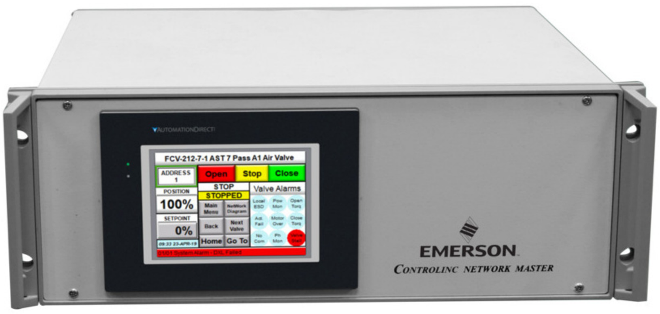
Installation, Operations and Maintenance Manual
MAN-01-09-91-0726-EN Rev. 2
September 2023

Controlinc Network Master

Model M250 Version 5.2



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Section 1: Introduction

Emerson Controlinc Network Masters are the master of Emerson Controlinc valve actuator networks with Modbus RTU protocol. The system provides network management, data concentration and protocol conversion, off-loading the host system of these tasks. This enhances overall system performance and minimizes software development and system configuration tasks by the system integrator. The Network Master serves as the master of a master/slave network. It manages the network by keeping an orderly cycle of data transfers to and from the slave devices (valve actuators). It handles error detection, alarming, and network recovery. The Network Master serves as a data concentrator for the host by providing a common database for all slave devices. The host is required to communicate with only one slave device (network master) for all data transfers to and from the field. Data can be transferred between the network master and host in large blocks at a much higher communications rate than would be possible if the host communicated with each slave device (valve actuator) on the field network. The Network Master acquires data from the valve actuators by polling or scanning each device in a sequence of slave address from a table called a scan list. Polling is a process of the Network Master sending to each slave address, a command to return its status information, including alarms, discrete and analog inputs and outputs. When control commands (valve open, stop, close, position set point, etc.) are generated by a host system up-line of the Network Master, it then sends the appropriate commands over the network to the addressed slave device. A more detailed functional description of operation is provided in the Theory of Operation section of this manual.

1.1 Reference Documents

In addition to this Controlinc Network Master Installation and Operations Manual, the following references are required for proper installation, configuration and operation of the Network Master. All referenced documents are supplied with the system. Paragraph numbers, as listed below, are used for reference to these documents in this manual.

1. Emerson Controlinc 320B Quick Start Guide
2. FACTS Engineering 205 Basic CoProcessor User's Manual
3. FACTS Extended BASIC Reference Manual
4. Direct Logic DL205 User Manual
5. Bettis XTE3000/Biffi ICON3000 Electric Actuator IOM
6. Bettis RTS Electric Actuator IOM

All manuals and software are provided in electronic format with the system on CD.

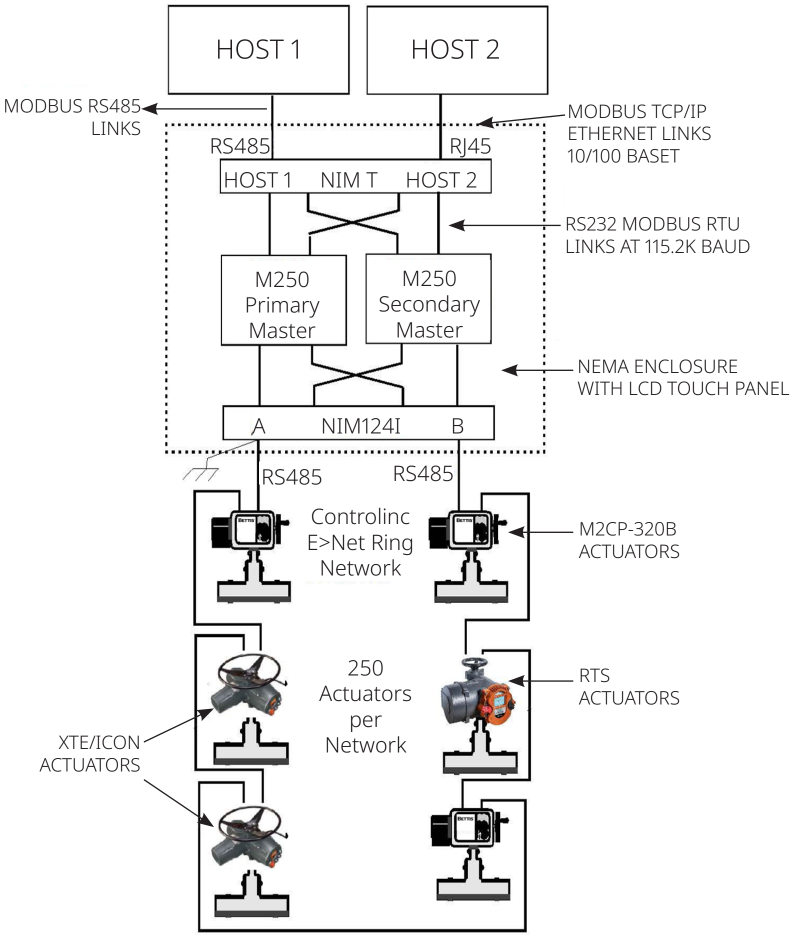
1.2 System Configuration

Controlinc Network Master Model M250N contains redundant valve actuator network masters in a single enclosure. M250N supports one Controlinc E>Net ring network with up to 250 valve actuators. Options for support of redundant bus networks and redundant E>Net rings are also available. The supplied system uses standard RS485 and Modbus RTU protocol for the valve actuator networks. Ethernet TCP/IP encapsulated Modbus protocol connections are provided for redundant host computer networks. The Ethernet links are IEEE 802.3 with RJ45 connectors for 10/100Base-TX. Protocol is Ethernet v2 encapsulation TCP/IP Version 4.

Redundant systems consist of two identical chassis with identical software. One is the primary master and the other a hot stand-by master. The two chassis may switch roles of primary and hot stand-by at any time. Figure 1 shows the specific system configuration of the supplied system. The network masters communicate with Controlinc valve actuators that control both block valves (Open, Stop, Close) and modulating or positioner type valves. The system consists of two six-slot chassis with each chassis having a central processor located in Slot 0, which provides a global database for the CoProcessors installed the chassis. The central processor also performs such functions as watchdog timers and system alarm generation for the CoProcessors. It also provides interrupt control for fast data transfers between processor modules. The main processor in each chassis supports a "Data Exchange Link" (DxL) to share all data between redundant databases. See Figures 2 and 3 for internal communication link connections.

Each chassis consists of two Modbus Slave modules located in Slots 3 and 4. These slave modules communicate with redundant Modbus host systems up line. The CoProcessor installed in Slot 1 is the Controlinc Network Master to a ring field network. Two ports of the Network Master module are connected to Network Interface Module (NIM) Model M124I with redundant, isolated ports. Each NIM has connections to the redundant Network Master modules of the redundant chassis. Any one of the four ports may acquire data from and control all actuators in the field in either direction around the network. Multiple M250N systems may be networked from a single host or redundant hosts to automate any size system from a few valves to thousands of valves covering a large network area. Ten (10) independent processors ensure full redundancy of all functions in a single unit.
All components except display are redundant with double-redundant host links to redundant hosts and automatic processor hot swapping. Host equipment is not required to implement any fail-over logic. Full-time redundant Modbus host links are standard. Plug-in modular construction and DIN-rail mounting of components ensure minimum MTR, minimizing down time. LCD touch panel provides valve actuator monitor and control of all valves in case redundant host links fail. All valve status and alarms may be displayed by the LCD touch panel for maintenance purposes. The LCD touch panel is a valuable troubleshooting tool during system commissioning. A more detailed description of operation is provided in the Theory of Operation section of this manual.

