Using a Factory Network for Inverter Operation

4

In This Chapter. . . . page

Setting Up a Network Interface

Introduction

In addition to providing a full-featured operator interface, the SC-OPE 3I provides a factory network interface function. Using a factory network allows a host computer or controller to command multiple inverters on a single network. Each inverter will have its own address (or station number) on the network (except for Allen-Bradley DF1). The protocol you will need to use is determined by the requirements of the master controller (or host) on the factory network. The SC-OPE is configurable to use one of the following networks:

Protocol	Inverter Address Range	Default Address
DirectNet	1 to 90	1
Allen-Bradley DF1	—	—
ModBus RTU	1 to 255	1
ModBus ASCII	1 to 255	1
Metasys N2	1 to 255	2

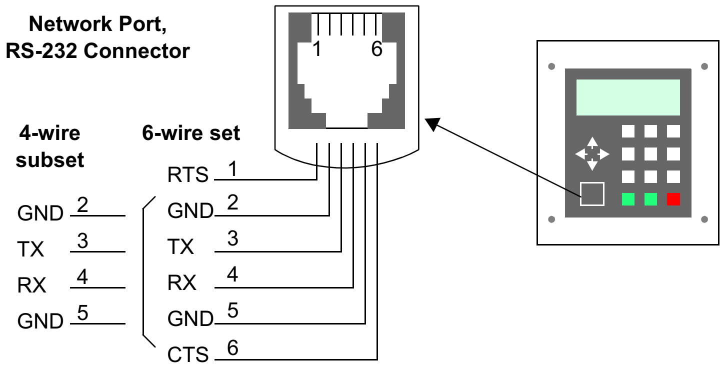
Network Port Mode (Electrical) Selection The electrical characteristics of your factory network will be selected independently of the protocol selection. Factors that determine the proper electrical mode include the network length, number of inverters on the network, and the serial port electrical characteristics of the network master computer. In simplex operation, the same wires are used alternately for transmitting and receiving. Half duplex operation uses separate transmit and receive wiring, but only one half (TX or RX) will be in operation at a time. Note that while some protocols support up to 255 node addresses (address of each device), RS-485 networks are limited to a maximum of 32 devices.

The following table lists the SC-OPE serial port modes and the typical application for each one:

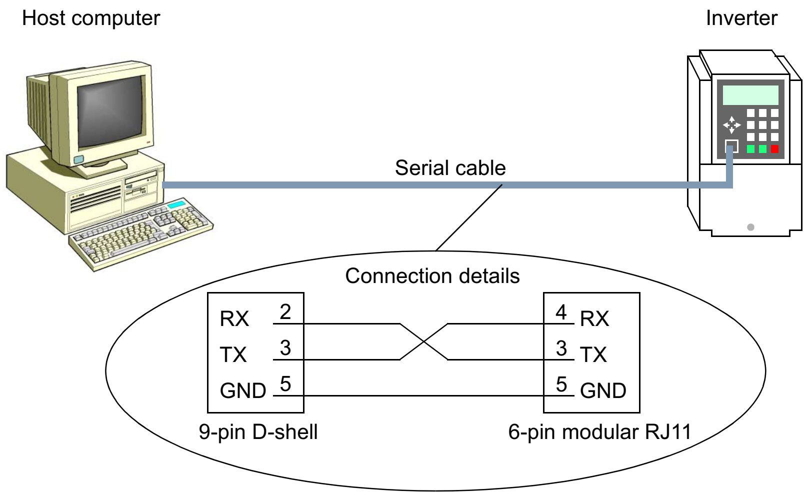
Communications Mode	Application			Network Port Connector
	Distance	Devices	Simplex/ Duplex	
RS-232	Up to 15 m	2 only	Half duplex	Front (RJ11)
RS-485 2-wire	Up to 100 m	Up to 32	Simplex	Bottom (10-pin)
RS-485 4-wire	Up to 100 m	Up to 32	Half duplex	Bottom (10-pin)
RS-422 4-wire	Up to 100 m	Up to 2	Half duplex	Bottom (10-pin)

RS-232 Serial Port Wiring Diagrams

The RS-232 Port is accessible on the front panel of the SC-OPE as shown below. Its most common use is for connecting to a PC for OEM configuration tasks. However, the serial port can respond to network commands, with the proper SC-OPE configuration). The cable included in the Configuration Kit has a 4-wire RJ11 connector, using the 4-wire subset. You can also make a custom cable (using the 6-wire set or the 4-wire subset) and connect the SC-OPE to a PC or host computer.



A typical RS-232 network port connection is between a PC and the SC-OPE only.



An RS-232 connection provides an easy way to connect two devices. Since the connection is limited to only two devices, RS-232 type communications is not a part of the 2-wire network discussion.

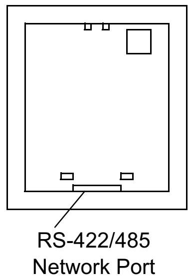
Guidelines to configure a RS-232 connection:

- The port of the device you connect to the SC-OPE must also be RS-232 type.
- The TX line of one device connects to the RX line of the other device.
- Remember to make the ground connection between the two ports.
- The wiring distance will be limited to 50 feet at 19.2k baud.

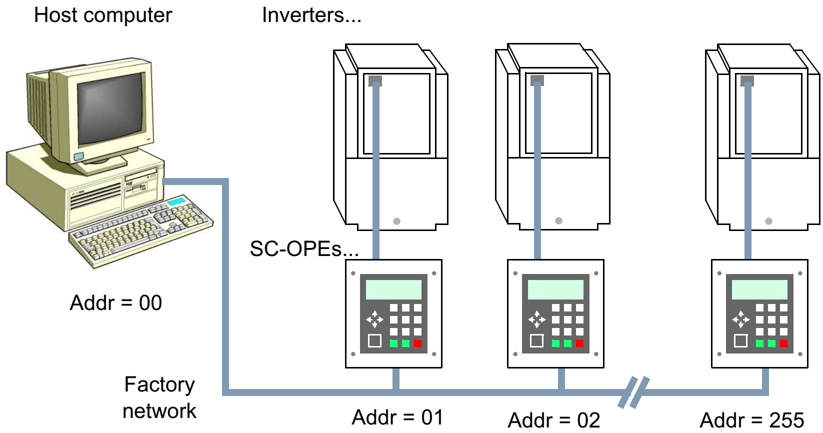
Note: *When using a factory network protocol, you can use the front panel network port for the connection. However, RS-232 signal levels limit the network to a point-to-point connection (SC-OPE and one other device). If your network requires more than two devices, use the RS-485 network port described on the following page. Alternatively, you can use the RS-232 port with an external RS-485 converter.*

Network Wiring Configurations

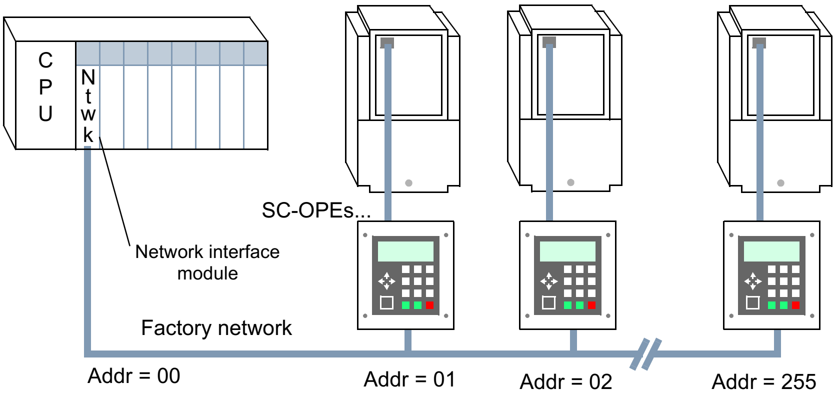
The RS-422/485 port is accessible on the 10-pin connector at the bottom of the SC-OPE assembly as shown below. The connector for use in making a matching cable is included in the Bezel Kit. The connector provides individual retention of wires, facilitating daisy-chain network topologies that are typical in factory networks with multiple inverters.



