Introduction to Serial Communications

Appendix K

In This Appendix...

Introduction to Serial Communications

*Direct*LOGIC® PLCs have two built-in serial communication ports which can be used to communicate to other PLCs or to other serial devices. To fully understand the capabilities and limitations of the serial ports, a brief introduction to serial communications is in order.

There are three major components to any serial communications setup:

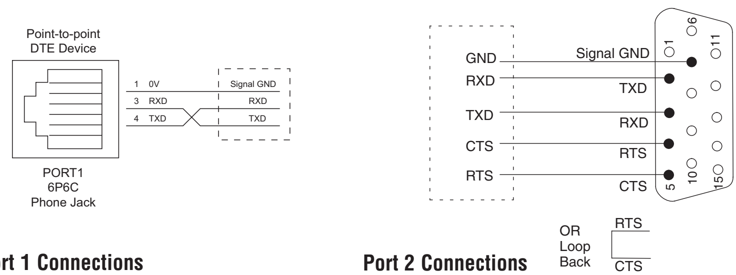
- Wiring standard
- Communications protocol
- Communications parameters

Each of these will be discussed in more detail as they apply to ***Direct***LOGIC PLCs.

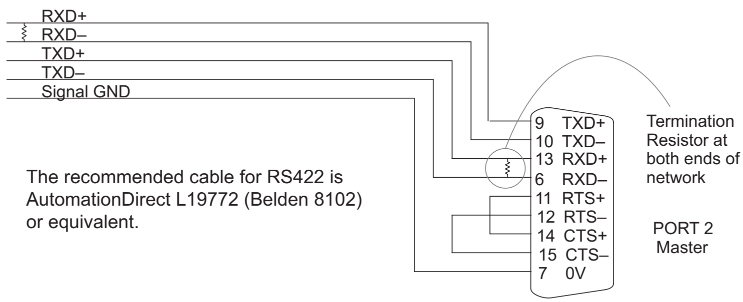
Wiring Standards

There are three different wiring standards that can be used with ***Direct***LOGIC PLCs: RS-232C, RS-422 and RS-485.

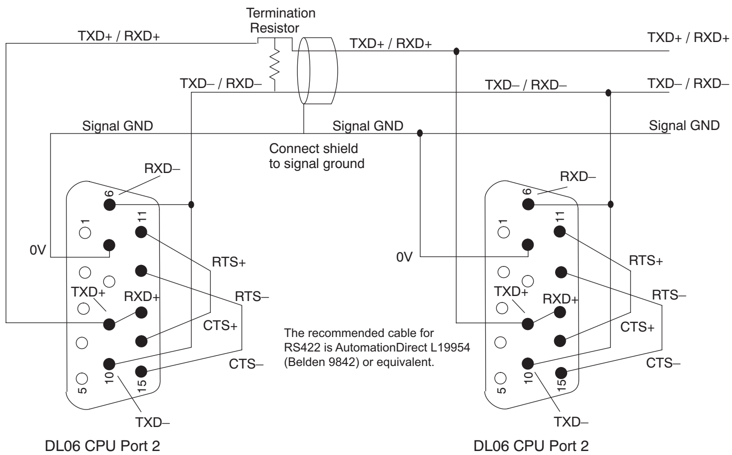
RS-232C is a point-to-point wiring standard with a practical wiring distance of 15 meters (50 feet) maximum. This means that only two devices can communicate on an RS-232C network – a single master device and a single slave device. The total cable length cannot exceed 50 feet. AutomationDirect L19772 (Belden® 8102), or equivalent, is recommended for RS-232C networks.



RS-422 is a multi-point wiring standard with a practical wiring distance of 1000 meters (3280 feet) . The RS-422 wiring standard does not specify a network topology, but in practice, a daisy-chain topology with the master at one end is the only way to ensure network reliability. AutomationDirect L19772 (Belden® 8102), or equivalent, is recommended for RS-422 networks. Use a terminating resistor equal in value to the characteristic impedance of the cable being used (100 Ω for AutomationDirect L19772 [Belden® 8102]).