Figure 1. DCS System Diagram



1.3 General System Specifications

1.3.1 Environmental

Storage temperature:	-20 to 70 °C
Ambient operating temperature:	0 to 55 °C
Ambient humidity:	5 to 95% (non-condensing)
Vibration resistance:	MIL STD 810C, Method 514.2
Shock resistance:	MIL STD 810C, Method 516.2

1.3.2 Electrical

Standard input voltage:	117 V AC at 50/60 Hz (100 to 240 V AC)
Total current at nominal voltage:	450 mAmps (includes LCD panel)
Maximum inrush current:	60 Amps
Total power consumption:	35 VA nominal (includes LCD)
Isolation resistance:	>10 MΩ at 500 V DC
Dielectric withstand voltage:	1500 V AC at 1 min.

1.3.3 LCD Touch Panel Specifications

Display type:	5.7 in. diagonal color TFT
Enclosure:	NEMA 4/4X (IP65)
Input voltage:	12 to 24 V DC
Power consumption:	16.0 W, 1.30 A at 12 V DC, 0.66 A at 24 V DC
Operating temperature:	0 to 50 °C

1.3.4 M250 PLC Port 2 Setup for Database Exchange Link (DxL)

Primary Master	Secondary Master
DirectNet	DirectNet
Base Timeout x 1	Base Timeout x 1
RTS/CTS 0 mS, 0 mS	RTS/CTS 0 mS, 0 mS
Station Address 2	Station Address 1
38400,1, Odd, Hex	38400, 1, Odd, Hex

PLC to PLC cable is RS232, 3-wire, rolled, with 15-pin D connectors

Primary	Secondary
Pin/Wire	Pin/Wire
2 Red	3 Red
3 White	2 White
7 Green	7 Green
8 Black	8 Black

Figure 2. M250 NEMA TP Internal Wiring

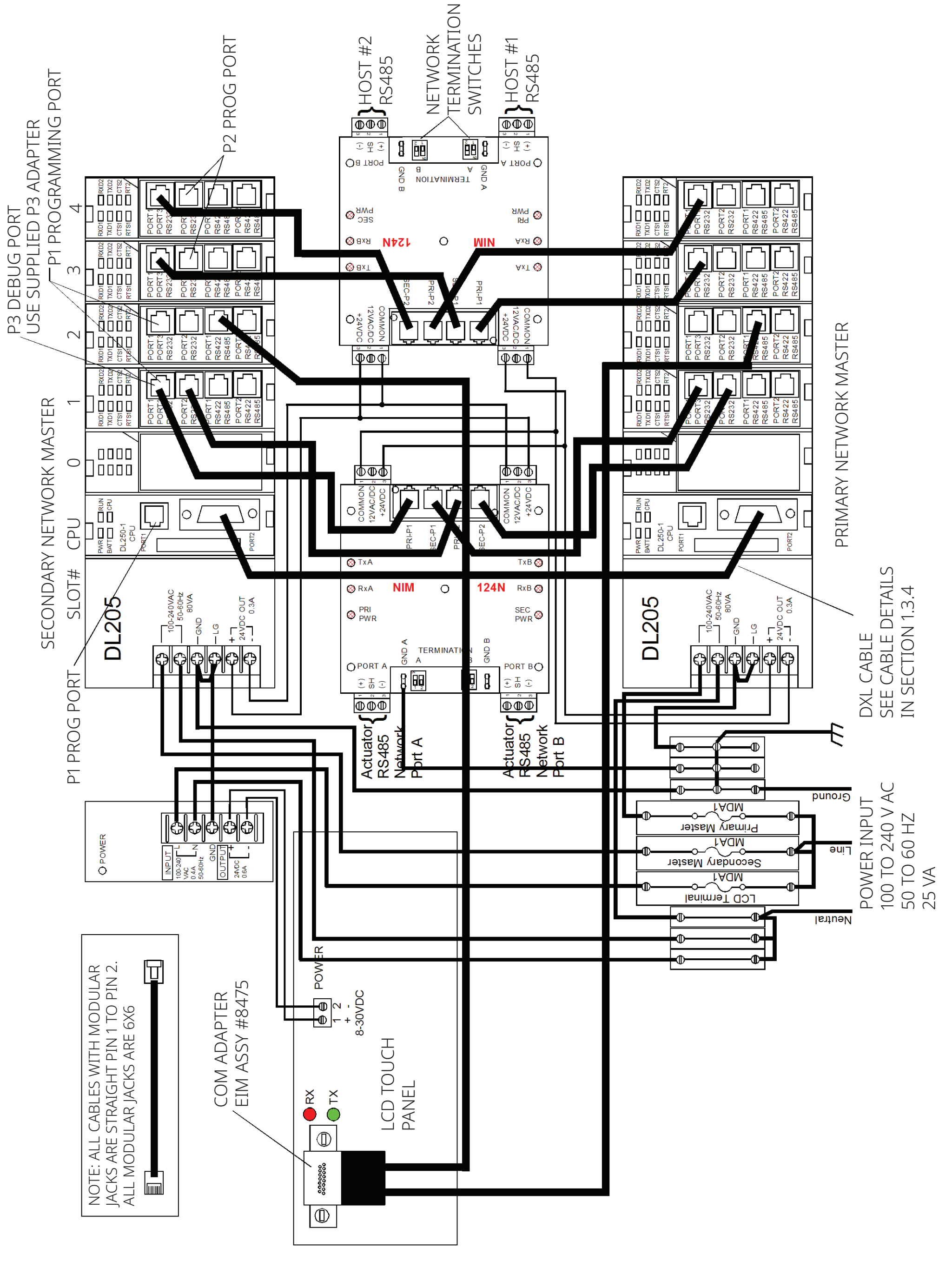
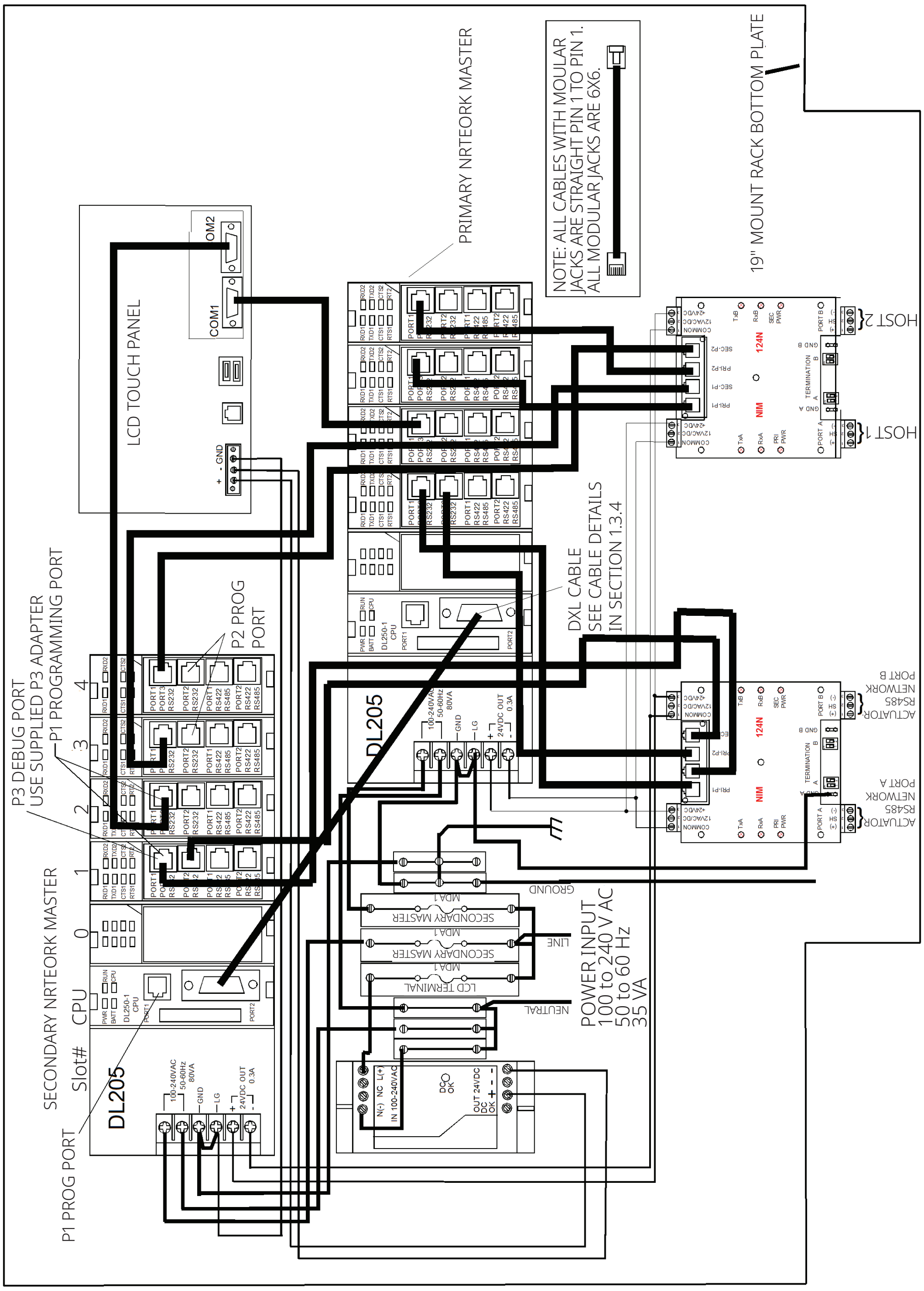