In a factory network with multiple inverters and/or end-to-end lengths of more than 15 meters (45 ft.), we recommend using the RS-422 / 485 network port. Networks with three or more devices will require using the RS-485 mode. Each SC-OPE must be configured with a unique network address (described later in this section).



Some factory networks originate in programmable logic controllers (PLCs). The CPU or network interface module in the base (as shown below) will provide the interface.

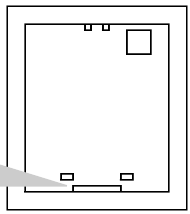


RS-422/485 Serial Port Wiring Diagrams

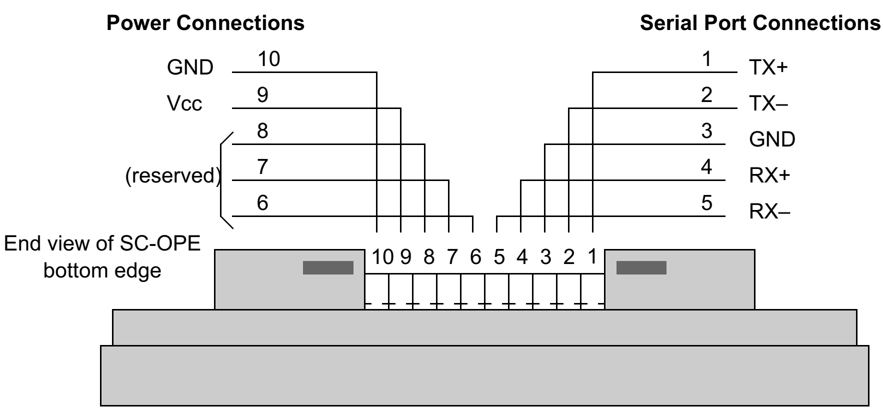
The SC-OPE's RS-422/485 port can connect to 2-wire or 4-wire networks as listed to the right. The figure below shows the port's connections. The power connections are typically unused, as the SC-OPE is powered by the inverter. For details, see "Network Port Configuration" on page 2–26.

RS-422/485 port configurations:

- RS-485 2-wire
- RS-485 4-wire
- RS-422 4-wire



Network Port, RS-422/485 Connector



You will need to decide whether your network will be a 4-wire or 2-wire type. If any device on the network is a two-wire device (or otherwise has combined TX/RX lines), then the network must be a 2-wire type.

Guidelines to configure a 4-wire network:

• Configure the host computer or controller as the network master. The SC-OPE(s) on the network are the slave(s).

• Remember to configure the SC-OPE network port (see “Network Port Configuration” on page 2–26).

• The master’s TX and RX lines connect to the RX and TX lines on the slave(s) respectively. In other words, they cross: TX+ (master) connects to RX+ (slaves), and TX– (master) connects to RX– (slaves).

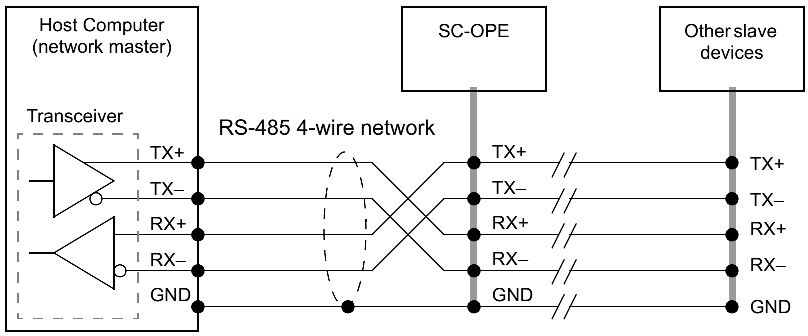
• Each device on the network must have a unique address.

• If you have more than one slave device, wire all of them (as a group) in parallel.

• Remember to make the ground connection between all ports on the network.

• Add network termination resistors (see “Network Termination” on page 4–8).

• Limit the total number of devices to 32 for RS-485.



Guidelines to configure a 2-wire network:

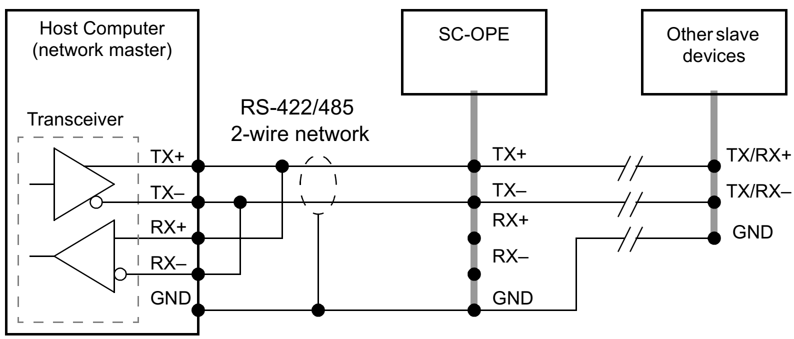
• Configure the host computer or controller as the network master. The SC-OPE(s) on the network are the slave(s).

• Remember to configure the SC-OPE network port for 2-wire operation (see “Network Port Configuration” on page 2–26).

(continued, next page...)

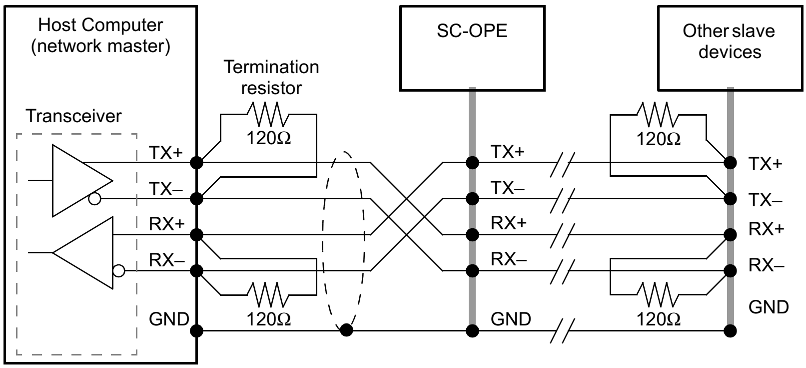
- The network master device or other devices on the network may also need firmware configuration to 2-wire operation. In this way, each device on the network will not attempt to transmit and receive at the same time (would cause a comm error).
- Connect only the TX+ and TX– lines of the SC-OPE to the network: That is, connect its TX+ to TX/RX+, connect its TX– to TX/RX–. This works only because the SC-OPE automatically connects transmit and receive circuits to the two lines.
- For wiring instructions of other network devices, refer to the respective product documentation from the manufacturer. But in general, we can say:
    - If the device has two wires (typically labeled TX/RX+ and TX/RX–), these connect directly to the network.
    - If the device has four wires, you may need to jumper its transmitter/receiver lines together. Jumper TX+ to RX+, and jumper TX– to RX–.
- All devices' TX/RX+ lines and TX/RX– lines connect in parallel.
- Remember to make the ground connection between all ports on the network.
- Add termination resistors (see "Network Termination" on page 4–8). Note that the device at each end of the network will only have *one* termination resistor.
- Limit the total number of devices to 32 for RS-485, 2 for RS-422.
- Each device on the network must have a unique address.