RS-485 is a multi-point wiring standard with a practical wiring distance of 4000 feet maximum. This wiring standard provides for the possibility of up to 32 masters communicating to up to 32 slaves, all within the maximum distance of 4000 feet. Note that while the RS-485 wiring standard provides for multiple masters on the same network, **the *Direct*LOGIC PLCs do not support multiple masters on a single network.** The RS-485 wiring standard does not specify a network topology, but in practice, a daisy-chain topology with the master at one end is the only way to ensure network reliability. AutomationDirect L19954 (Belden 9842), or equivalent is recommended for RS-485 networks. Use a terminating resistor equal in value to the characteristic impedance of the cable being used (120Ω for AutomationDirect L19954 [Belden 9842]).



Communications Protocols

A communications protocol is the language the devices on a network use to communicate with each other. All the devices on the network must use the same communications protocol in order to be able to communicate with each other. The protocols available in the *Direct*LOGIC PLCs are listed in the following table.

Communications Protocols							
Protocol	**Master**	**Slave**	**Port 1***	**Port 2**	**RS-232C**	**RS-422**	**RS-485****
K-Sequence	No	Yes	Yes	Yes	Yes	Yes	No
*Direct*NET	Yes	Yes	Yes	Yes	Yes	Yes	No
MODBUS RTU	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ASCII (Non-Sequence)	Out	In	No	Yes	Yes	Yes	Yes

*** Port 1 supports slave only and is only RS-232C with fixed communications parameters of 9600 baud, 8 data bits, 1 start bit, 1 stop bit, odd parity and station address 1. It is an asynchronous, half-duplex DTE port and auto-selects between K-Sequence, DirectNET and MODBUS RTU protocols.**
**** RS-485 is available on Port 2 for MODBUS RTU and Non-Sequence protocol.**

K-Sequence protocol is not available for use by a master DL06 PLC. Therefore, it cannot be used for networking between PLCs. Its primary use in the DL06 PLC is as a slave to *Direct*SOFT programming software and to an operator interface.

*Direct*NET protocol is available for use by a master or by a slave DL06 PLC. This, and the fact that it is *native* protocol, makes it ideal for PLC-to-PLC communication over a point-to-point to multipoint network using the RX and WX instructions.

MODBUS RTU protocol is a very common industry standard protocol, and can be used by a master or slave DL06 to communicate with a wide variety of industrial devices which support this protocol.

ASCII (**Non-Sequence**) is another very common industry standard protocol, and is commonly used where alpha-numeric character data is to be transferred. Many input devices, such as, barcode readers and electronic scales use ASCII protocol, and many output devices accept ASCII commands, as well.

It doesn't matter which wiring standard or protocol is used, there are several communications parameters to select for each device before they will be able to communicate. These parameters include:

Baud Rate	Flow Control
Data Bits	Echo Suppression
Parity	Timeouts
Stop Bits	Delay Times
Station Address	Format

All of these parameters may not be necessary, or available, for your application. The parameters used will depend on the protocol being used and whether the device is a master or slave.

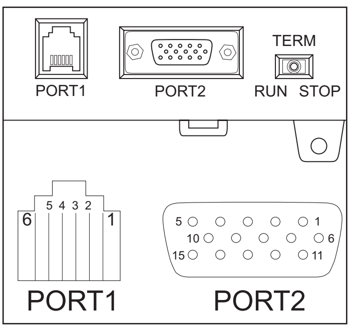
NOTE: *REMEMBER: When the same parameter is available in the master and in the slave (i.e. Baud Rate, Parity, Stop Bits, etc.) the settings must match.*

DL06 Port Specifications

Communications Port 1	
Port 1	Connects to HPP, ***Direct***SOFT, operator interfaces, etc.
	6-pin, RS232C
	Communication speed (baud): 9600 (fixed)
	Parity: odd (fixed)
	Station Address: 1 (fixed)
	8 data bits
	1 start, 1 stop bit
	Asynchronous, half-duplex, DTE
	Protocol (auto-select): K-sequence (slave only), ***Direct***NET (slave only), MODBUS (slave only)

