BCD format.

This ladder shows how a table starting address of V5000 is specified for a F4-SLV-MB installed in slot 4.

SP0	LD K5000	Word configuration will start at V5000.
	OUT V7634	Table starting address for slot 4.

MODE WORD

Each bit in the mode word enables/disables the corresponding feature shown in the table below. The mode word is read from the slot dependent V-Memory location shown in the table on page 2.5 at power up and when the PLC CPU is mode is changed from program to run.

Mode Word Table

Bit	Function	On	Off	Binary Weight
0	Modbus Port	Port 1	Port 2	1 (1H)
1	Diagnostic Mode	Enable	Disable	2 (2H)
2	RS-422 / RS-485 Multidrop	Enable	Disable	4 (4_H)
3	Timer / Count Values in Hex / BCD	Hex	BCD	8 (8_H)
4	Carrier Adjust	Enable	Disable	16 (10_H)
5	Automatic Address Recognition	Enable	Disable	32 (20_H)
6	D4-DCM Compatible	D4-DCM	FACTS	64 (40_H)
7	Mode	ASCII	RTU	128 (80_H)
8	Duplex	Full	Half	256 (100_H)
9-15	Reserved			

Modbus Port

The F4-SLV-MB determines which port to communicate Modbus through by reading this bit. Turn this bit 'ON' to select Port 1 for Modbus, 'OFF' to select Port 2 for Modbus. If diagnostic mode will be used select Modbus on port 2.

Diagnostic Mode

If enabled and the selected Modbus Port is Port 2 then all Modbus communications will be echoed out Port 1. In this mode all messages received and all replies transmitted are echoed out of port 1 at 9600 baud (no parity, 8-bit word, 1 stop bit). Data bytes are displayed in hexadecimal. Received and transmitted messages are preceded by "RXD =" and "TXD =" respectively. At power up the current module configuration will be printed out of port 1. This mode is only recommended during start-up or troubleshooting.

RS-422/RS-485 Multidrop

If enabled the RS422/485 transmitters will be enabled only when a Modbus response is sent. Turn this feature ON for hardwired multidrop-network configurations.

Timer/Counter Values in BCD

On to enable accumulated Timer (V0-V177) and Counter (V1000-1177) BCD values to be converted to hex for Modbus reads and converted from hex to BCD for Modbus writes.

Carrier Adjust

If enabled and Port 2 is the Modbus Port and Debug Mode is Enabled then the radio keying relay is closed and the radio carrier is output until this bit is reset. If Modbus is on Port 2 and Diagnostic mode is enabled the message "Adjusting Radio Modem Carrier" is printed out of port 1 until the Carrier Adjust bit is turned off. If this is not a F4-SLV-MBR module then RTS will be turned ON on port 2. This feature is for adjustment purposes only.

Automatic Address Recognition

Valid for Port 1 only. If enabled it forces an 11-Bit data frame with an 8-bit word and 1 stop bit. The 9th parity bit is used to distinguish between address and data bytes. The hardware on the F4-MAS-MB or the F4-SLV-MB checks this bit, if it is a 1 and the address byte matches, the subsequent data bytes are loaded and processed. Use this feature when all remotes are FACTS modules and the host supports AAR. The FACTS Modbus Master module F4-MAS-MB supports the AAR feature.

D4-DCM Compatibility Mode

When enabled the F4-SLV-MB or MBR uses the same memory map as a DL405 Data Communications Unit in Modbus Mode (see D4-DCM table for address). This is useful when D4-DCM's and F4-SLV's are used on the same network.

Mode

On to select Modbus ASCII. Off to select Modbus RTU.

Duplex

On to select full duplex operation. Off to select half duplex operation. Half duplex operation is typically used for Radio applications. Full duplex is typically used for direct wire applications. With half duplex operation the input buffer is cleared at the end of each response message. With full duplex messages are received in the input buffer and processed in the order they are received.

Example: Configure a F4-SLV-MB installed in Slot 4 for address 10, 9600 baud, Modbus Port 2, RS-422/RS-485 Multidrop, D4-DCM compatibility Mode, and Full Duplex operation.

```
    SP0        ┌─────────────────────┐   Word configuration start @ V5000
──┤ ├──────────┤LD                   │
              │       K5000         │
              └─────────────────────┘
              ┌─────────────────────┐   Table Starting Address for Slot 4
              │OUT                  │
              │       V7364         │
              └─────────────────────┘
              ┌─────────────────────┐   Modbus on Port 2(0) + Multidrop (4) + D4-DCM
              │LD                   │   Compatibility (64) + Full Duplex (256) = 324
              │       K324          │
              └─────────────────────┘
              ┌─────────────────────┐             0    3    2    4 (BCD)
              │BIN                  │   Convert  0000 0011 0010 0100  to
              │                     │            0000000101000100 (BIN)
              └─────────────────────┘
              ┌─────────────────────┐   Put Mode Word in Slot 4 Mode Word location
              │OUT                  │
              │       V7365         │
              └─────────────────────┘
              ┌─────────────────────┐   Specify baud rate code for 9600
              │LD                   │
              │       K6            │
              └─────────────────────┘
              ┌─────────────────────┐   Table Starting Address
              │OUT                  │
              │       V5000         │
              └─────────────────────┘
              ┌─────────────────────┐   Specify station Address 10
              │LD                   │
              │       K10           │
              └─────────────────────┘
              ┌─────────────────────┐   Table starting Address + 1
              │OUT                  │
              │       V5001         │
              └─────────────────────┘
```

MODULE REVISION

The F4-SLV-MB module writes the module revision number to this location after configuration information has been read from the PLC. The revision number is in BCD format.

CONFIGURATION TABLE

V-Memory Location	Description
V5000 (Table Beginning Address + 0)	Communication Rate Code
V5001 (Table Beginning Address +1)	Modbus Station Address
V5002 (Table Beginning Address +2)	Radio Keying On-Delay Time
V5003 (Table Beginning Address +3)	Radio Keying Off-Delay Time
V5004 (Table Beginning Address +4)	Wait for Last Character Time-Out
V5005-V5007	Reserved for future enhancements

Communication Rate Code

The Location specified as the Table Beginning Address (V5000) contains the communication rate code for the Modbus communication port. The Communication Rate Code table shows each communication rate code. If an invalid code is found the baud rate will default to 9600. The maximum baud rate for port 2 on the F4-SLV-MB is 9600. The maximum baud rate for port 2 on the F4-SLV-MBR is 1200 baud.