The diagram below shows a 2-wire network. In this example, the host computer has a 4-wire port that has been jumpered for 2-wire operation. Sometimes a host computer will have internal jumpers or firmware settings that have the same effect as the jumpers shown. However they are configured, only two wires (plus GND) will connect one device to another.

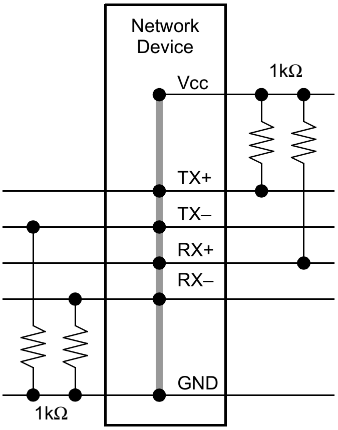


Network Termination

Termination Resistors When wiring a factory network it is important to consider the reliability and noise immunity of network communications. Differential transceivers provide general noise immunity. However, factors that degrade noise immunity include longer total network lengths, noisy environments, and a large number of devices on the network. The Network Termination Board (included in the Bezel Kit) contains network termination resistors. These resistors connect across TX+ / TX– and RX+ / RX– at the physical end of the wiring pairs as shown in the figure below.

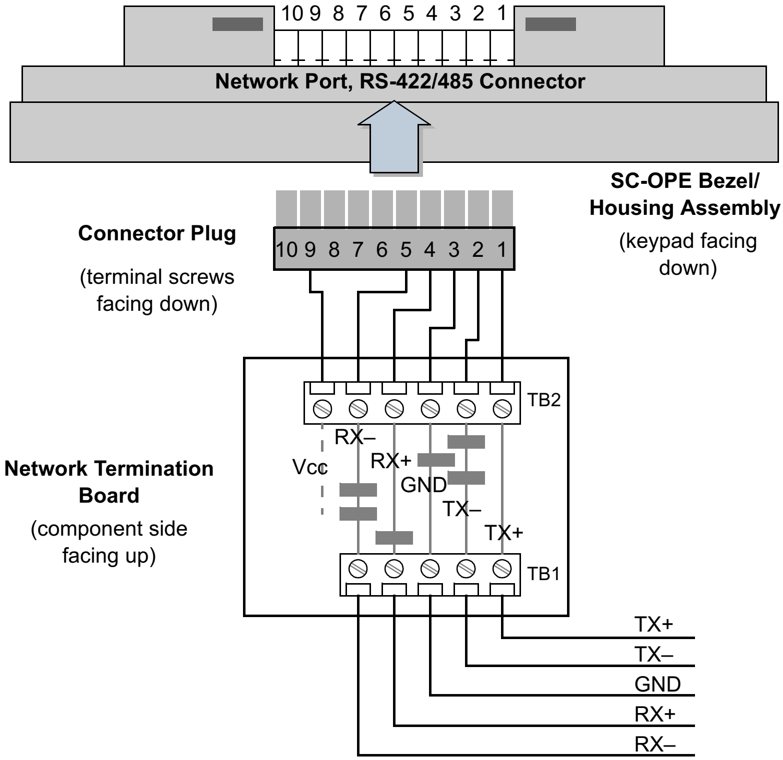


Bias Resistors A transceiver's differential signals are in a tri-state condition (floating, with respect to GND) between transmissions. This can make a network more susceptible to noise particularly with higher baud rates. The maximum speed of SC-OPE communications is 19.2 k Baud, still low enough for reliable communications in many applications. The Network Termination Board contains bias resistors. These include 1kΩ pull-up and pull-down resistors at each node.



Connecting a Network Termination Board

The Network Termination board contains termination and bias resistors. This board is a component in the Bezel Kit. Your network will need termination at the device on each physical end of the cabling. A wiring procedure is on the following page.



To install a Network Termination Board:

1 Mount the SC-OPE 3I in the bezel/housing and secure the SC-OPE assembly as outlined in Chapter 2, Installation.

2 Ensure the SC-OPE location will be at one physical end of the network cabling.

3 Locate the Connector Plug and Network Termination Board in the Bezel kit. Refer to the wiring diagram on the previous page. Use wires approximately 2" long to connect the Network Termination Board TB 2 connector to the Connector Plug. Take care to orient the two components as shown (board is component side up, connector block is screw terminal side down).

(continued, next page...)

4 Plug the assembly into the network connector at the bottom of the SC-OPE.

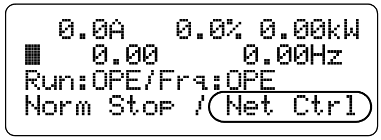
5 Attach the network wiring to the Network Termination Board.

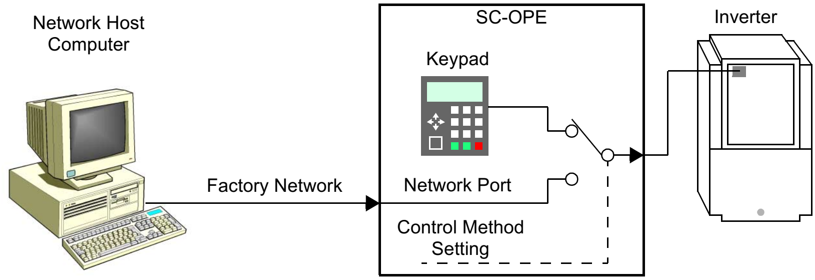
Note: *A host computer or another device besides the SC-OPE may be at one end of some networks. In this case, please refer to the device manufacturer's instructions regarding network termination. Some devices have internal termination resistors that may be connected/disconnected with jumpers.*

Tip: *If needed, you can use a Network Termination Board as termination for a device other than a SC-OPE. First, be sure that device does not already have built-in termination resistors.*

Configuring Network Control of Inverter

Network Control Setting The SC-OPE configuration contains the Control Method Setting that determines whether the SC-OPE keypad or the factory network commands received are in control of the inverter. Use Monitor Mode to view the current setting as shown. After you have connected a network host to the SC-OPE and you are ready to try network control, it will be necessary to change the Control Method Setting to “Network” (Net Ctrl). See “Selecting Keypad or Network Control” on page 3–4.



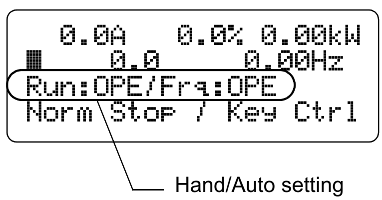


Hand/Auto Setting When receiving and interpreting network write commands, the SC-OPE will command the inverter as if an operator were using the SC-OPE (from the inverter’s point of view). If the inverter is configured for control via its own keypad or input terminal, it will ignore network commands sent via the SC-OPE. So, controlling the inverter from a network requires that you set the following:

- A002 Run Command Source = 02 (Operator keypad – REM) = Run:OPE
- A001 Frequency Setting Source = 02 (Operator keypad – REM) = Frq:OPE

If either source setting is set for control terminal operation, Run:TRM or Frq:TRM, the corresponding control from the network will not be possible. It is desirable, for some applications, to split the control source. For example, you may want network control of Run/Stop functions, and use control terminals for the frequency setting input—Run:OPE/Frq:TRM.