Communications Port 2	
Port 2	Connects to HPP, ***Direct***SOFT, operator interfaces, etc.
	15-pin, multifunction port, RS232C, RS422, RS485 (RS485 with 2-wire is only available for MODBUS and Non-sequence)
	Communication speed (baud): 300, 600, 1200, 2400, 4800, 9600, 19200, 38400
	Parity: odd (default), even, none
	Station Address: 1 (default)
	8 data bits
	1 start, 1 stop bit
	Asynchronous, half-duplex, DTE
	Protocols can be pre-selected: K-sequence (slave only), ***Direct***NET (master/slave), MODBUS (master/slave), Non-Sequence/Print/ASCII in/out

DL06 Port Pinouts



Port 1 Pin Descriptions		
1	0V	Power (-) connection (GND)
2	5V	Power (+) connection
3	RXD	Receive data (RS-232C)
4	TXD	Transmit data (RS-232C)
5	5V	Power (+) connection
6	0V	Power (-) connection (GND)

Port 2 Pin Descriptions		
1	5V	Power (+) connection
2	TXD	Transmit data (RS-232C)
3	RXD	Receive data (RS-232C)
4	RTS	Ready to send (RS-232C)
5	CTS	Clear to send (RS232C)
6	RXD-	Receive data (-) (RS-422/485)
7	0V	Power (-) connection (GND)
8	0V	Power (-) connection (GND)
9	TXD+	Transmit data (+) (RS-422/485)
10	TXD-	Transmit data (-) (RS-422/485)
11	RTS+	Ready to send (+) (RS-422/485)
12	RTS-	Ready to send (-) (RS-422/485)
13	RXD+	Receive data (+) (RS-422/485)
14	CTS+	Clear to send (+) (RS-422/485)
15	CTS-	Clear to send (-) (RS-422/485)

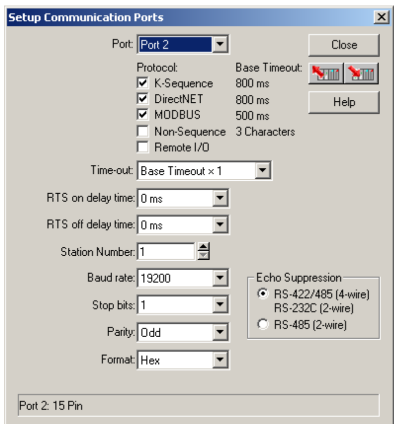
Note that the default configuration for port 2 is:

- Auto-detect among K-Sequence, DirectNET, and MODBUS RTU protocols
- Timeout = Base Timeout x 1 (800 ms)
- RTS on delay time = 0 ms
- RTS off delay time = 0 ms
- Station Number = 1
- Baud rate = 19200
- Stop bits = 1
- Parity = odd
- Format = Hex
- Echo Suppression = RS-422/485 (4-wire) or RS-232C

Port Setup Using DirectSOFT or Ladder Logic Instructions

Port 2 on the DL06 can be configured for communications using the various protocols which have been previously mentioned. Also, the communications parameters can be configured to match the parameters in the other device(s) with which the PLC will be communicating. The port may be configured using the ***Direct***SOFT PLC programming software, or by using ladder logic within the PLC program. It is important to note that the settings for port 2 are never saved to disk with ***Direct***SOFT, so if you are using port 2 in other than its default configuration (see page K-6) it is a good idea to include the port setup in the ladder program, typically on a first scan bit, or in an initialization subroutine.

To setup port 2 using ***Direct***SOFT, the PLC must be turned on and connected to ***Direct***SOFT. If the PLC Setup toolbar is displayed, either select the **Port 2** button or select **PLC > Setup > Setup Sec. Comm Port...** from the menu bar located at the top of the programming window. A dialog box like the one below will appear. Make the appropriate settings and write them to the PLC.



In order to setup port 2 in your relay ladder logic, the appropriate values must be written to V7655 (Word 1), V7656 (Word 2) and V7650 (Word 3, for ASCII only) to specify the settings for the port. Then write the 'setup complete' flag (K0500) to V7657 (Word 4) to request the CPU to accept the port settings. Once the CPU sees the 'setup complete' flag in V7657 it will test the port settings which have selected for validity, and then change the value in V7657 according to the results of this test. If the port settings are valid, the CPU will change the value in V7657 to 0A00 (**A** for Accepted). If there was an error in the port settings, the CPU will change the value in V7657 to 0E00 (**E** for Error).