Communication Rate Code Table

Communication Rate Code	Communication Rate (bps)
1	300
2	600
3	1200
4	2400
5	4800
6	9600
7	19200
8	38400
9	57600
A	115200

Modbus Station Address

The Modbus station address should be placed at the Table Beginning Address + 1 (V5001). The valid addresses are between 1 and 247. If an invalid address is found the remote address will default to 1.

Radio Keying On-Delay Time

The Radio Keying On-Delay Time should be placed at the Table Beginning Address + 2 (V5002). The value is in BCD in units of milliseconds between 0 and 9999. This value is used for Port 1 and Port 2. It should be set to zero if a direct wire connection is used.

Radio Keying Off-Delay Time

The Radio Keying Off-Delay Time should be placed at the Table Beginning Address + 3 (V5003). The value is in BCD in units of milliseconds between 0 and 9999. This value is used for Port 1 and Port 2. It should be set to zero if a direct wire connection is used.

Radio Keying Timing

If the Modbus port is a RS-232 port, the Radio Keying Delays affect the RTS line of that port. If the Modbus port is a Radio Modem, the Radio Keying Delays affect the Keying Relay of that port.
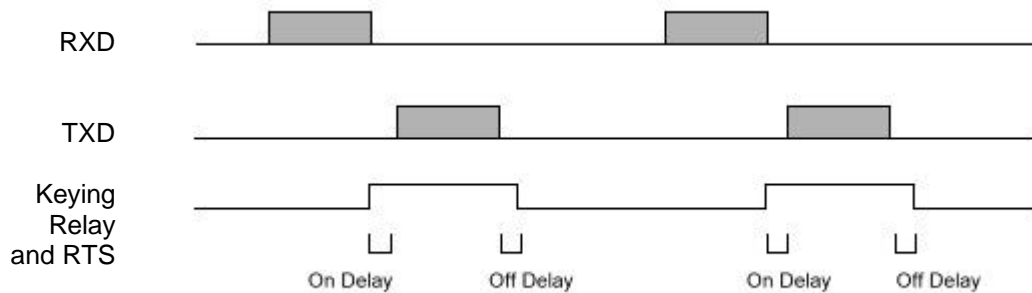
Wait for Last Character Time-Out

The Wait for Last Character Time-Out should be placed at the Table Beginning Address + 4 (V5004). The value is in BCD in units of milliseconds between 1 and 9999. This value is used for Port 1 and Port 2. This is useful for adjusting out radio noise when the carrier is dropped. If a value of zero is in this location the Wait for Last Character Time-Out will default to 3.5 character times based on the current baud rate.

MODULE CONFIGURATION

Parity and Data Bit Options

The parity and number of data bits that the selected Modbus port will uses is determined by the value at the Table Beginning Address + 5 (V5005). This value is a BCD number between 0 and 5, see the table below. If this value is greater than 5 then no parity and 8 data bits will be used. One start and one stop bit will be used with the selected parity and data bits.

Parity and Data Bit Options Table

Value	Parity	Data Bits
0	None	8
1	Odd	8
2	Even	8
3	None	7
4	Odd	7
5	Even	7

F4-SLV-MB PORT PINOUTS

PORT 1		
Pin	Symbol	Description
1	RXD1+	Data Input High, RS-422
2	TXD1	Data Output, RS-232
3	RXD1	Data Input, RS-232
4	RTS1	DTE has data to xmit, RS-232
5	CTS1	DTE may xmit data, RS-232
6	RXD1-	Data Input Low, RS-422
7	GND	Signal Ground
8	TXD1-	Data Output Low, RS-422
9	TXD1+	Data Output High, RS-422

PORT 2		
Pin	Symbol	Description
1	RXD2+	Data Input High, RS-422
2	TXD2	Data Output, RS-232
3	RXD2	Data Input, RS-232
4	RTS2	DTE has data to xmit, RS-232
5	CTS2	DTE may xmit data, RS-232
6	RXD2-	Data Input Low, RS-422
7	GND	Signal Ground
8	TXD2-	Data Output Low, RS-422
9	TXD2+	Data Output High, RS-422

F4-SLV-MBR PORT PINOUTS

PORT 1		
Pin	Symbol	Description
1	n/c	No Connection, reserved
2	TXD1	Data Output, RS-232
3	RXD1	Data Input, RS-232
4	RTS1	DTE has data to xmit, RS-232
5	CTS1	DTE may xmit data, RS-232
6	n/c	No Connection, reserved
7	GND	Signal Ground
8	n/c	No Connection, reserved
9	n/c	No Connection, reserved

PORT 2	
Pin	Description
1	Modem Transmit -
2	Modem Transmit +
3	reserved
4	Modem Receive -
5	Modem Receive +
6	no connection
7	Relay Output N.O.
8	Relay Output Com
9	no connection

Transmit Relay

An on-board Solid State relay provides a normally open contact closure which can be used to key a radio transmitter. Maximum load current is 100 mA from 0 to 300 V ac or dc. Maximum ON state resistance is 24Ω. The relay closes when the RTS line is asserted. See page 2.10 for a description of the timing of the radio keying relay.

F4-SLV-MBR WIRING DIAGRAM

F4-SLV-MBR

PC Serial port, 25 pin

Port 1	Pin
n/c	1
TXD1	2
RXD1	3
RTS1	4
CTS1	5
n/c	6
GND	7
n/c	8
n/c	9

Pin	
22	RI
3	RXD (input)
2	TXD (output)
4	RTS (output)
5	CTS (input)
7	GND (logic com)
6	DSR (input)
8	DCD (input)
20	DTR (output)