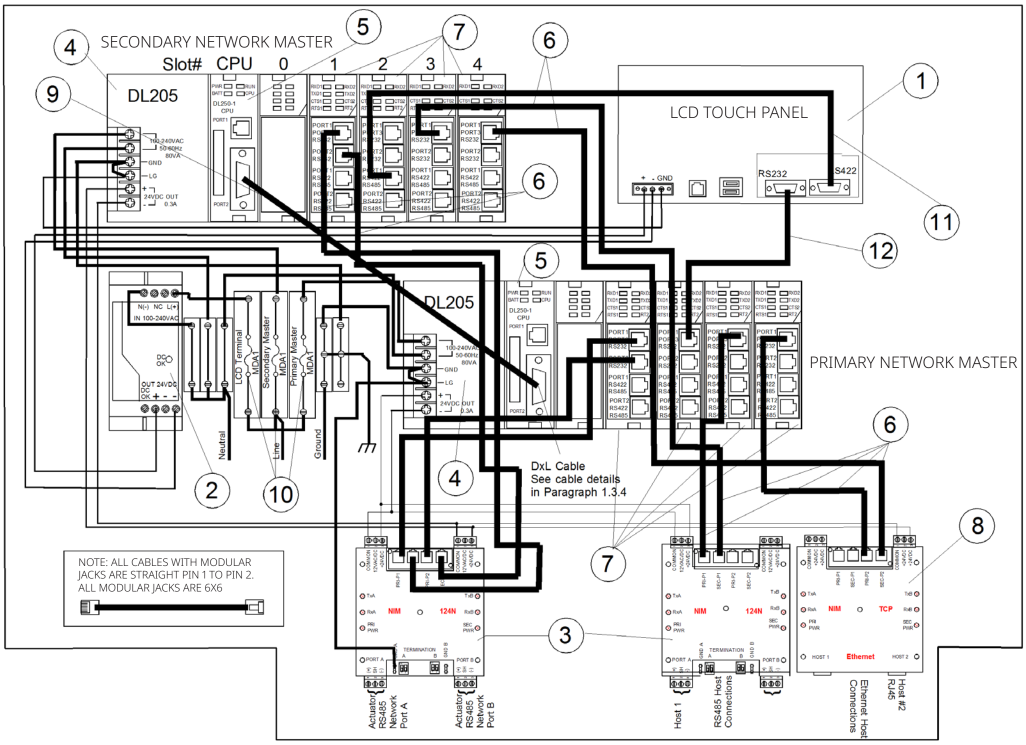
Figure 3.


PRIMARY NRTEORK MASTER
NOTE: ALL CABLES WITH MOULAR JACKS ARE STRAIGHT PIN 1 TO PIN 1. ALL MODULAR JACKS ARE 6X6.
19" MOUNT RACK BOTTOM PLATE
LCD TOUCH PANEL
COM1
HOST 2
HOST 1
DXL CABLE SEE CABLE DETAILS IN SECTION 1.3.4
DL205
P3 DEBUG PORT
USE SUPPLIED P3 ADAPTER
P1 PROGRAMMING PORT
P2 PROG PORT
SECONDARY NRTEORK MASTER
Slot# CPU 0 1 2 3 4
P1 PROG PORT
DL205
ACTUATOR RS485 NETWORK PORT B
ACTUATOR RS485 NETWORK PORT A
GROUND
SECONDARY MASTER
LINE
LCD TERMINAL
NEUTRAL
POWER INPUT
100 to 240 V AC
50 to 60 Hz
35 VA

1.4 Parts List

Figure 4 is a list of materials supplied within each Network Master enclosure. This may be used as a spare parts list.

Figure 4.