NOTE: This is a Helpful Hint: *Rather than build the setup words manually from the tables, use* ***Direct****SOFT to setup the port as desired then use a Dataview to view the setup words as BCD/HEX. Then simply use these numbers in the setup code.*

The data that is written to the port setup words has two formats. The format that is used depends on whether K-Sequence, ***Direct***NET, MODBUS RTU (method 1) or ASCII (method 2) is selected.

Port 2 Setup for RLL Using K-Sequence, DirectNET or MODBUS RTU

V7655 (Word 1)	RTS On-delay	Timeout (% of timeout)	Protocol	RTS Off-delay
0yyy 0ttt mmmm mxxx	yyy	ttt	mmmmm	xxx
	000 = 0ms	000 = 100%	10000 = K-Sequence	000 = 0ms
	001 = 2ms	001 = 120%	01000 = ***Direct***NET	001 = 2ms
	010 = 5ms	010 = 150%	00100 = MODBUS RTU	010 = 5ms
	011 = 10ms	011 = 200%		011 = 10ms
	100 = 20ms	100 = 500%		100 = 20ms
	101 = 50ms	101 = 1000%		101 = 50ms
	110 = 100ms	110 = 2000%		110 = 100ms
	111 = 500ms	111 = 5000%		111 = 500ms

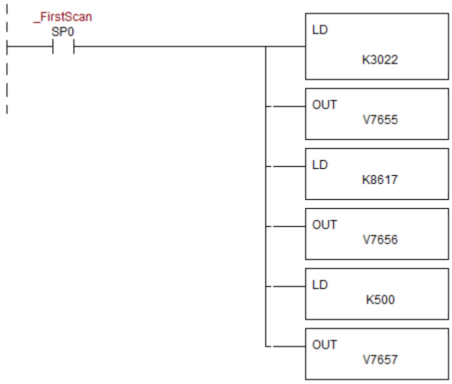
V7656 (Word 2)	Parity	Stop Bits	Echo Suppression	Baud Rate
K-Sequence, *Direct*NET & MODBUS RTU				
pps0 ebbb xaaa aaaa	pp	s	e	bbb
	00 = None	0 = 1 bit	0 = RS232/RS422/ RS485 (4-wire)	000 = 300
	10 = Odd	1 = 2 bits	1 = RS485, 2 wire	001 = 600
	11 = Even			010 = 1200
				011 = 2400
				100 = 4800
				101 = 9600
				110 = 19200
				111 = 38400

V7656 (Word 2) cont'd	Protocol	Secondary Address
K-Sequence, *Direct*NET & MODBUS RTU	(***Direct***NET)	xaaaaaaa (***Direct***NET)
pps0 ebbb xaaa aaaa	x	_aaaaaaa (K-Sequence & MODBUS RTU)
	0 = Hex	K-Sequence: 1-90
	1 = ASCII	***Direct***NET: 1-90
		MODBUS: 1-247

V7650 (Word 3)	V-memory address for data
DL05/DL06	For Non-Sequence (ASCII) only

V7657 (Word 4)	Setup and Completion Code
DL05/DL06	Write K0500 to accept Port 2 setup. When PLC accepts the changes, it changes the value to K0A00 in the same location. If there is an error it changes the value to K0E00 in the same location.

To setup port 2 for MODBUS protocol for the following: RTS On-delay of 10ms, Base timeout x1, RTS Off-delay of 5ms, Odd parity, 1 Stop bit, echo suppression for RS232-C/ RS422, 19,200 baud, Station Number 23 you would use the relay ladder logic shown below.



Port 2 Setup for RLL Using ASCII (Non-Sequence)