Typical Data Radio

Port 2	Pin
-Send	1
+Send	2
	3
-Rcvd	4
+Rcvd	5
	6
N.O.	7
Com	8
	9

1	-Data IN (microphone)
2	+Data IN
4	-Data OUT (speaker)
5	+Data OUT
7	+Key Transmitter
8	-Key (Push to talk)
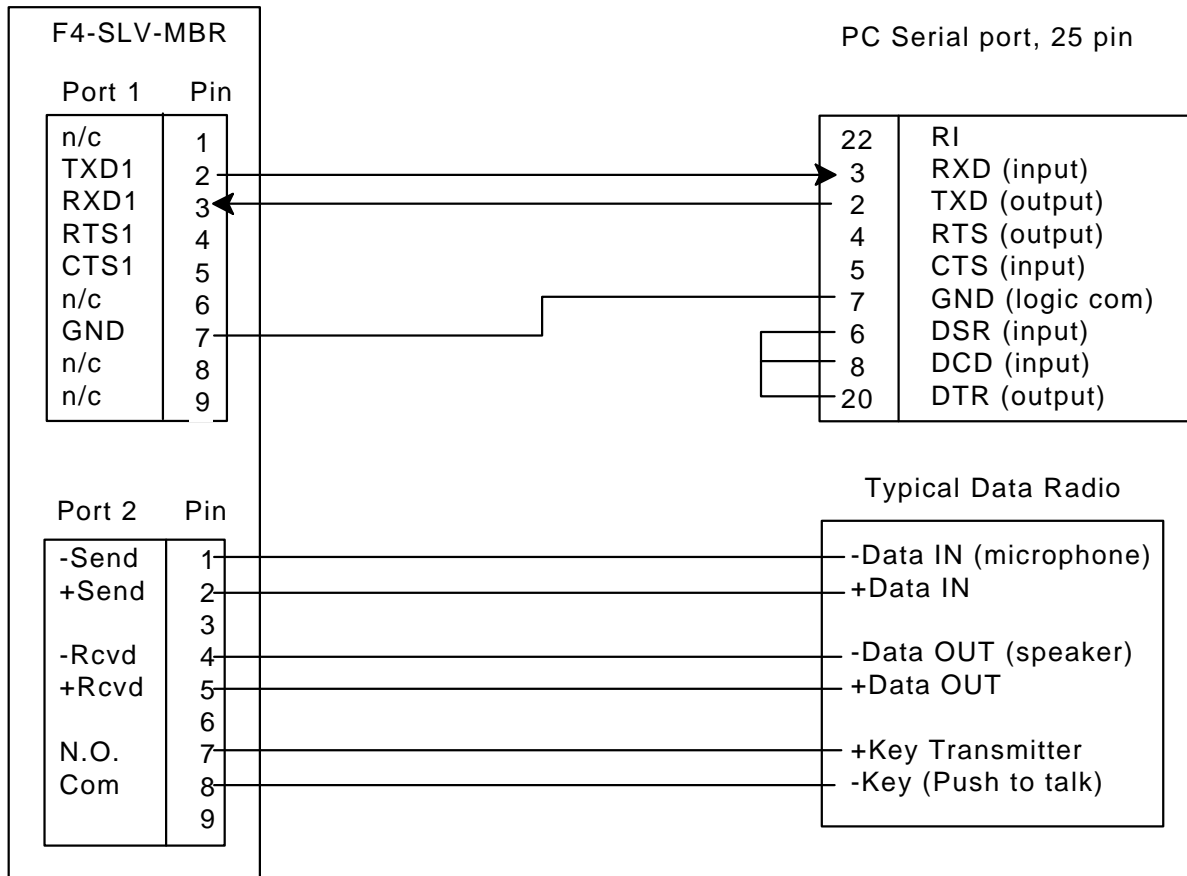
✴ For half duplex (2-wire) operation, connect Port 2 pins 1 to 4 and pins 2 to 5.

CHAPTER 3 : ADDRESSING

Modbus Data Types

The Modbus Protocol defines 4 data types, these data types are Coils, Inputs, Holding Registers, and Input Registers. The following table shows the offset (Modbus Addr. Range (Dec) and (Hex)) from the typical starting address of the particular Modbus data type.

The Modbus Coil data type uses Function Codes (FC) 1, 5, and 15 and corresponds to 405 data types Y, CR, S, T, and CT. Modbus Coil addresses are typically specified starting at 1 (484 and 584/984 addressing mode).

The Modbus Input data type uses FC 2 and corresponds to 405 data types X, GX, and SP. Modbus Input addresses are typically specified starting at 1001 (484) or 10001 (584/984).

The Modbus Input Register data type uses FC 4 and corresponds to 405 V-Memory including Accumulated Time, Accumulated Count, Data V-Memory, and System Parameter V-Memory. Modbus Input Register addresses are typically specified starting at 3001 (484) or 30001 (584/984).

The Modbus Holding Register data type uses FC 3, 6, 16 and corresponds to 405 V-Memory including Accumulated Time, Accumulated Count, Data V-Memory, and System Parameter V-Memory. Modbus Holding Register addresses are typically specified starting at 4001 (484) or 40001 (584/984).

FACTS Engineering Modbus Address Map (if bit 6 Mode Word is OFF)

Series 405 Data type	Qty	Octal Range Series 405 ref.	Modbus type	Modbus Address range (dec.)	Modbus Address range (Hex)	Function code
Accumulated Time	128	T0 - T177	I/H Reg	0 - 127	0000 - 007F	3,4,6,16
Accumulated Count	128	CT0 - CT177	I/H Reg	512 - 639	0200 - 027F	3,4,6,16
Data V-Memory	3072	V1400 - V7377	I/H Reg	768 - 3839	0300 - 0EFF	3,4,6,16
System Parameters	256	V7400 - V7777	I/H Reg	3840 - 4095	0F00 - 0FFF	3,4,6,16
Inputs	320	X0 - X477	Input	0 - 319	0000 - 013F	2
Outputs	320	Y0 - Y477	Coil	0 - 319	0000 - 013F	1,5,15
Control Relays	480	CR0 - CR737	Coil	1024 - 1503	0400 - 05DF	1,5,15
Stage Status	384	S0 - S577	Coil	3072 - 3455	00C0 - 0D7F	1,5,15
Timer Status	128	T0 - T177	Coil	4096 - 4223	1000 - 107F	1,5,15
Counter Status	128	CT0 - CT177	Coil	4608 - 4735	1200 - 127F	1,5,15
Special Purpose	96	SP0 - SP137	Input	6144 - 6239	1800 - 185F	2
Special Purpose	192	SP320 - SP617	Input	6352 - 6543	18D0 - 198F	2

D4-DCM Modbus Address Map (if bit 6 of Mode Word is ON)

Series 405 Data type	Qty	Octal Range Series 405 ref.	Modbus type	Modbus Address range (dec.)	Modbus Address range (Hex)	Function code
Accumulated Time	128	T0 - T177	I/H Reg	0 - 127	0000 - 007F	4
Accumulated Count	128	CT0 - CT177	I/H Reg	512 - 639	0200 - 027F	4
Data V-Memory	3072	V1400 - V7377	I/H Reg	768 - 3839	0300 - 0EFF	3,4,6,16
System Parameters	256	V7400 - V7777	I/H Reg	3840 - 4095	0F00 - 0FFF	3,4,6,16
Remote Inputs	512	GX0 - GX777	Input	0-511	0000 – 01FF	2
Inputs	320	X0 - X477	Input	2048 – 2367	0800 – 093F	2
Outputs	320	Y0 - Y477	Coil	2048 – 2367	0800 – 093F	1,5,15
Control Relays	480	CR0 - CR737	Coil	3072 – 3551	0C00 – 0DDF	1,5,15
Stage Status	384	S0 - S577	Coil	5120 – 5503	1400 – 157F	1,5,15
Timer Status	128	T0 - T177	Coil	6144 – 6271	1800 – 187F	1,5,15
Counter Status	128	CT0 - CT177	Coil	6400 – 6527	1900 – 197F	1,5,15
Special Purpose	96	SP0 - SP137	Input	3072 – 3167	0C00 – 0C5F	2
Special Purpose	192	SP320 - SP617	Input	3280 – 3471	0CD0 – 0D8F	2