Item	Qty	Model	Emerson Part Number	Description
1	1	EA9-T6CL-R	2000802501	Color graphics LCD touch panel
2	1	2938730	2001803004	Power Supply, 24 V DC, 3 A
3	1	NIM124I	84713 -C	Network Interface Module, Iso. RS485
4	2	D2-06B-1	2001805050	Base, 6-slot with 110/220 V AC P/S
5	2	D2-250-1	2001805052	CPU, DL205-250
6	6	-	37586-1	Cable, CoProcessor to NIM, 6x6, 11"
7	8	F2-CP128	2001805051	CoProcessor, Overdrive
8	1	NIM-TCP	87065	Network Interface Module, Ethernet
9	1	-	37587-1	Cable, CPU to CPU DxL
10	3	BK/MDA-1	7019900428	Fuse, 1 A, 250 V, Time Lag, CRM MDA
11	2	-	37586-4	Cable, CoProcessor to LCD, 6x6, 15"
12	2	-	37586-3	Cable, CoProcessor to NIM, 6x6, 13"
13	2	-	37586-2 (NEMA)	Cable, CoProcessor to LCD, 6x6, 46"
14	1	-	37587 (NEMA)	Cable, CPU to CPU DxL

Section 2: Installation

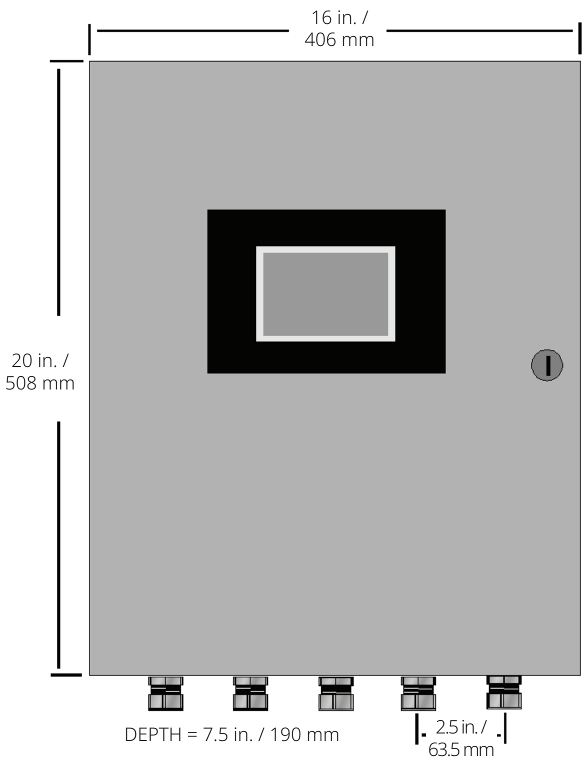
2.1 Network Master Mounting

If the system is supplied from the factory in an NEMA enclosure, no internal wiring is required except for connecting power and field network wiring. The next three sections (Sections 2.1, 2.2 and 2.3) discuss mounting, power input and field network wire connections to the NIM.

2.1.1 Mounting of NEMA Enclosure

The enclosure is rated for NAMA 4/12 and IP65/IP55. Dimensions of the enclosure are shown in Figure 5. Mounting dimensions are shown in Figure 6. The enclosure may be bulkhead mounted using the internal mounting holes. External mounting brackets may be used if desired. When mounting using the internal mounting holes, caution must be used to ensure the holes are sealed to maintain the NEMA/IP rating. The enclosure is supplied with five 1/2 in. compression type cable entry hubs. These may be fitted with conduit type fittings if desired. If the system includes backup LCD keypad terminal, some planning is required to allow for proper height above the floor to view the display and properly operate the keypad.

Figure 5.

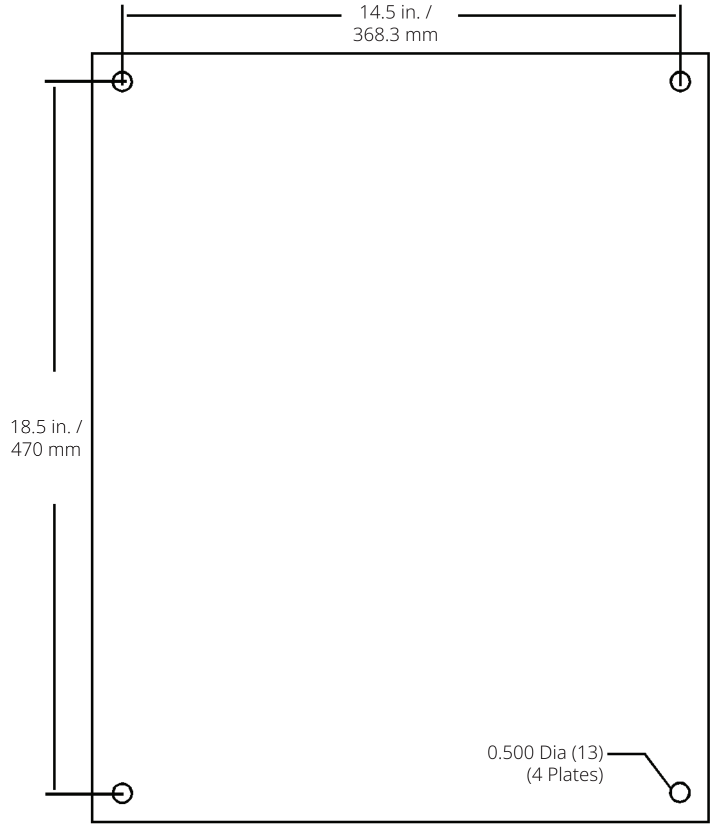


(5) Cable entries are provided for:
(1) Power Cable
(2) Field RS485 Network Cables
(2) Host RS485 Network Cables

NOTE

Allow 1 in. clearance on left side for ventilation and room for the door to swing open to left.

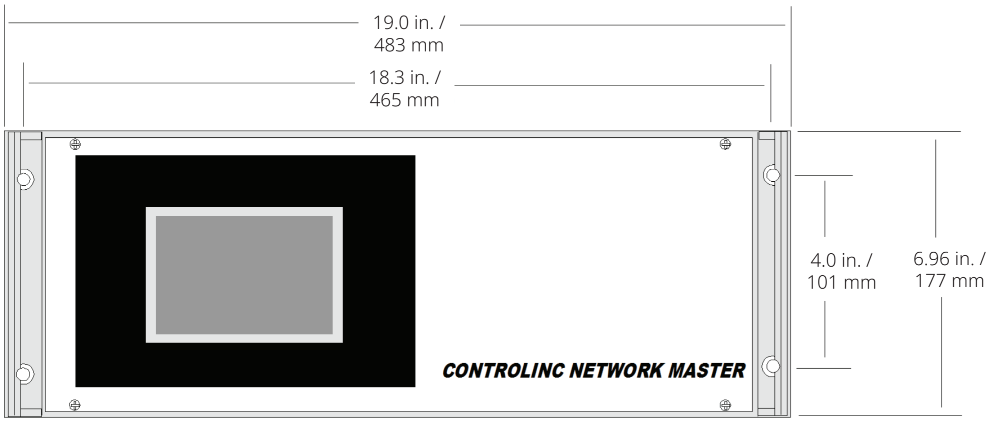
Figure 6. NEMA Box Mounting



2.1.2 Mounting of Rack Mount Enclosure

The enclosure is designed for standard EIA 19 in. DIN rail rack mounting. Dimensions of the enclosure are shown in Figure 7. The enclosure conforms to EIA RS-310, IEC 297-1, and DIN 41 494, Part 1 standards. The rack in which the enclosure(s) are mounted must allow a minimum of 20 in. / 508 mm depth, allowing space for cable connections. If the system includes backup LCD keypad terminals, some planning is required to allow for proper height above the floor to view the display and operate the keypad properly.