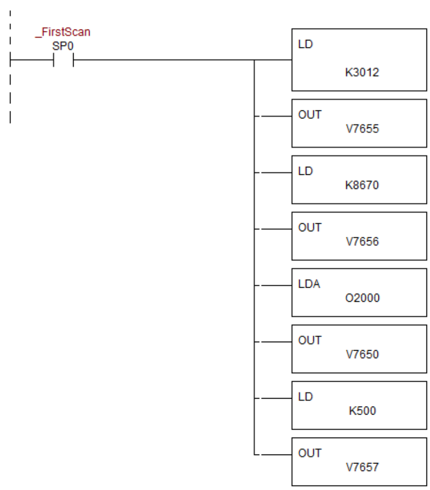
Word 1	RTS On-delay	Timeout (in% of std. timeout)	Protocol	RTS Off-delay
0yyy 0ttt mmmm mxxx	yyy	ttt	mmmmm	xxx
DL05/06: V7655	000 = 0ms	000 = Base timeout	00010 = Non-Sequence	000 = 0ms
	001 = 2ms	001 = Base timeout + 2ms		001 = 2ms
	010 = 5ms	010 = Base timeout + 5ms		010 = 5ms
	011 = 10ms	011 = Base timeout + 10ms		011 = 10ms
	100 = 20ms	100 = Base timeout + 20ms		100 = 20ms
	101 = 50ms	101 = Base timeout + 50ms		101 = 50ms
	110 = 100ms	110 = Base timeout + 100ms		110 = 100ms
	111 = 500ms	111 = Base timeout + 500ms		111 = 500ms

Word 2	Parity	Stop Bits	Data Bits	Echo Suppression (valid for DL06 only)	Baud Rate	Protocol Mode
ppsd ebbb xaaa aaaa	pp	s	d	e	bbb	aaaa aaaa
DL05/06: V7656	00 = None	0 = 1 bit	0 = 8 bits	0 = RS-232/RS-422/ RS-485 (4 wire)	000 = 300	0111 0000 = No flow control
	10 = Odd	1 = 2 bits	1 = 7 bits	1 = RS-485 (2 wire)	001 = 600	0111 0001 = Xon/Xoff flow control
	11 = Even				010 = 1200	0111 0010 RTS flow control
					011 = 2400	0111 0011 = Xon/Xoff and RTS flow control
					100 = 4800	
					101 = 9600	
					110 = 19200	
					111 = 38400	

Word 3	V-memory address for data
DL05/06: V7650	Hex value of the V-memory location to temporarily store the ASCII data coming into the PLC. Set this parameter to the start of a contiguous block of 64 unused words.

Word 4	Setup and Completion Code
DL05/06: V7657	Write K0500 to accept Port 2 setup. When PLC accepts the changes, it changes the value to K0A00 in the same location. If there is an error, it changes the value to K0E00 in the same location.

To setup port 2 for Non-sequence (ASCII) communications with the following: RTS On-delay of 10ms; Base timeout x1; RTS Off-delay of 5ms; Odd parity; 1 Stop bit; echo suppression for RS232-C/RS422; 19,200 baud; 8 data bits; V-memory buffer starting at V2000; and no flow control, you would use the relay ladder logic shown below.



K-Sequence Communications

The K-Sequence protocol can be used for communication with *Direct*SOFT, an operator interface or any other device that can be a K-Sequence master. The DL06 PLC can be a K-Sequence **slave** on either port 1 or port 2. The DL06 PLC cannot be a K-Sequence **master.**

In order to use port 2 for K-Sequence communications you first need to set up the port using either *Direct*SOFT or ladder logic as described above.

DirectNET Communications

The *Direct*NET protocol can be used to communicate to another PLC or to other devices that can use the *Direct*NET protocol. The DL06 can be used as either a master, using port 2 or as a slave, using either port 1 or port 2.

In order to use port 2 for *Direct*NET communications you must first set up the port using either *Direct*SOFT or ladder logic as previously described.

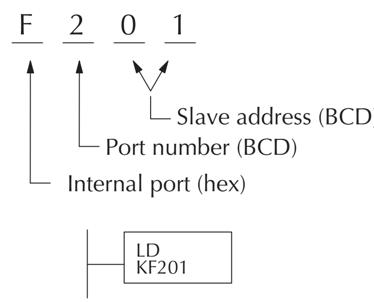
For network slave operation, nothing more needs to be done. Port 2 will function as a slave unless network communications instructions are executed by the ladder logic program.

For a network master operation you will simply need to add some ladder rungs using the network communication instructions RX and/or WX. If more than one network communication instruction is used, the rungs need to be interlocked to ensure that only one communication instruction is executed at any given time. If you have just a few network communications instructions in your program, you can use discrete bits to interlock them. If you are using many network communications instructions, a counter or a shift register will be a more convenient way to interlock the instructions.