Modbus Data Addressing

Some host software packages require you to select between 484 and 584/984 addressing. You should select 584/984 addressing for the F4-SLV-MB(R) so that the full range of each 405 data type can be accessed. If your host software only supports 484 addressing then there will be some addresses that you cannot read or write. Use the tables on the previous page and the descriptions below to select Modbus data addresses.

If your host software requires you to specify one of the 4 Modbus data types (Coil, Input, Input Register, or Holding Register), then select the data type and the address to read/write from the Modbus Addr. Range (Dec.) column.

If your host software only requires a Modbus address then use 1, 10001, 30001, or 40001 (depending on the data type) added to the address to read/write from the Modbus Addr. Range (Dec.) column.

The address offset for any 405 V-memory location is the octal V-memory location converted to decimal plus the appropriate Modbus starting address (1, 10001, 30001, 40001).

Example: What is the Modbus address for Timer 100 Current Value?
                     Timer 100 Current is V100, Octal 100 = 64 Decimal
                     Address = 30001+64 = 30065

Example: What is the Modbus address for V2100?
                     Octal 2100 = 1088 Decimal
                     Address = 40001+1088 = 41089

The address offset for 405 discrete locations (GX, X, Y, CR, S, T, CT, SP) can be determined using the appropriate address map on the previous page. Find the 405 discrete data type that you want to read/write in the address map and note the starting address from Modbus Addr. Range (Dec) column. Convert the octal address of the discrete element to decimal and add that to the first address of that data type. Add this value to 10001 if the data type is GX, X, or SP otherwise add 1.

Example: What is the Modbus address for C150?
                     Start = 1024, Octal 150 = 104 Decimal
                     Address = 1024+104+1 = 1129

Example: What is the Modbus address for X20 in D4-DCM Mode?
                     Start = 2048, Octal 20 = 16 Decimal
                     Address = 2048+16+10001 = 12065

Supported Modbus Function Codes

Code	Description	405 Data Type
01	Read group of coils	Y, CR, T, CT (all)
02	Read group of inputs	X, SP (all)
05	SET / RST single coil	Y, CR, T, CT (all)
15	SET / RST group of coils	Y, CR, T, CT (all)
03	Read value of 1 or more holding registers	V0 - V177, V1000 - V1177
03	Read value of 1 or more holding registers	V0 - V7777
04	Read value of 1 or more holding registers	V0 - V177, V1000 - V1177
04	Read 1 or more holding registers	V0 - V7777
06	Write value into a single holding register	V0 - V177, V1000 - V1177
06	Write value into a single holding register	V0 - V7777
16	Write into a group holding registers	V0 - V177, V1000 - V1177
16	Write into a group holding registers	V0 - V7777

Note: Some Modbus communication drivers may require timer / counter values (V0 - V177, V1000, V1177, V1000, V1177) to be converted from BCD to Hex for reads and from Hex to BCD for writes. This can be selected by bit 3 in the mode word.

CHAPTER 4 : TROUBLESHOOTING

Description of Normal Operation (F4-SLV-MB, Modbus on Port 2, Diagnostic Mode Enabled)

1.   At power up the F4-SLV-MB power LED comes on and stays on.

2.   The F4-SLV-MB signs on as a D4-DCM in the I/O Configuration.

3.   The Slot Dependent V-memory and the Configuration Table V-memory is read to determine the configuration. The Version/Error Code information is written to the slot dependent V-memory location.

4.   The TX1 LED flashes green while the module configuration is printed out of port 1.

5.   The RX2 LED flashes green each time a request from the Modbus master is received. The TX1 LED flashes green while the Modbus request is echoed out of Port 1 in a readable format.

6.   If the Modbus request is addressed to this slave the TXD2 LED flashes green while the response is transmitted out of port 2. The TX1 LED flashes green while the Modbus response is echoed out of Port 1 in a readable format.

7.   Steps 5 and 6 repeat.

Description of Normal Operation (F4-SLV-MB, Modbus on Port 1, RS232 with RTS/CTS)

1.   At power up the F4-SLV-MB power LED comes on and stays on.

2.   The F4-SLV-MB signs on as a D4-DCM in the I/O Configuration.

3.   The Slot Dependent V-memory and the Configuration Table V-memory is read to determine the configuration. The Version/Error Code information is written to the slot dependent V-memory location.

4.   The RX1 LED flashes green and the RX2 LED flashes red (indicates port1 CTS asserted) each time a request from the Modbus master is received.

5.   If the Modbus request is addressed to this slave the TXD1 LED flashes green and the TXD2 LED flashed red (indicates port 1 RTS) while the response is transmitted out of port 1.

6.   Steps 4 and 5 repeat.

Common F4-SLV-MB Problems and Solutions

Problem: I changed values in the Slot Dependent V-memory or Configuration Table V-memory but the changes do not have any effect.

Cause: Slot Dependent V-memory and Configuration Table V-memory is only read at power up.

Solution: Power Cycle the PLC for the changes to take effect.

Problem: The Power LED is ON and the TX LED flashes but the RX LED never flashes and the Modbus master reports a time-out error on this module's address.

Cause 1:   The baud rate does not match the Modbus master.

Solution 1:   Change the baud rate (Table Beginning Address + 0) so it matches.

Cause 2:   The address does not match the address in the Modbus master request.

Solution 2:   Verify the address the master is sending requests to and make sure the F4-SLV-MB address (Table Beginning Address + 1) contains the correct address in BCD format.

Cause 3:   The Port configuration jumper is set wrong.

Solution 3:   Set the jumper to RS232 or RS422 to match the master.

Cause 4:   The delay between each character of the Modbus master's request is too long and the F4-SLV-MB is timing out before the end of the message is received.

Solution 4:   Increase the Wait for Last Character Time-Out (Table Beginning Address + 4).