Tip: *To automatically set A002 and A001 as required for network control, simple press the Hand/Auto key to select “OPE” as the Run Command and Frequency Setting sources as shown. See “Hand/Auto Key Operation” on page 3–31.*



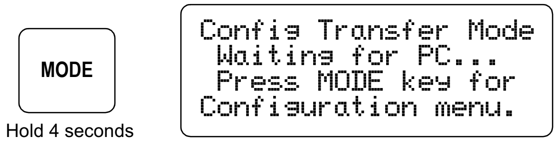
SC-OPE Network Configuration

The SC-OPE 3I supports several factory network protocols. You must configure it before connecting it to a particular factory network. The configuration may be edited directly on the SC-OPE, or you may use the Configuration Editor on a PC and download the configuration.

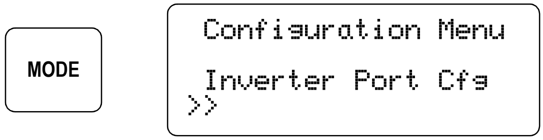
To configure a SC-OPE 3I for connecting to a DF1 factory network:

Press the keys shown in the sequence below.

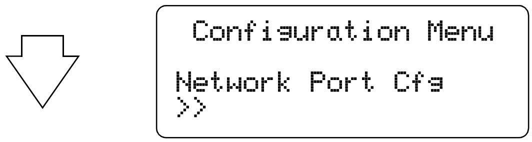
1 Press the MODE key for 4 seconds.



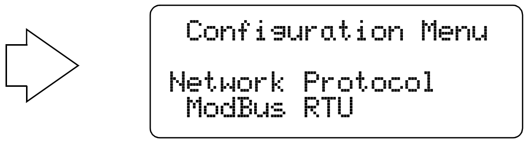
2 Press the MODE key again (briefly).



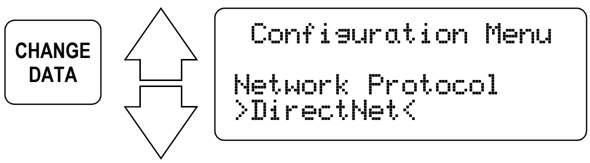
3 Press the Down Arrow key once.



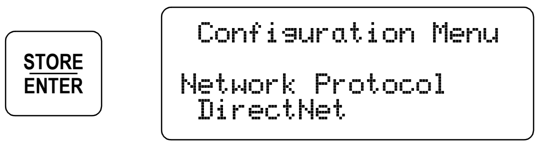
4 Press the Right Arrow key.



5 Press the Change Data key and use the Up Arrow key to select the desired protocol from the list.



6 Press the Store/ Enter key to store the change (or Esc/Cancel to exit without changing).



7 Press the Down Arrow key to access the other network configuration parameters. to edit a parameter, use the Change Data key, the Arrow keys, and the Store/Enter key as in Step 5 and Step 6 above.

The complete Network Configuration submenu is shown below.

- **Configuration Menu**
  - Inverter Port Cfg
  - Network Port Cfg
    - Network Protocol
    - Network Address
    - Network Port Type
    - Baud Rate
    - Data Bits
    - Parity
    - Stop Bits
    - Flow Control
    - RTS Delay
    - Mode (Master/Slave)
    - Max Gap Time
    - Stop Key Action
  - Store Configuration

Note: *When editing the network node address, be sure to assign a unique number for each device on the network.*

```
 Configuration Menu
Network Address
 2
```

8 In the Network Port type setting, be sure your configuration matches the physical network connection that will exist on the SC-OPE.

```
 Configuration Menu
Network Port Type
 RS485 4-Wire
```

9 The Stop Key Action item (at bottom of list) selects whether the Stop/Reset key on the SC-OPE will be disabled (no action) or enabled (disables network control when pressed and returns control to the keypad). The proper setting depends on your particular application.

```
 Configuration Menu
Stop Key Action
 No Action
```

10 After making all the Change Data / Store changes to the network settings, press the Left Arrow key to exit the Network Settings submenu.

```
 Configuration Menu

Network Port Cfg
>>
```

11 Press the Down Arrow key to scroll down to the Store Configuration menu item.

```
 Configuration Menu

Store Configuration
[Enter}
```

12 Press the Store/ Enter key to store the configuration in the SC-OPE.

STORE
ENTER

```
 Configuration Menu

Store Configuration
Configuration Stored
```

13 Press the Down Arrow key twice to access the Monitor Mode menu item.

Press twice

```
 Configuration Menu

Monitor Mode
{Enter]
```

14 Press the Store/ Enter key to cause the SC-OPE to reset and enter Monitor Mode.

STORE
ENTER

```
-------- ----------
HITACHI AMERICA, Ltd
 SC-OPE 3I -SJ300
----- Ver 2.09 -----
```

Connecting to a ModBus RTU Network

Overview

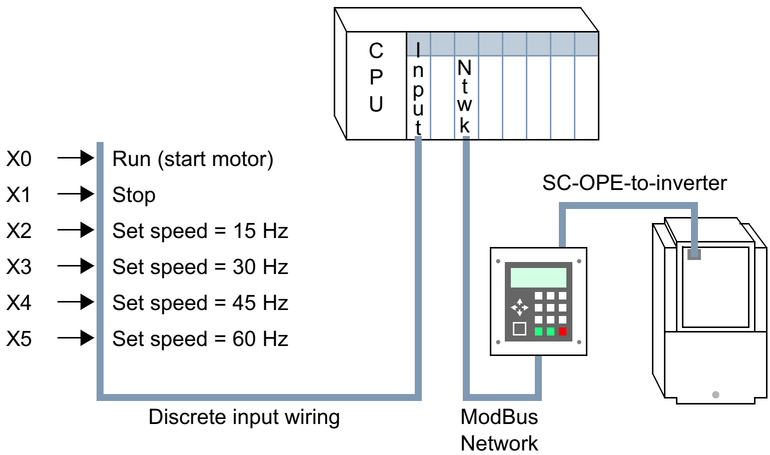
Many PLCs are available with built-in ModBus communication protocol. The relay ladder logic (RLL) example in this section uses an arbitrary set of input points, internal relays, registers, etc. for a DirectLogic PLC as a typical example. Therefore, it is not intended for use as-is in an actual application.

When using network control of the inverter, the SC-OPE maps (translates) network commands to specific inverter parameters. When writing your host computer control program, you will need a map of network registers and inverter parameters. Please refer to Appendix D and Appendix E for network register maps.