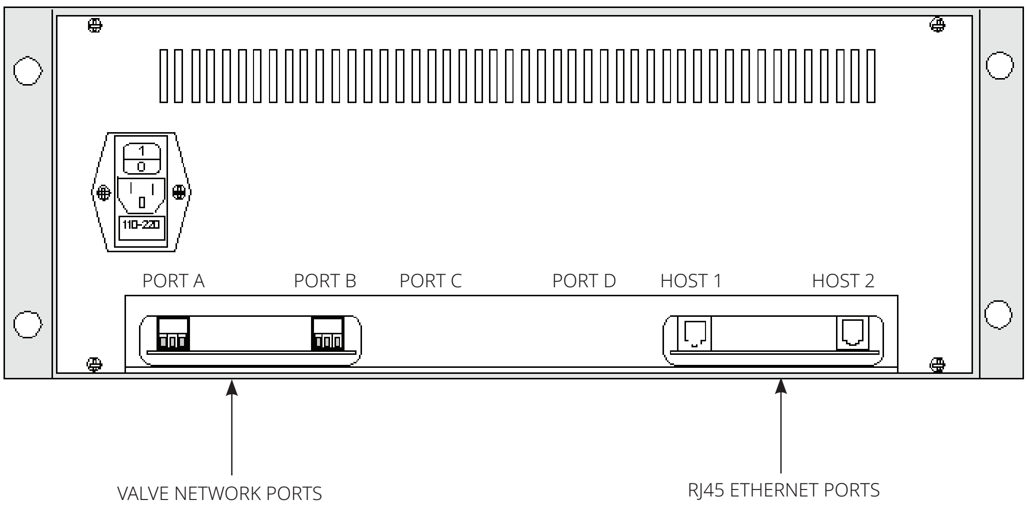
Figure 7.



Enclosure Depth = 15.0 in. / 381 mm

Allow a total depth of 20 in. / 508 mm for rear panel cable connections.

Figure 8. Rear Panel View



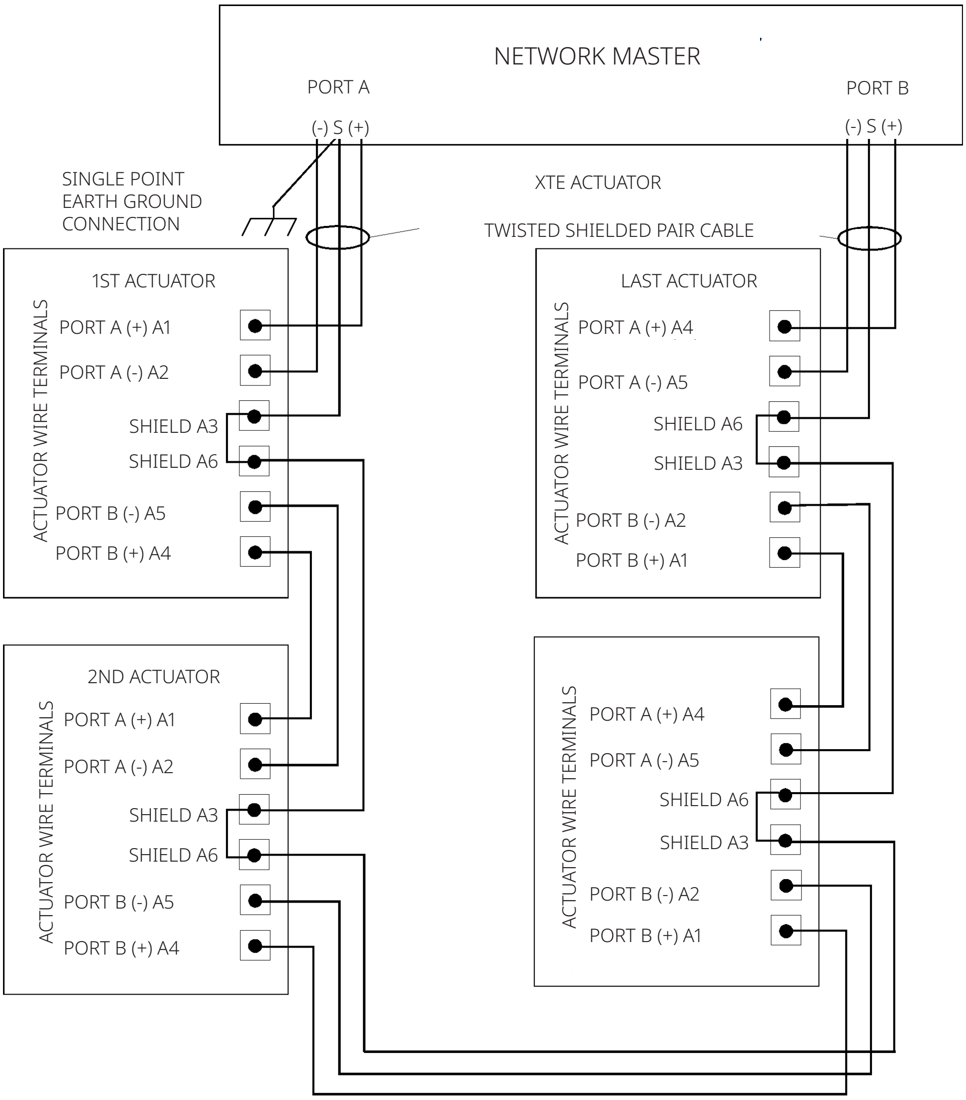
2.2 Power Input

The system operates from 120 V AC or 220 V AC, 50/60 Hz single-phase power with internal three wire power terminals. Ensure that a good safety ground is provided to the electrical supply to which the power input is connected. The system contains three main fuses (6.3x32 mm, 1 A) in the DIN-rail mounted fuse blocks. Each chassis and the LCD touch panel are independently fused. Each NIM is powered from redundant 24 V DC power supplies from the two chassis power supplies. The LCD touch panel is powered from an independent 24 V DC power supply. All other modules within the unit are powered over the base back plane from the associated main chassis power supply.

2.3 Field Network Wiring

The field network is wired in a ring configuration from Port A around a loop to Port B of the network master. Beginning at Port A, the network is wired to Port A of the first actuator and then from Port B of the first actuator to Port A of the second actuator and so on until the network returns from Port B of the last actuator to Port B of the network master. Networks may have parallel wired (bus wired) actuators between series wired actuators. Always wire parallel actuators to Port A and remove termination and bias. Do not connect more than 15 actuators in parallel between any two series connected actuators. Networks are polarized with (+) and (-) symbols on all drawings. Proper operation requires that polarity be observed at all connections. Connect the field networks to the Port A and B connectors on the NIM in the network master as shown in Figure 9. The networks must be connected to Port A and Port B of the valve actuators as shown in the wiring diagram of the XTE3000/ICON3000 IOM. Others 320B and RTS, please refer to their IOM for network wiring diagram. Controlinc 320B Quick Start manual. Controlinc supports many different network topologies. This manual supports only a single ring E>Net network topology that allows a combination of parallel (bus) and series E>Net connections on the same network.