Problem: The Power LED is ON and the RX LED flashes and the TX LED flashes but the Modbus master reports a CRC-16 or time-out errors on this module's address.

Cause: In a Radio Modem application delays may be required to prevent communication errors.

Solution: The Radio Keying Delays (Table Beginning Address +2 and +3) need to be increased.

APPENDIX A : RADIO MODEM/LEASED LINE MODEM SPECIFICATIONS

TRANSMITTER SPECIFICATIONS

Description	Min	Typ	Max	Units
Fixed Carrier Output Level		-10	-9	dBm
Adjustable Carrier Output Level	-40		0	dBm
Frequency Accuracy (Except 202)	-0.4		0.4	Hz
Frequency Accuracy (202 Mark)	-1.0		1.0	Hz
Request to Send (RTS) to Clear to Send (CTS) ON Delay (std.)		25 8		ms @ 300 bps ms @ 1200 bps
Request to Send (RTS) to Clear to Send (CTS) OFF Delay (std.)		.5		msec

RECEIVER SPECIFICATIONS

Description	Min	Typ	Max	Units
Received Signal Range	-45		0	dBm
Carrier Detect ON Level		-42		dBm
Carrier Detect Hysteresis		5.5		dB
Frequency Deviation Tolerance	-16		16	Hz
Carrier Detect ON Delay	10 3		16 5	ms @ 300 bps ms @ 1200 bps
Carrier Detect OFF Delay	7 2		20 8.5	ms @ 300 bps ms @ 1200 bps

FREQUENCY PARAMETERS

Modem Mode	Baud Rate	Transmit Frequency		Receive Frequency	
		Space Hz	Mark Hz	Space Hz	Mark Hz
Bell 103 Origin	300	1070	1270	2025	2225
Bell 103 Answer	300	2025	2225	1070	1270
CCITT V.23 Mode 1	600	1700	1300	1700	1300
CCITT V.23 Mode 2	1200	2100	1300	2100	1300
CCITT V.23 Mode 2 Equalized	1200	2100	1300	2100	1300
Bell 202	1200	2200	1200	2200	1200
Bell 202 Equalized	1200	2200	1200	2200	1200

APPENDIX B : RS232 AND 422/485 WIRING DIAGRAMS

RS-232 STANDARD

RS-232-C (RS-232) is an interface standard from the Electronic Industries Association (EIA). The standard names and defines 20 communication signals, assigned to separate pins in a 25-pin connector. The five unassigned pins may carry nonstandard signals required by any individual system.

Each signal is transmitted as a positive or negative electric current between 3 and 15 volts (usually 12 volts). The signal assigned to each pin flows in one direction only. Signals output, for example, from a computer must input to a terminal, and vice versa.
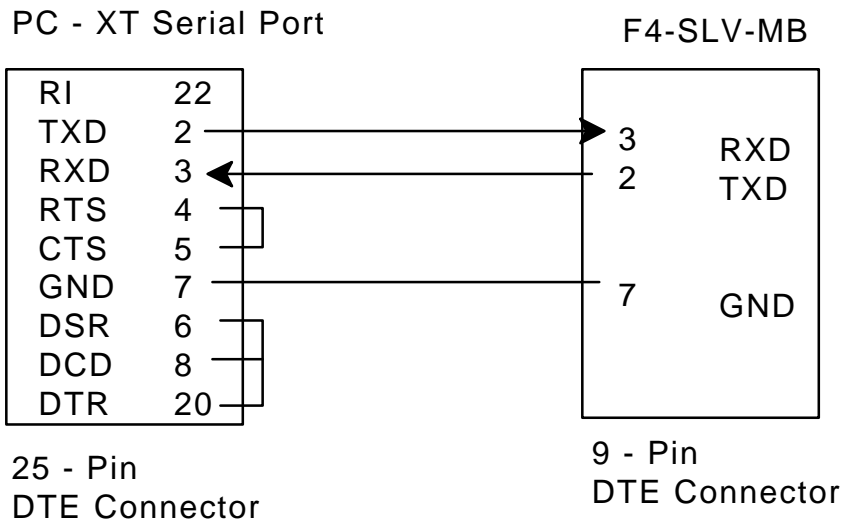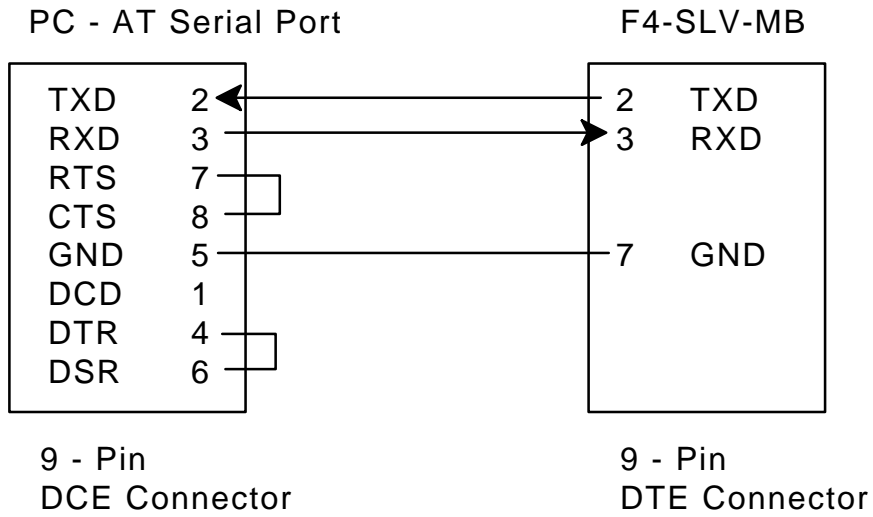
RS-232 signals travel over a serial interface cable that may have up to 25 wires. Since most signals are not required for simple communication, cables have as few as 2 or 3 wires. As shown in the following cabling diagrams, jumpers often are installed at one or both of the connectors to ensure that flow control signals are satisfied.

The signals flow between two types of interface ports, data communication equipment (DCE) and data terminal equipment (DTE). The pin names are the same for both DCE and DTE equipment, however, the direction of signal flow is reversed.