Warning: *Be sure to set up the basic drive parameters* ***before*** *connecting the PLC to the drive and running it. Failure to do this could result in damage to the drive or the equipment connected to the drive.*

Note: *Remember that the number format of the registers in the drive is decimal, while the number format of the registers in your PLC may be in BCD/HEX. If you are viewing the drive values in a data view window, be sure to select decimal as the format for viewing. If you are writing values to the drive, be sure to change the value to decimal.*

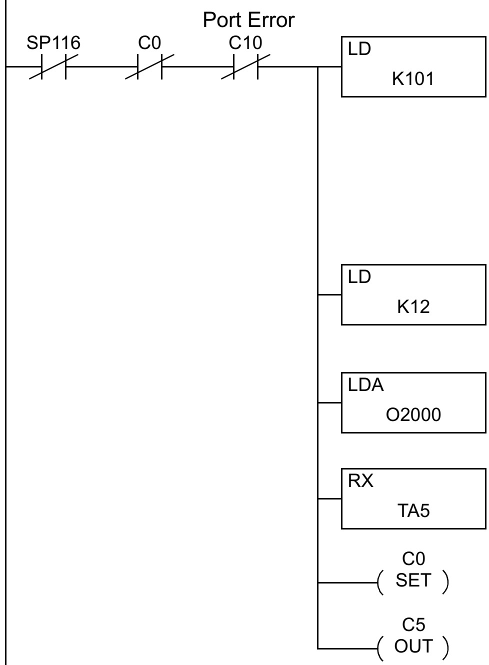
The following block diagram of the PLC controller shows its input switch assignment for the following example program and the resulting inverter command.



Ladder Program Example for ModBus Comm.

Special relay SP117 reports a communication error between the PLC and the SCOPE (for example, broken cable, etc.)

The following rung moves values from the SC-OPE to PLC memory register V2000.

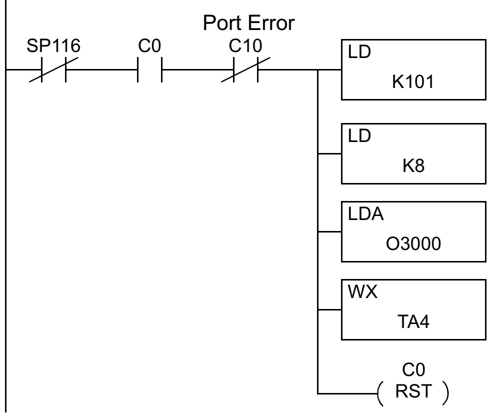


The LD box designates the bottom port of the DirectLogic CPU as master and specifies address 1 as the slave address. The last digit (“1) corresponds to the number of SC-OPEs (devices) on the network.

LD box specifies the amount of data to be read in bytes. K12 specifies 12 bytes or 6 words.

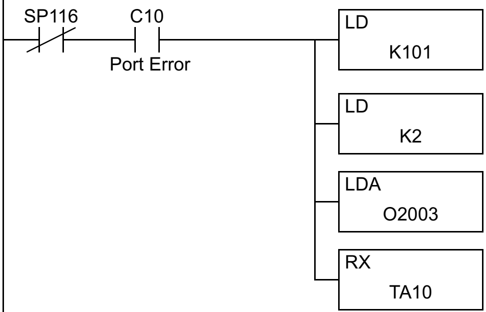
LDA box specifies the destination of the values being read.

Read from TA5 (V5) in the RX operation. The equivalent MODBUS RTU address = 40006.

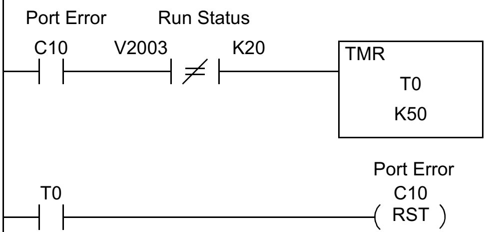


This rung writes values to the SC-OPE. We are loading the values from V3000 in the DL250 CPU and moving them into TA4 (V4). The equivalent MODBUS address = 40005.

The following rung helps to ensure the PLC is reading valid data. It utilizes the fact that if either the comm port of the inverter, the SC-OPE's inverter port, or the cable between the SC-OPE and the drive has a fault (error), the only register that will not fail communications to the PLC is the Run Status register. When a port error occurs we will attempt to read this register. A read failure indicates the problem is between the PLC and SC-OPE. In this event, increment a counter five times and, when the counter is done, turn control relay C34 ON.

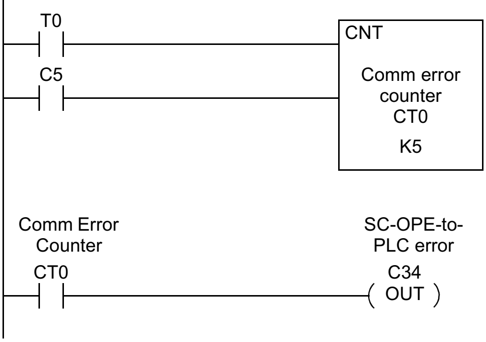


Attempt to read the Run Status register when a port error or communications error occurs.

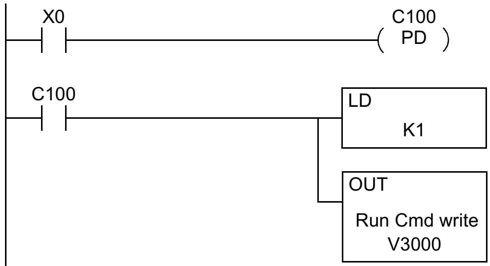


Keep reading the run status register until the comm error clears between the SC-OPE and the Drive. K20 is the value of the run status register when there is an error for SC-OPE-to-inverter communications.

The following rung monitors communications for port errors after attempting to read the run status register.

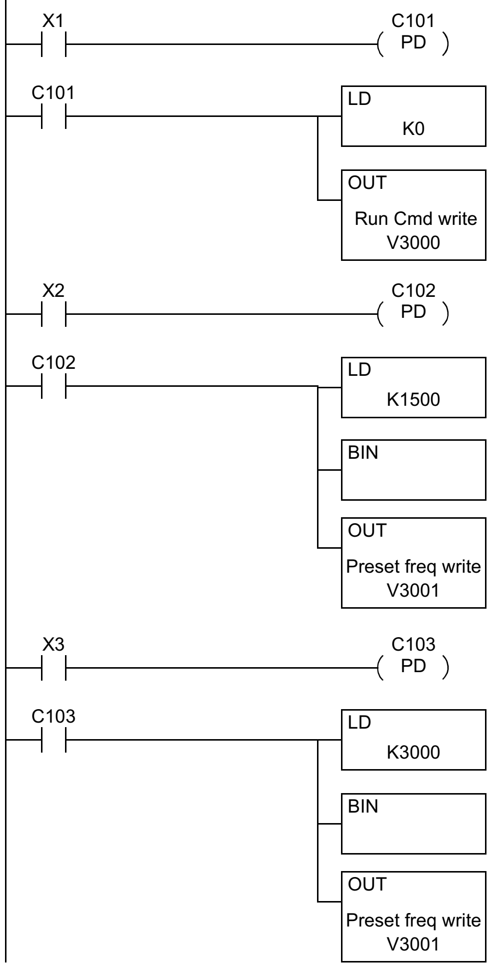


If errors persist, then increment the counter 5 times. When the counter is done, turn control relay C34 ON to record the error for SC-OPE-to-PLC communications. Control relay C5 turns ON once normal communication is resumed to reset the counter.



Start the inverter from input X0 by loading the constant K1into V3000 (run command register) of the SC-OPE (K1=FWD, K2=REV).