Figure 9. Controlinc TEC2000 E>Net Ring Network Wiring (Typical)



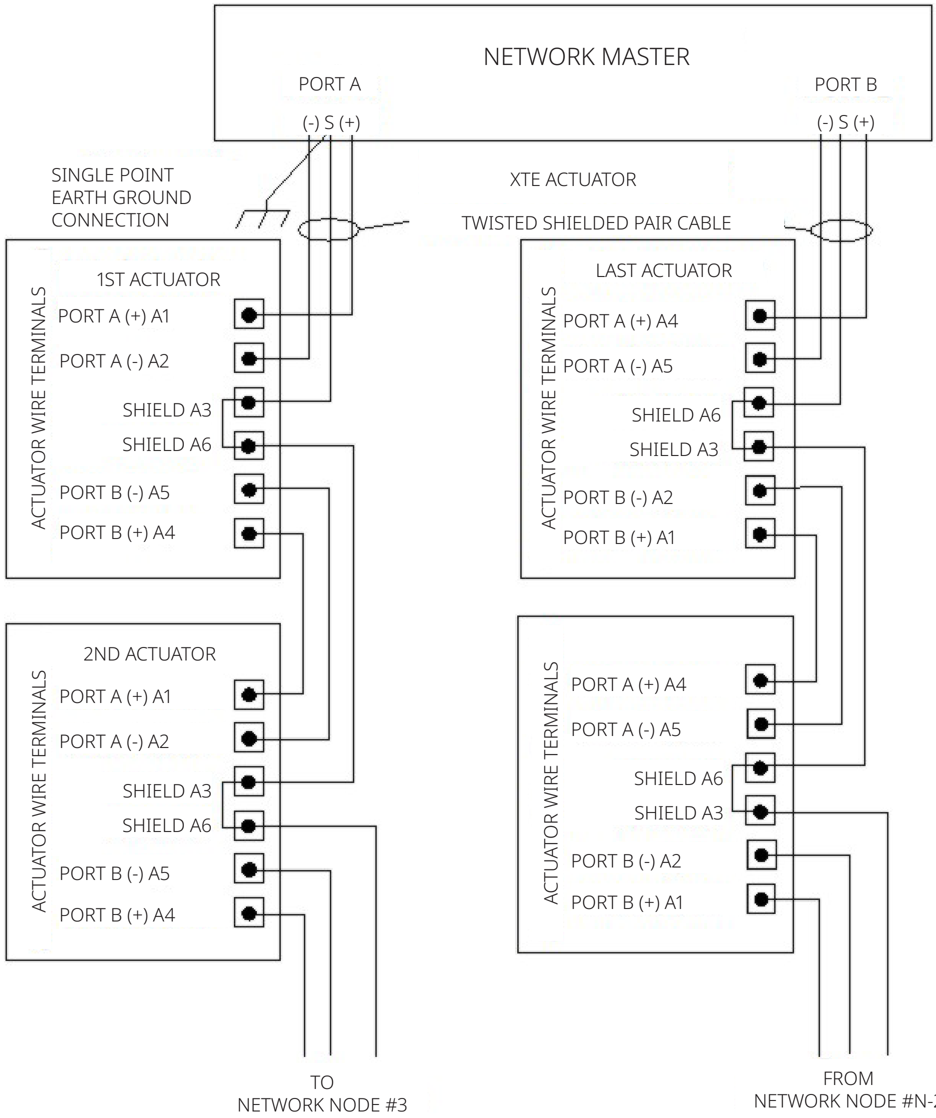
2.3.1 Network Grounding

The shield or drain wire of the network must be earth grounded at only one point per network segment. This single ground point may be at any location in the system where a good earth ground can be obtained. This may be Port B of each actuator if desired. If the network shield is connected to the internal ground or the chassis of the valve actuator, then the actuator housing must have a good earth ground. The NIM connection is normally the building/vessel hull equipment ground grid. A jumper may be installed between terminals A3 and A6 on the TBM of each actuator to carry the ground throughout the loop. Do not connect the network cable shields to a power line ground cable. Power lines can conduct lightning and other transients into the network. Do not connect both ends of the network shield to earth ground at the network master. This can cause a ground loop, making the transient protection system ineffective.

2.3.2 Network Termination

The network requires termination and bias to be asserted at every network segment in the E>Net ring. Parallel (bus) connected actuators must have termination and bias turned off. Setting DIP switches S1 and S2 on the NIM to the ON position terminates the Network Master (NIM).

Figure 10. TEC2000 Controlinc E>Net Ring Network Wiring (Typical)



Section 3: Configuring the System

The system is shipped from the factory pre-configured per customer's supplied data. This section of the manual is provided only for configuration from a Modbus host port. The user should read this entire section before attempting to configure the system. It may also be helpful to read Theory of Operation Section 5 of this manual for a better understanding of the system before attempting system configuration. Configuration data and associated Modbus registers are shown in Table 14, Section 4 of this manual. The system is configured from any Modbus host capable of reading and writing up to 540 configuration registers in the range of 42326 through 42866 shown in Table 14. The system may be configured using the LCD touch panel. The system is configured at the factory per the customer specifications. If the user changes the total number of actuators on the field network or other operational parameters, then the system configuration must be changed. If the actuators are not addressed in sequence around the loop, then the user must enter the actuator address sequence in the Network Address Scan List. Other parameters such as Modbus port baud rate, network master receiver time-out, and enabling/disabling diagnostic mode may be required during system integration and start-up.

NOTICE

When configuration changes are made, the affected module will automatically reset and re initialize with the new configuration parameters. Caution must be used when configuring the Modbus slave module to which the configuration computer is connected. The communication port of the configuration computer must match the configuration written to the connected slave module. Both primary and secondary chassis are configured at the same time regardless of which Module slave port is used to configure the system.

3.1 System Protection and Software Versions

3.1.1 Password Protection

All software is protected by password available only to the programmer. The software development package is not supplied with the system. Source code is supplied only for backup and must not be modified by the user. Should a development software package be acquired, the software on the system is password protected. This means the user may not edit the software without the password. This does not limit the user's ability to configure any part of the system via the Modbus host communication ports.

3.1.2 CoProcessor Software Protection

Access to all application software in the CoProcessor modules is disabled unless each module is put into diagnostic mode. The user must access the Modbus register containing the Diagnostic Mode register by one of the Host communication links or the touch panel.

3.1.3 Software Version Identification

Software version number of each module may be obtained by reading the associated "Software Version" Modbus register shown in Table 14. Software versions are reported as a three-digit number with an implied decimal point between the first and second most significant digits.

3.2 Selecting Diagnostic/Programming Mode

The chassis near the bottom or back of the enclosure is the Primary chassis. The chassis near the top or front of the enclosure is the Secondary chassis. Each chassis identifies itself by setting the appropriate bit in the "System Status Word", Modbus Register 40254 as shown in Table 11 in Section 4.10 of this manual. If Bit 8 is set, then the chassis with which you are communicating is the Primary Network Master. If Bit 9 is set, then the chassis with which you are communicating is the Secondary Network Master. Either chassis may be in Hot Stand-by mode. Bits 4 and 5 of register 40254 identify the chassis that is in hot standby. The two chassis may be forced to swap roles of active and hot standby mode by writing a non-zero value to Modbus Register 40255. This register will be reset to zero after mode swap is executed.