RS-232 DTE and DCE Pin Names and Signal Flow

Pin	Abrev.	Name	Signal Direction		Description
			DCE	DTE	
1	FG	Frame Ground	None	None	
2	TXD	Transmit Data	Input	Output	DTE Output Data Path
3	RXD	Receive Data	Output	Input	DCE Output Data Path
4	RTS	Request to Send	Input	Output	DTE has data to XMIT
5	CTS	Clear to Send	Output	Input	DTE may XMIT data
6	DSR	Data Set Ready	Output	Input	DCE has data to XMIT
7	SG	Signal Ground	Input	Output	
8	DCD	Data Carrier Detect	Output	Input	Modem has carrier
20	DTR	Data Terminal Ready	Input	Output	DCE may XMIT data
22	RI	Ring Indicator	Output	Input	

IBM COMPUTER CABLES

PC - AT Serial Port   F4-SLV-MB

TXD	2		2	TXD
RXD	3		3	RXD
RTS	7			
CTS	8			
GND	5		7	GND
DCD	1			
DTR	4			
DSR	6			

9 - Pin   9 - Pin
DCE Connector   DTE Connector

PC - XT Serial Port   F4-SLV-MB

RI	22			
TXD	2		3	RXD
RXD	3		2	TXD
RTS	4			
CTS	5			
GND	7		7	GND
DSR	6			
DCD	8			
DTR	20			

25 - Pin   9 - Pin
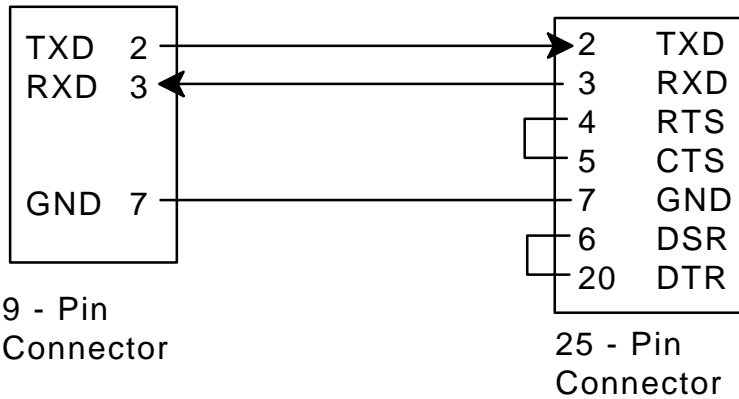DTE Connector   DTE Connector

IDENTIFYING A COMMUNICATION PORT AS DCE OR DTE

With an unknown RS-232 port powered, measure the dc voltage between pin-2 and ground (pin-7) and pin-3 and ground. If the most negative pin is pin-2 then the port is DTE. If the most negative pin is pin-3 then the port is DCE. Improper connection of pins 2 and 3 will not damage the interface.
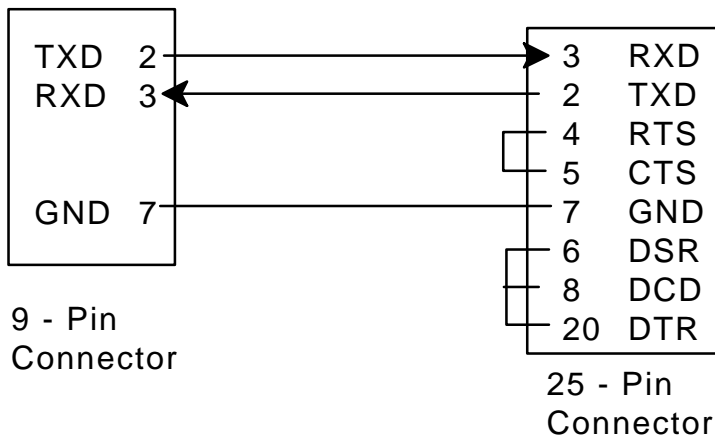
F4-SLV-MB
DTE

DCE Device

```
TXD   2 ─────────────────► 2    TXD
RXD   3 ◄───────────────── 3    RXD
                           4    RTS
                         ┐ 5    CTS
GND   7 ───────────────── 7    GND
                         ┐ 6    DSR
                         └ 20   DTR
```

9 - Pin
Connector

25 - Pin
Connector

F4-SLV-MB
DTE

DTE Device

```
TXD   2 ─────────────────► 3    RXD
RXD   3 ◄───────────────── 2    TXD
                         ┐ 4    RTS
                         └ 5    CTS
GND   7 ───────────────── 7    GND
                         ┐ 6    DSR
                         ├ 8    DCD
                         └ 20   DTR
```
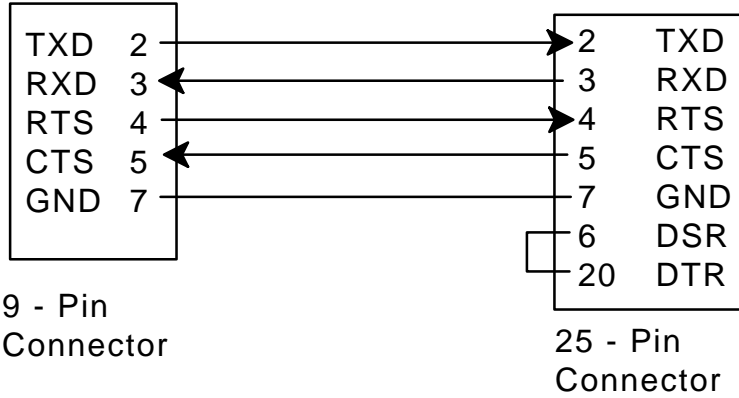
9 - Pin
Connector

25 - Pin
Connector

RS-232 WITH HARDWARE HANDSHAKE

F4-SLV-MB
DTE

Modem or other DCE Device
requiring Hardware Handshaking

F4-SLV-MB				Modem/DCE
TXD	2	→	2	TXD
RXD	3	←	3	RXD
RTS	4	→	4	RTS
CTS	5	←	5	CTS
GND	7	—	7	GND
			6	DSR
			20	DTR

9 - Pin
Connector

25 - Pin
Connector

F4-SLV-MB
DTE

DTE Device requiring
hardware Handshaking

F4-SLV-MB				DTE Device
TXD	2	→	3	RXD
RXD	3	←	2	TXD
RTS	4	→	6	DSR
CTS	5	←	20	DTR
GND	7	—	7	GND
			8	DCD
			5	CTS
			4	RTS