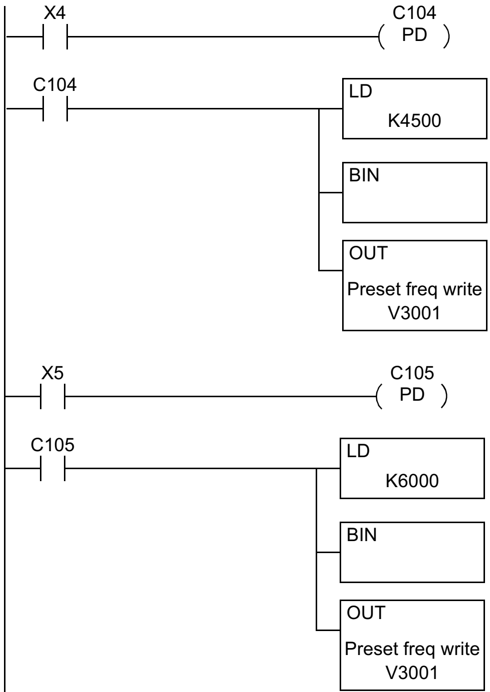
NOTE: This example program uses separate Start and Stop switch inputs. However, it is possible to use the NOT state of X0 to load a zero into the run command register and achieve both start and stop functions with one input switch.



Stop the inverter by loading K0 into V3000, the run command register of the drive.

These next few rungs load different speeds into the Preset Frequency register in the drive. The speed reference resolution is in 0.01 Hz, so a load of K1500 yields 15.00 Hz.

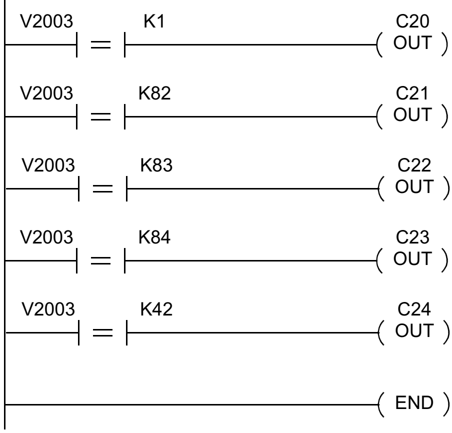
Set the inverter speed to 30 Hz.



Set the inverter speed to 45 Hz.

Set the inverter speed to 60 Hz.

The following rungs implement diagnostic monitoring that you can access from the run status register 40009. The status register consists of bit-level indicators of status events. By viewing the register in binary, you will see that bit 7 is ON when the inverter is running, bit 0 is ON when the inverter is stopped, bit 7 and bit 2 are ON when the inverter is in deceleration. Consult the register map for a detailed explanation on the status register.



Inverter stopped – 82 is the hex equivalent of 130 in decimal

Inverter in deceleration – 83 is the hex equivalent of 131

Inverter at preset frequency – 84 is the hex equivalent of 132

Inverter in acceleration – 84 is the hex equivalent of 132

Inverter in trip – 42 is the hex equivalent of 66

End of program

Connecting to a DirectNet Network

Overview

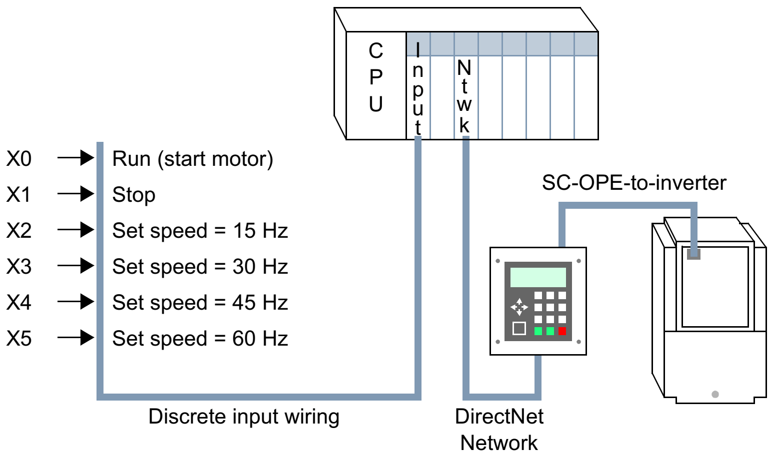
Some PLCs are available with built-in DirectNet communication protocol. The relay ladder logic (RLL) example in this section uses an arbitrary set of input points, internal relays, registers, etc. for a DirectLogic PLC as a typical example. Therefore, it is not intended for use as-is in an actual application.

When using network control of the inverter, the SC-OPE maps (translates) network commands to specific inverter parameters. When writing your host computer control program, you will need a map of network registers and inverter parameters. Please refer to Appendix D and Appendix E for network register maps.

Warning: *Be sure to set up the basic drive parameters* ***before*** *connecting the PLC to the drive and running it. Failure to do this could result in damage to the drive or the equipment connected to the drive.*

Note: *Remember that the number format of the registers in the drive is decimal, while the number format of the registers in your PLC may be in BCD/HEX. If you are viewing the drive values in a data view window, be sure to select decimal as the format for viewing. If you are writing values to the drive, be sure to change the value to decimal.*

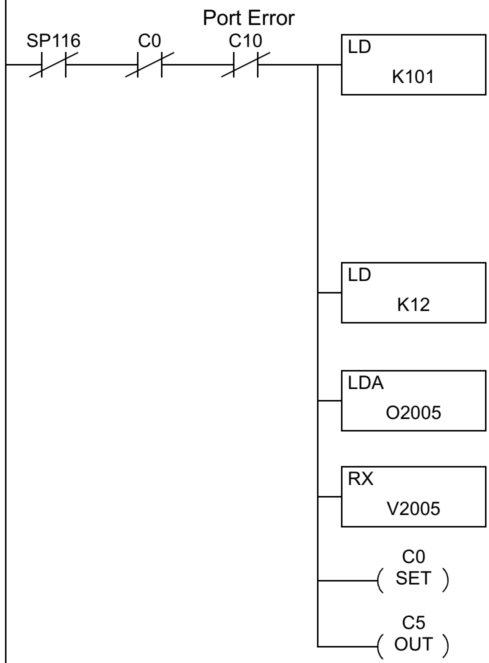
The following block diagram of the PLC controller shows its input switch assignment for the following example program and the resulting inverter command.



Ladder Program Example for DirectNet Comm.

Special relay SP117 reports a communication error between the PLC and the SCOPE (for example, broken cable, etc.)

The following rung moves values from the SC-OPE to PLC memory register V2000.

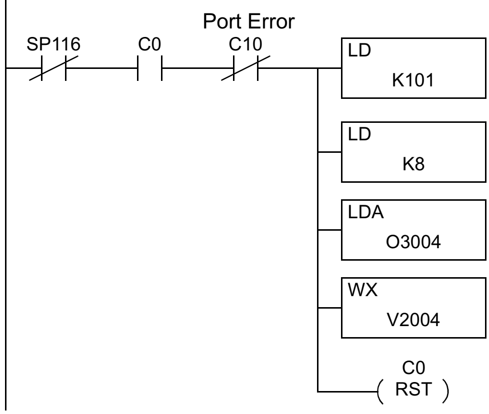


The LD box designates the bottom port of the DirectLogic CPU as master and specifies address 1 as the slave address. The last digit (“1) corresponds to the number of SC-OPEs (devices) on the network.

LD box specifies the amount of data to be read in bytes. K12 specifies 12 bytes or 6 words.