3.3 Chassis Identification and Hot Standby

The chassis near the bottom or back of the enclosure is the Primary chassis. The chassis near the top or front of the enclosure is the Secondary chassis. Each chassis identifies itself by setting the appropriate bit in the "System Status Word," Modbus Register 40254 as shown in Table 11 in Section 4.10 of this manual. If Bit 8 is set, then the chassis with which you are communicating is the Primary Network Master. If Bit 9 is set, then the chassis with which you are communicating is the Secondary Network Master. Either chassis may be in Hot Stand-by mode. Bits 4 and 5 of register 40254 identify the chassis that is in hot standby. The two chassis may be forced to swap roles of active and hot standby mode by writing a non-zero value to Modbus Register 40255. This register will be reset to zero after mode swap is executed.

3.4 Configuring Modbus Host Port Interface(s)

The host port may be configured for RS232 full duplex or RS422/RS485 with either 4-wire or 2-wire half duplex by writing to the Port Hardware Mode register as shown in Table 13. The module must be configured for RS232 if a NIM is used for connecting the Host RS485 networks. Modbus slave address, baud rate, and parity may be configured by writing to the associated configuration register shown in Table 13.

3.4.1 Configuring Ethernet Ports

If your system is equipped with Ethernet host ports, the two ports for Host 1 and Host 2 must be configured independently. Each port may be configured using Telnet or the supplied Device Installer software. All network master parameters may be configured using Emerson Master Configuration software. Setting of all Modbus coprocessor ports and the NIM-TCP ports must match, else communication link will be lost. If no IP address was assigned at time of order, the default IP address (169.254.132.147) labeled at each port on the NIM-TCP module may be used to access the ports and assign an IP address. Both ports may be assigned the same IP address only when connected to two independent Ethernet links. Software is supplied on the CD with the system to configure the system, set IP addresses and test the system via the Ethernet ports.

3.5 Configuring the Field Network

Editing the values loaded to Modbus registers 42828 through 42833 as shown in Table 13 configure the field network ports and network master functions. Each parameter is discussed in the following paragraphs.

3.5.1 Configuring the Number of Slaves

The number of slaves (valve actuators) on the field network is configured by editing the constant loaded to "Number of Field Network Devices" in Modbus register 42830.

3.5.2 Configuring Field Network Baud Rate

Editing the constant written to Modbus register 42831 as shown in Table 14 change network baud rate of the Network Master. If the number written to this register is not a valid baud rate, the system will default to 9600 baud. The baud rate must match the baud rate of the valve actuators connected to the network. The default baud of all devices and all ports of the Network Master is 9600.

3.5.3 Configuring Network Master Receiver Time-Out

Editing the constant loaded to Modbus register 42832 may change receiver time-out of the network masters. Receiver time-out is the amount of time the network master will wait for a response from a slave device before moving on to the next device. If this time is too short (less than 10 mS) it could cause collisions on the network, degrading communications throughput. If this time is too long, it will cause time to be wasted while the master is trying to put unconnected devices on the network. The default setting is 50 mS.

3.5.4 Configuring Report-By-Exception (RBE)

Loading a zero to Modbus register 42833 will disable RBE. Writing a non-zero value to register 42833 enables RBE, the default setting.

3.6 Configuring Network Address Sequence

The network master must know the sequence of slave addresses around the network ring in order to properly perform network fault location. Unless otherwise specified, all systems are shipped with a scan list in contiguous sequence starting at address #1 at Port A and ending with the last address at Port B. To change the sequence of addresses in the scan list, it is necessary to edit the scan list located in Modbus registers 42326 through 42575 or the number of registers equal to the number of actuators on the network. If the system reloads default settings, the contiguous sequence of 1 to 250 will be loaded to this list.

3.7 Configuring Device Types

The network master must know the type of slave device connected to the network corresponding to each network address in order to acquire the desired data. There are five different device types that may be selected for each unit connected to the network. All device types return valve status (inputs 16 to 31). Remaining data acquired is listed below. For EHO extended status and alarms, please use Device Type 4.

DeviceData Acquired

Type 0 Valve position (0 to 100% in 1% increments)
Type 1 Valve position (0 to 100% in 1% increments)
Coils (0 to 15)
Inputs (0 to 15)
Type 2 Valve position (0 to 4095)
Position setpoint (0 to 4095)
Analog output (0 to 4095)
Type 3 Valve position (0 to 4095)
Position setpoint (0 to 4095)
Analog output (0 to 4095)
Coils (0 to 15)
Inputs (0 to 15)
Type 4 Valve position (0 to 4095)
Position setpoint (0 to 4095)
Analog output (0 to 4095)
Valve torque (0 to 4095)
User analog input #1 (0 to 4095)
User analog input #2 (0 to 4095)
Type 5 Valve position (0 to 4095)
Position setpoint (0 to 4095)
Analog output (0 to 4095)
Valve torque (0 to 4095)
User analog input #1 (0 to 4095)
User analog input #2 (0 to 4095)
Coils (0 to 15)
Inputs (0 to 15)
Type 7 XTE3000/ICON3000 actuators
Valve position (0 to 4095)
Position setpoint (0 to 4095)
Valve torque (0 to 4095)
User analog input #1 (0 to 4095)
Type 8 RTS actuators
Valve position (0 to 4095)
Position setpoint (0 to 4095)
Valve torque (0 to 4095)

Unless otherwise specified, all systems are shipped with all devices configured as Type 2. To change the device type for any one or all devices, it is necessary to edit the device type list located in Modbus registers 42576 through 42825 or the number of registers equal to the number of devices on the network. The touch panel may be used to edit device types. If the system reloads default settings, all devices will be set as Device Type 2.

Section 4: Modbus Register Maps

4.1 Valve Status and Command Registers per Modbus Function Code

Controlinc Network Masters communicate with host computer equipment using Modbus RTU protocol. Valve actuator status and alarms data may be acquired from the Network Master using any one of four Modbus Function Codes (01 thru 04). Data is returned as either discrete (bit) type using Function Code 01 and 02 or as 16-bit unsigned integers using Function Code 03 and 04. Command outputs to the valves may be written to the Network Master using four Function Codes (05, 15, 06 and 16). Table 1 is the address map for valve actuators up to a maximum of 250. Status of each valve is stored as 16 discrete inputs and as 16 coils. Discrete commands to each valve consist of eight bits (coils) per valve and are stored as coils in one 16-bit register per actuator. Position setpoint is an analog word (0 to 4095) value written to the valve actuator using the 06 or 16 function codes. All registers are unsigned 16-bit integers.

NOTE:

Modbus addressing shown in the tables of this section is the normal configuration addressing method used by most SCADA and DCS systems. If you are building Modbus messages at the communication driver level, keep in mind that HEX-starting addresses in the Modbus message are offset by one. You must subtract one from the address in the tables when building a Modbus message. For example, to read the first valve status bits as coils using Function Code 01, the starting address of 1025 shown in Table 1 would be 400 Hex (1024 decimal) in the Modbus message. If valve status of the first valve is read using Function Code 02, the starting address of 10001 shown in Table 1 would be 00 Hex in the Modbus message. If valve status of the first valve is read using Function Code 03, the starting address of 40001 shown in Table 1 would be 00 Hex in the Modbus message.