9 - Pin
Connector

25 - Pin
Connector
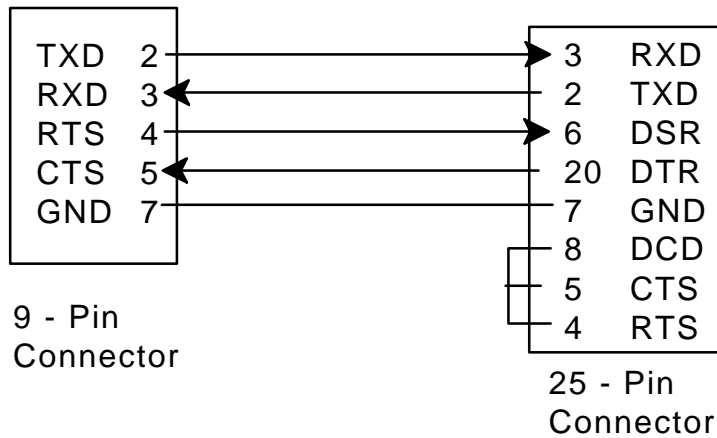
RS-422/485 STANDARD

The RS-485 transceivers on CoProcessor's so equipped are compatible with both RS-422 and RS-485 signals.
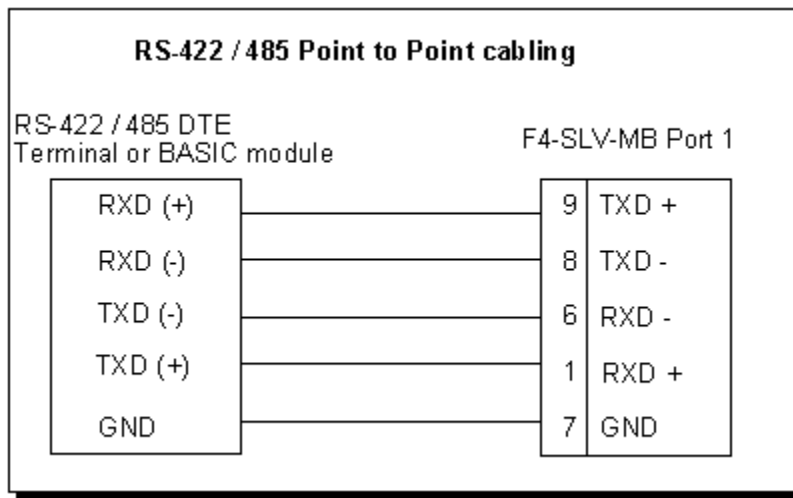
RS-422 uses high current differential outputs and is specified to 4000 feet at 10 Megabaud. Lower speed communications, such as 19.2K baud, may use substantially longer cables.

RS-485 is an upgraded version of EIA RS-422-A and offers higher current tri-state drivers which are internally protected from bus contentions caused by multiple drivers on the same line. RS-485 drivers will also withstand higher voltages on their outputs when disabled (high impedance state). RS-485 is specified for multiple transmitter and multiple receiver systems as well as single and multi-drop RS-422 applications. The RS-422 specification permits only one driver and 10 receivers on a line. The RS-485 standard allows up to 32 drivers and receivers on the same transmission line.
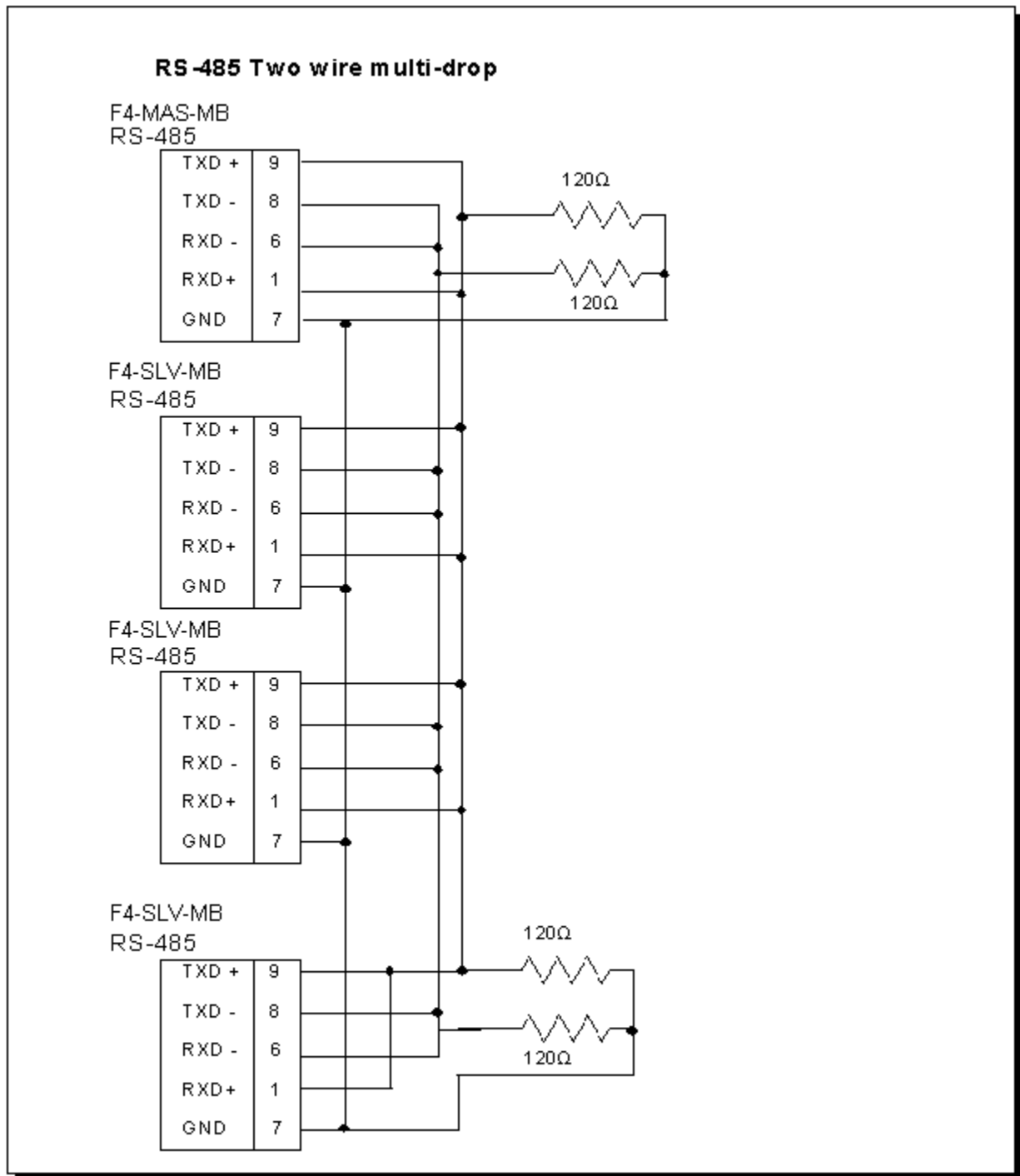
RS-422/485 COMMUNICATION

Most CoProcessors have one RS-422/485 communication interface some have two. To select a port for RS232 or RS422/485 data reception mode, please refer to "JUMPER DESCRIPTIONS AND LOCATIONS" in the chapter for the CoProcessor module that you are using. Transmissions from a selectable port are always available at RS-232 and RS-422/485 signal levels simultaneously.