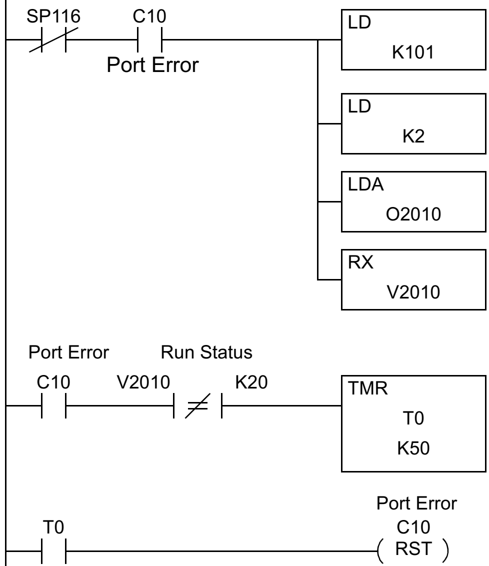
LDA box specifies the destination of the values being read.

Read from V2005 in the RX operation, the preset frequency (according to the register map).



This rung writes values to the SC-OPE. We are loading the values from V3004 in the DL250 CPU and moving them into V2004 in the inverter.

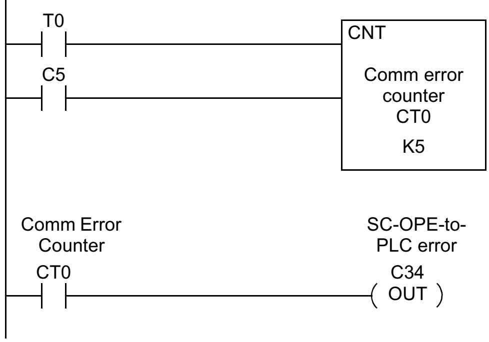
The following rung helps to ensure the PLC is reading valid data. It utilizes the fact that if either the comm port of the inverter, the SC-OPE's inverter port, or the cable between the SC-OPE and the drive has a fault (error), the only register that will not fail communications to the PLC is the Run Status register. When a port error occurs we will attempt to read this register. A read failure indicates the problem is between the PLC and SC-OPE. In this event, increment a counter five times and, when the counter is done, turn control relay C34 ON.



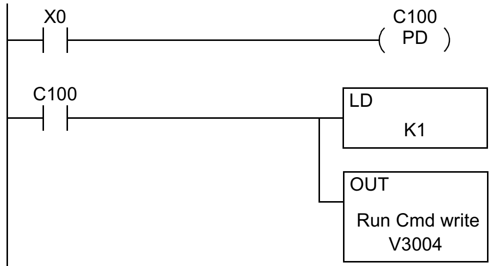
Attempt to read the Run Status register when a port error or communications error occurs.

Keep reading the run status register until the comm error clears between the SC-OPE and the Drive. K20 is the value of the run status register when there is an error for SC-OPE-to-inverter communications.

The following rung monitors communications for port errors after attempting to read the run status register.

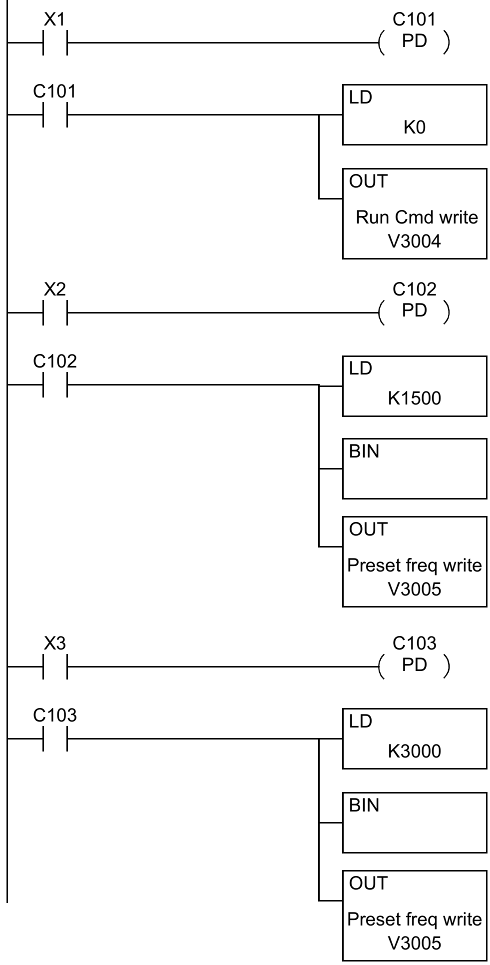


If errors persist, then increment the counter 5 times. When the counter is done, turn control relay C34 ON to record the error for SC-OPE-to-PLC communications. Control relay C5 turns ON once normal communication is resumed to reset the counter.



Start the inverter from input X0 by loading the constant K1into V3004 (run command register) of the SC-OPE (K1=FWD, K2=REV).

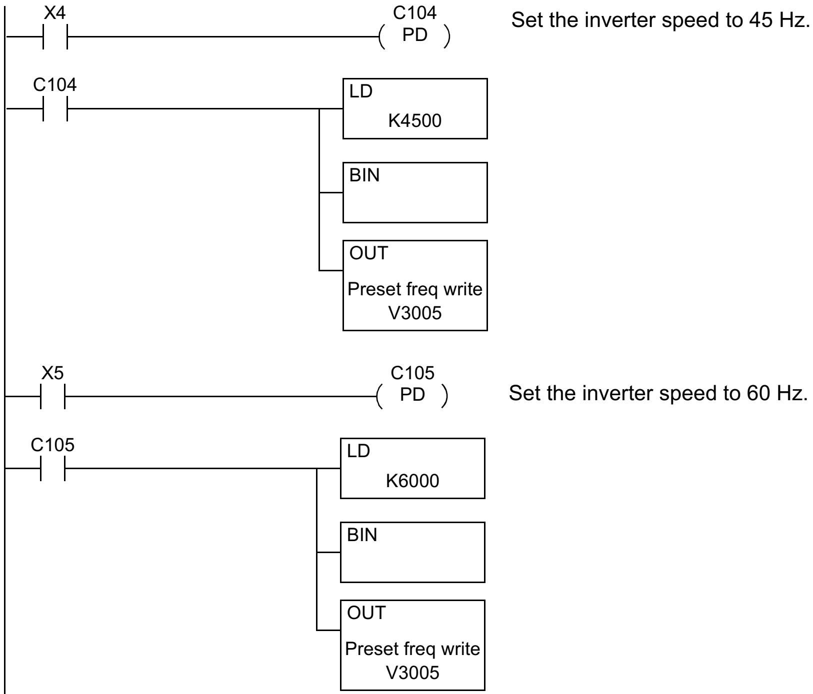
NOTE: This example program uses separate Start and Stop switch inputs. However, it is possible to use the NOT state of X0 to load a zero into the run command register and achieve both start and stop functions with one input switch.



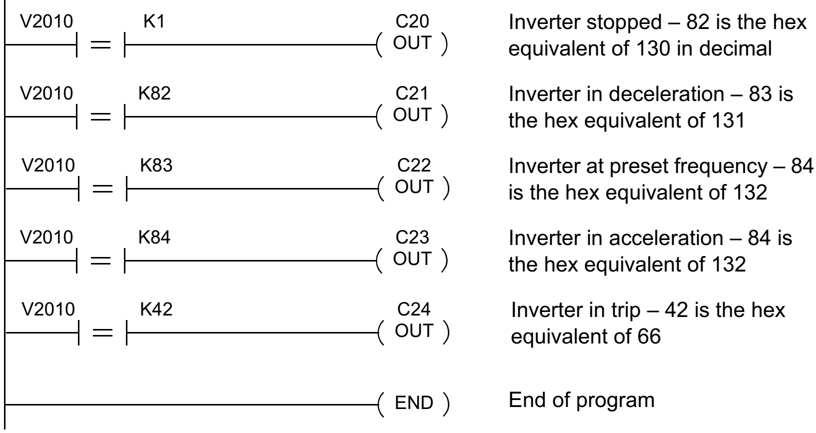
Stop the inverter by loading K0 into V3000, the run command register of the drive.