The following step-by-step procedure will provide the information necessary to set up your ladder program to receive data from a network slave.

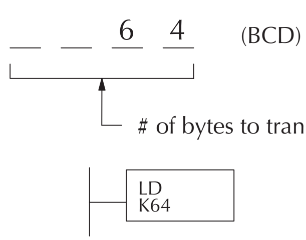
Step 1: Identify Master Port # and Slave

The first Load (LD) instruction identifies the communications port number on the network master (DL06) and the address of the slave station. This instruction can address up to 99 MODBUS slaves, or 90 *Direct*NET slaves. The format of the word is shown to the right. The **F2** in the upper byte indicates the use of the right port of the DL06 PLC, port number 2. The lower byte contains the slave address number in BCD (01 to 99).



Step 2: Load Number of Bytes to Transfer

The second Load (LD) instruction determines the number of bytes which will be transferred between the master and slave in the subsequent WX or RX instruction. The value to be loaded is in BCD format (decimal), from 1 to 128 bytes.



The number of bytes specified also depends on the type of data you want to obtain. For example, the DL06 Input points can be accessed by V-memory locations or as X input locations. However, if you only want X0 – X27, you'll have to use the X input data type because the V-memory locations can only be accessed in 2-byte increments. The following table shows the byte ranges for the various types of *Direct*LOGIC products.

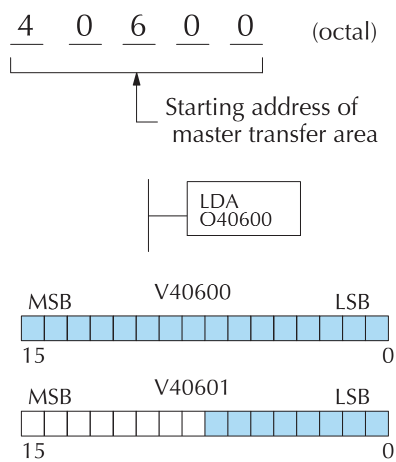
DL05 / 06 / 205 / 350 / 405 Memory	Bits per unit	Bytes
V-memory T / C current value	16 16	2 2
Inputs (X, SP)	8	1
Outputs (Y, C, Stage, T/C bits)	8	1
Scratch Pad Memory	8	1
Diagnostic Status	8	1

DL330 / 340 Memory	Bits per unit	Bytes
Data registers T / C accumulator	8 16	1 2
I/O, internal relays, shift register bits, T/C bits, stage bits	1	1
Scratch Pad Memory	8	1
Diagnostic Status(5 word R/W)	16	10

The third instruction in the RX or WX sequence is a Load Address (LDA) instruction. Its purpose is to load the starting address of the memory area to be transferred. Entered as an octal number, the LDA instruction converts it to hex and places the result in the accumulator.

For a WX instruction, the DL06 CPU sends the number of bytes previously specified from its memory area beginning at the LDA address specified.

For an RX instruction, the DL06 CPU reads the number of bytes previously specified from the slave, placing the received data into its memory area beginning at the LDA address specified.

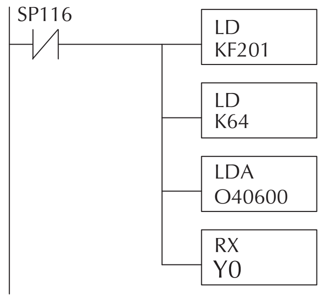


Step 3: Specify Master Memory Area

NOTE*: Since V-memory words are always 16 bits, you may not always use the whole word. For example, if you only specify 3 bytes and you are reading Y outputs from the slave, you will only get 24 bits of data. In this case, only the 8 least significant bits of the last word location will be modified. The remaining 8 bits are not affected.*

Step 4: Specify Slave Memory Area

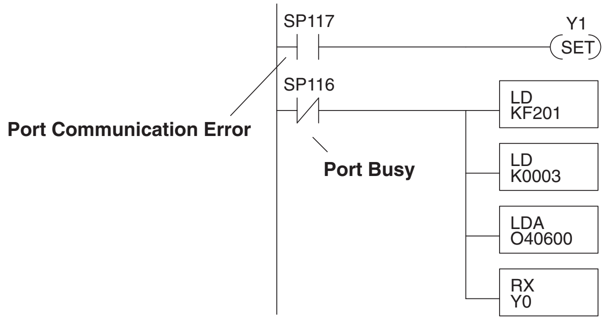
The last instruction in our sequence is the WX or RX instruction itself. Use WX to write to the slave, and RX to read from the slave. All four of our instructions are shown to the right. In the last instruction, you must specify the starting address and a valid data type for the slave.