RS-422/485 POINT-TO-POINT CABLING

RS-422 / 485 Point to Point cabling

RS-422 / 485 DTE Terminal or BASIC module		F4-SLV-MB Port 1	
RXD (+)		9	TXD +
RXD (-)		8	TXD -
TXD (-)		6	RXD -
TXD (+)		1	RXD +
GND		7	GND

RS-485 TWO WIRE MULTI-DROP

RS-422 / 485 four wire multi-drop

F4-MAS-MB
RS-422

RXD +	1
RXD -	6
TXD -	8
TXD+	9
GND	7

120Ω

120Ω

F4-SLV-MB
RS-422

TXD +	9
TXD -	8
RXD -	6
RXD+	1
GND	7

F4-SLV-MB
RS-422

TXD +	9
TXD -	8
RXD -	6
RXD+	1
GND	7

F4-SLV-MB
RS-422

TXD +	9
TXD -	8
RXD -	6
RXD+	1
GND	7

120Ω

120Ω
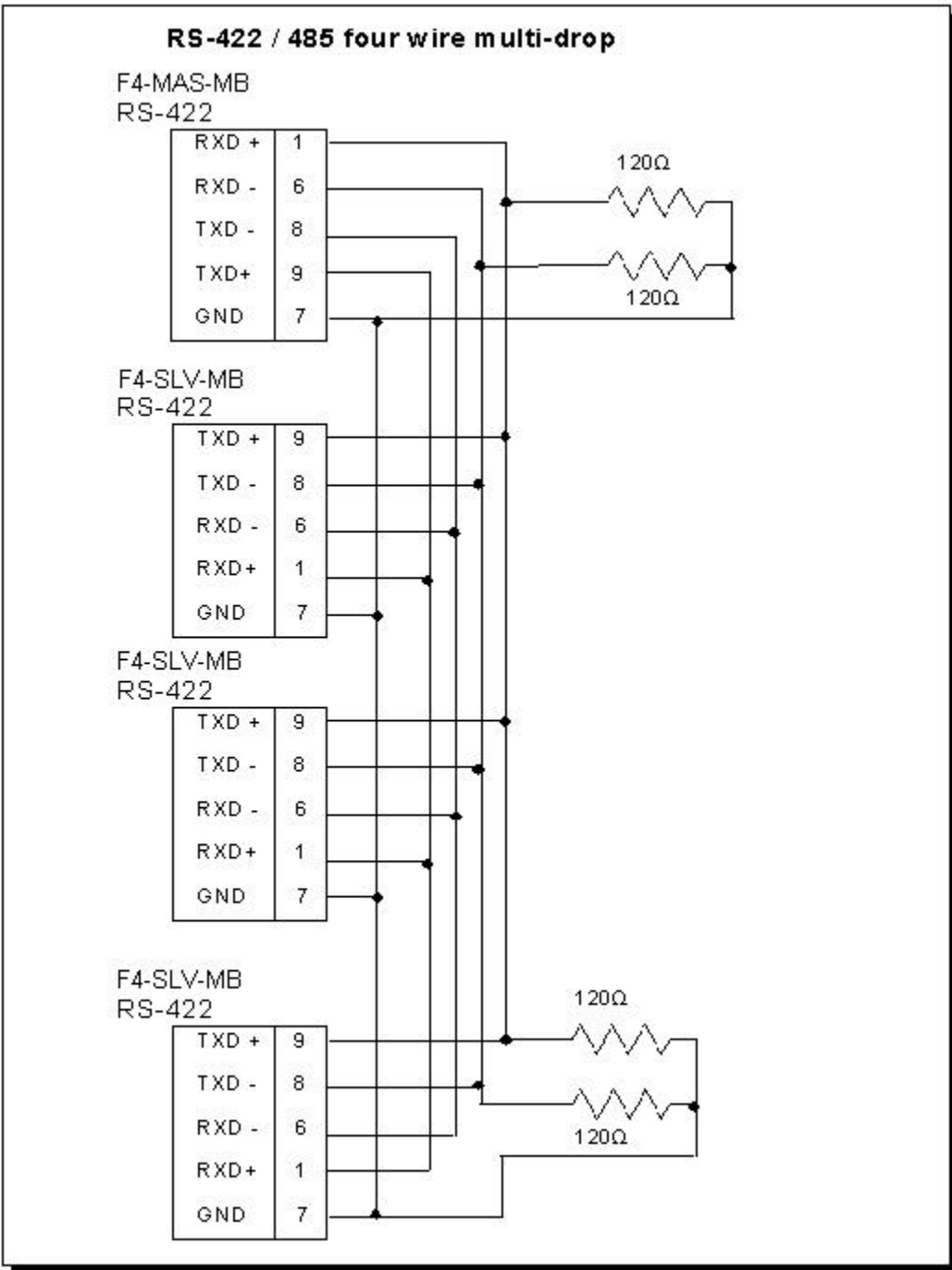
Cable Shielding

Shielding improves noise immunity (magnetic field protection). It is important to ground the shield at the receiver end only. Grounding the receiver end only provides the least high frequency signal attenuation and the best rejection of unwanted signals. Grounding both ends of the shield will cause magnetic field induced noised currents to flow through ground. Noise may then appear on the data lines due to transformer like coupling with the shield. If the cable shield is used as the system ground conductor then placing a 100Ω resistor in series with the shield and the ground connection will reduce noise producing ground currents.

Connecting Cables and Line Termination

A dual twisted pair plus ground connection is recommended for 4-wire RS-422 networks. Proper termination of the balanced transmission line is required to prevent data errors. A typical AWG 22 solid wire with .060 inch plastic cover, twisted 4.5 times per foot has a characteristic impedance of about 120Ω. Thus the selection of the two 62Ω line-to-ground terminating resistors. Line-to-ground termination is preferred to the often shown line-to-line 120Ω termination. In noisy or long line applications the much better line-to-ground common-mode rejection capability is particularly important. In multidrop networks, the line must be terminated at the extreme ends only as shown in the two previous diagrams. Addition of intermediate terminations will adversely load the line. If both the transmit and receive ends of the same twisted pair are terminated, double the value of the termination resistors.