These next few rungs load different speeds into the Preset Frequency register in the drive. The speed reference resolution is in 0.01 Hz, so a load of K1500 yields 15.00 Hz.

Set the inverter speed to 30 Hz.



The following rungs implement diagnostic monitoring that you can access from the run status register 40009. The status register consists of bit-level indicators of status events. By viewing the register in binary, you will see that bit 7 is ON when the inverter is running, bit 0 is ON when the inverter is stopped, bit 7 and bit 2 are ON when the inverter is in deceleration. Consult the register map for a detailed explanation on the status register.



Connecting to an Allen-Bradley DF1 Network

The SC-OPE 3I includes the Allen-Bradley DF1 protocol. The SLC500 PLC family PLCs feature this network connection option. You can connect multiple inverters to a DF1 network, each inverter having its own network address. The example in this section covers the network configuration settings of a SLC500 PLC. RSLogix 500 is the programming software for the SLC500 family.

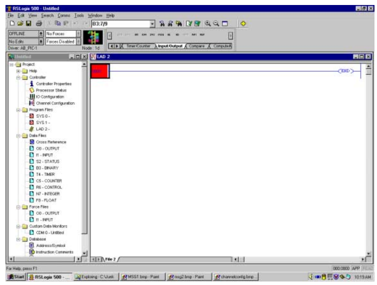
DF1 network configuration consists of these steps:

- Channel configuration
- Adding an MSG instruction for each network transaction in the ladder program
- Configuring the setup screen within each MSG instruction

Channel Configuration

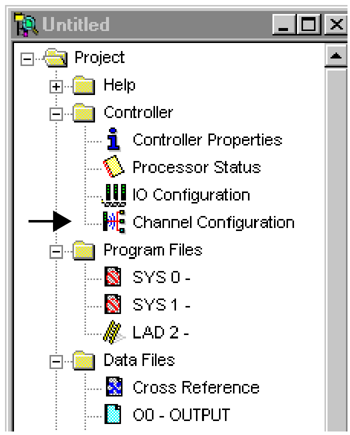
To configure the communications channel in a project:

1 In the RSLogix software, click File > New to begin a new project.

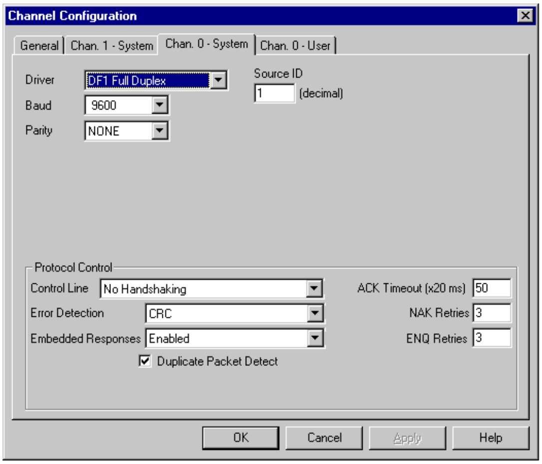


2 Click File > Save As... to name the project at this time.

3 Refer to the project element explorer pane to the left of the RSLogix window. In the Controller folder, double click the Channel Configuration item as shown. Then the Channel Configuration dialog will appear.



The remaining steps in this sequence refer to the Channel Configuration dialog below.



4 For the Driver setting, select “DF1 Full Duplex.”

5 Leave the Source ID setting at “1.”

6 In the Protocol Group, set the Control Line field to “No Handshaking.”

7 Set the Error Detection field to “CRC.”

8 Set the Embedded Responses field to “Enabled.”

9 Click (enable) the Duplicate Packet Detect check box.

MSG Instruction

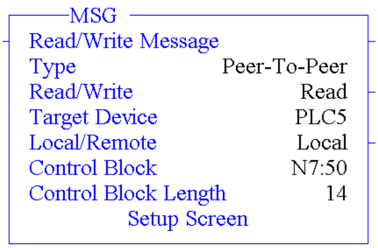
The ladder program in your project will need an MSG instruction for each communications transaction with each inverter on the DF1 network.

To configure an MSG instruction for inverter communications:

1 In RSLogix, use the Input/Output instruction list to find the MSG instruction.

2 Insert the MSG instruction in your ladder program. Remember to include logic to ensure the MSG instruction executes only when needed (and not on each scan).

3 In the Type field, choose “Peer-to-Peer.”



4 In the Read/Write field, select “Read” to read data from the inverter, or “Write” to write data to the inverter via the SC-OPE.

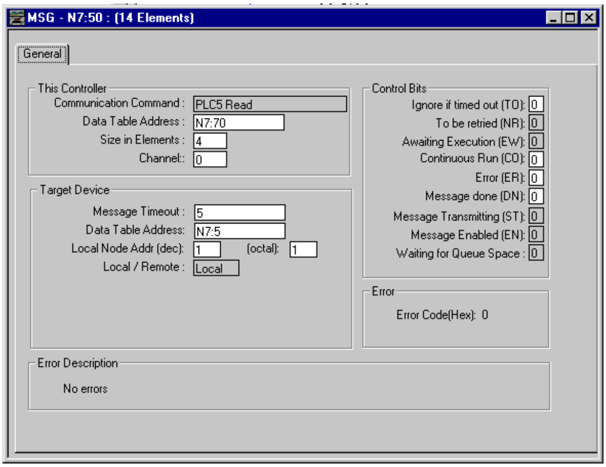
5 In the Target Device field, select “PLC5.” The SC-OPE’s DF1 protocol uses the PLC5 type.

6 In the Local/remote field, choose “Local.”

The MSG instruction includes an embedded setup screen for data not shown directly in the ladder program.

To configure the Setup Screen for each MSG instruction:

1 Double click “Setup Screen” at the bottom of the MSG instruction block.



2 In the General tab of the MSG dialog box, refer to the This Controller group. In the Data Table Address field, select the area of PLC memory to use in the read/write transaction with the inverter.

3 In the Size in Elements field, enter the number of data words (16-bit items) to read or write.

4 In the Channel field, select “0.”

5 The Target Device Group contains settings for the SC-OPE. In the Data Table Address field, enter the starting register address for the inverter data to be read or written. In this example, the following registers will be read:

Address	Data Contents
N7:5	Preset Frequency
N7:6	Acceleration Time
N7:7	Deceleration Time
N7:8	Run Status

6 In the Local Node Addr (dec) field, enter the node address (in decimal) of the targeted SC-OPE on the network for this MSG instruction.

When using network control of the inverter, the SC-OPE maps (translates) network commands to specific inverter parameters. When writing your host computer control program, you will need a map of network registers and inverter parameters. Please refer to Appendix D and Appendix E for network register maps.

Note: *For help in creating the ladder program for your application, please refer to your Allen-Bradley PLC documentation or distributor support.*