- DirectNET slaves – specify the same address in the WX and RX instruction as the slave's native I/O address
- MODBUS DL405, DL205, or DL06 slaves – specify the same address in the WX and RX instruction as the slave's native I/O address
- MODBUS 305 slaves – use the following table to convert DL305 addresses to MODBUS addresses.

DL305 Series CPU Memory Type–to–MODBUS Cross Reference (excluding 350 CPU)					
PLC Memory Type	**PLC Base Address**	**MODBUS Base Address**	**PLC Memory Type**	**PLC Base Address**	**MODBUS Base Address**
TMR/CNT Current Values	R600	V0	TMR/CNT Status Bits	CT600	GY600
I/O Points	IO 000	GY0	Control Relays	CR160	GY160
Data Registers	R401,R400	V100	Shift Registers	SR400	GY400
Stage Status Bits (D3-330P only)	S0	GY200			

Communications from a Ladder Program

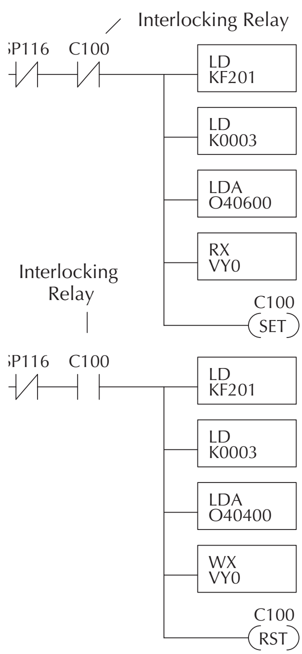


Typically, network communications will last longer than 1 scan. The program must wait for the communications to finish before starting the next transaction.

Port 2, which can be a master, has two Special Relay contacts associated with it (see Appendix D for comm port special relays). One indicates "Port busy"(SP116), and the other indicates "Port Communication Error"(SP117). The example above shows the use of these contacts for a network master that only reads a device (RX). The "Port Busy" bit is on while the PLC communicates with the slave. When the bit is off the program can initiate the next network request.

The "Port Communication Error" bit turns on when the PLC has detected an error. Use of this bit is optional. When used, it should be ahead of any network instruction boxes since the error bit is reset when an RX or WX instruction is executed.

Multiple Read and Write Interlocks



If you are using multiple reads and writes in the RLL program, you have to interlock the routines to make sure all the routines are executed. If you don't use the interlocks, then the CPU will only execute the first routine. This is because each port can only handle one transaction at a time.

In the example to the right, after the RX instruction is executed, C100 is set. When the port has finished the communication task, the second routine is executed and C100 is reset.

If you're using RLL*PLUS* Stage Programming, you can put each routine in a separate program stage to ensure proper execution and switch from stage to stage allowing only one of them to be active at a time.

MODBUS RTU Communications

The MODBUS RTU protocol can be used for communication with any device that uses the MODBUS RTU protocol. The protocol is very common and is probably the closest thing to an "industry standard" protocol in existence. The DL06 can be a MODBUS RTU slave on either port 1 or port 2, and it can be a MODBUS RTU master on port 2. The RS 485 wiring standard may be used on port 2 for the MODBUS RTU protocol only.

In order to use port 2 for MODBUS RTU communications you must first set up the port using either ***Direct***SOFT or ladder logic as previously described.

For network slave operation, nothing more needs to be done. Port 2 will function as a slave unless network communications instructions are executed by the ladder logic program.

For network master operation the MODBUS RTU network communication instructions MRX and/or MWX must be added to some ladder rungs. If more than one network communication instruction is used, the rungs need to be interlocked to ensure that only one communication instruction is executed at any given time. If only a few network communications instructions are used in your program, discrete bits can be used to interlock them. If many network communications instructions are used, either a counter or a shift register will be a more convenient way to interlock the instructions.