Table 1. Memory Map of Valve Data and Commands by Function Code (1)

Function Code and Valve Data/Command	Command Data Type	Begin Reg	Ending Reg	Max. Number
01 Discrete valve status	Read Coils (discrete)	01025	05024	4000
01 Discrete Outputs (0 to 15)	Read Coils (discrete)	05089	09088	4000
02 Discrete valve status	Read Inputs (discrete)	10001	14000	4000
02 Discrete Inputs (raw 0 to 15)	Read Inputs (discrete)	14065	18064	4000
03 Valve status word	Read Holding Register	40001	40250	250
03 Valve position feedback	Read Holding Register	40256	40505	250
03 Valve position setpoint	Read Holding Register	40576	40825	250
03 Aux. analog input #1	Read Holding Register	40826	41075	250
03 Aux. Analog input #2	Read Holding Resister	41076	41325	250
03 Aux. Analog output	Read Holding Register	41326	41575	250
03 Discrete Inputs (raw 0 to 15)	Read Holding Register	41576	41825	250
03 Discrete Outputs (0 to 15)	Read Holding Register	41826	42075	250
03 Raw torque analog input	Read Holding Register	42076	42325	250
04 Valve status word	Read Input Register	30001	30250	250
04 Discrete Inputs (raw 0 to 15)	Read Input Register	30256	30505	250
05 Discrete valve commands	Write Coils (discrete)	00001	01000	1000

Table 2. Memory Map of Valve Data and Commands by Function Code (2)

Function Code and Valve Data/Command	Command Data Type	Begin Reg	Ending Reg	Max. Number
05 Discrete Outputs (0 to 15)	Write Coils (user relays)	05089	09088	4000
15 Discrete valve commands	Write Multiple Coils	00001	01000	1000
15 Discrete Outputs (0 to 15)	Write Multiple Coils	05089	09088	4000
06 Discrete valve commands	Write Holding Register	40512	40575	64
06 Valve position setpoint	Write Holding Register	40576	40825	250
06 Aux. analog output	Write Holding Register	41326	41575	250
06 Discrete Outputs (0 to 15)	Write Holding Register	41826	42075	250
16 Discrete valve commands	Write Multiple Registers	40512	40575	250
16 Valve position setpoint	Write Multiple Registers	40576	40825	250
16 Aux. Analog output	Write Multiple Registers	41326	41575	250
16 Discrete Outputs (0 to 15)	Write Multiple Registers	41826	42075	250

4.2 Valve Status Bit Data for Each Valve

Valve status information is stored in contiguous registers in sequence with the valve actuator network address. Table 3 shows the valve status for valve address #1 when using Modbus Function Code 02.

Table 3. Valve Status Information for Valve at Network Address #1

Modbus Address	Valve Status	Description
10001	Open Limit Switch	Valve Fully Open
10002	Close Limit Switch	Valve Fully Closed
10003	Transition Opening	Valve is Moving Open
10004	Transition Closing	Valve is Moving Close
10005	Manual Mode	Selector Swt in Local
10006	Auto Mode	Selector Swt in Remote
10007	Open Torque Alarm	Open Torque Swt Tripped
10008	Close Torque Alarm	Close Torque Swt Tripped
10009	Valve Stall Alarm	Valve is Not Moving
10010	Power Monitor Alarm	Loss of Control Voltage
10011	Motor Overload Alarm	Overload Relay Tripped
10012	Phase Monitor Alarm	3-Phase power reversed
10013	Local ESD Alarm	Local ESD input activated
10014	Actuator Fail Alarm	Failed self-diagnostics
10015	Com No-Response Alarm	Com Failure on both lines
10016	Unit Alarm	Set when any alarm bit set

Note:
Unit alarm bit (10016) is set if any one or more alarm bits 7 through 13 are set.

For EHO extended status and alarms, please refer to Table 4.

Table 4. Valve Status Information for Valve at Network Address #1

Modbus Address	Valve Status	Description
10001	Off Mode	Not in Local or Remote
10002	Low Oil Pressure	Low Oil Pressure
10003	Low Oil Level	Low Oil Level
10004	PST Failed	Partial Stroke Fail
10005	Electronic Fault Alarm	Electronic Failed Alarm
10006	Hydraulic Power Unit Fault Alarm	Hydraulic Power Unit Fault Alarm
10007	Over Pressure Alarm	Over Pressure Alarm
10008	PST in Progress	Partial Stroke in progress
10009	PST Passed	Partial Stroke Passed
10010	-	-
10011	-	-
10012	-	-
10013	-	-
10014	-	-
10015	-	-
10016	-	-

4.2.1 Multiple Valve Status Locations Using Function Code 02

Valve status information shown in Table 4 is repeated for each actuator on the network in sequence of network address. Data for valve at network address number 2 is located at Modbus addresses 10017 through 10032. Data for valve at network address 3 is located at 10033 through 10048 and so on for up to 250 valves on the network as shown in Table 5.

Table 5. Using Modbus Function Code 02

Valve Actuator Network Address	Modbus Addresses for Valve Status
001	10001 thru 10016
002	10017 thru 10032
003	10033 thru 10048
004	10049 thru 10064
005	10065 thru 10080
thru	thru
248	13953 thru 13968
249	13969 thru 13984
250	13985 thru 14000

4.2.2 Multiple Valve Status Data Using Modbus Function Code 03

The same valve status data can be accessed by the Host using Function Code 03 by reading unsigned 16-bit integers from holding registers beginning at Modbus Address 40001 as shown in Table 6. The 16 bits of valve status for each valve actuator is the same as that shown in Table 3.

Table 6. Using Modbus Function Code 03

Valve Actuator Network Address	Modbus Addresses for Valve Status
001	40001
002	40002
003	40003
004	40004
005	40005
thru	thru
248	40248
249	40249
250	40250

4.2.3 Multiple Valve Status Data Using Modbus Function Code 04

The same valve status data can be accessed by the Host using Function Code 04 by reading unsigned 16-bit integers from input registers beginning at Modbus Address 30001 as shown in Table 10. The 16 bits of valve status for each valve actuator is the same as that shown in Table 4.

Table 7. Using Modbus Function Code 04

Valve Actuator Network Address	Modbus Addresses for Valve Status
001	30001
002	30002
003	30003
004	30004
005	30005
thru	thru
248	30248
249	30249
250	30250

4.3 Reading Valve Position and Setpoint

Valve position feedback is accessed by the Host using Modbus Function Code 03 to read holding registers beginning at Modbus address 40256. Position setpoint of each valve may be read in sequence with valve address starting at Modbus address 40576. Device types 0 and 1 return valve position as 0 to 100% in 1% increments. All other device types return analog data representing analog position and setpoint of each valve as unsigned 16-bit integer with a 12-bit value of 0 to 4095. Each valve's analog position and setpoint are located in holding registers in sequence of network address as shown in Table 8.

Table 8. Valve Position Feedback and Setpoint using Modbus Function Code 03

Valve Actuator Network Address	Modbus Addresses	
	Position	Setpoint
001	40256	40576
002	40257	40577
003	40258	40578
004	40259	40579
005	40260	40580
thru	thru	
248	40503	40823
249	40504	40824
250	40505	40825

4.4 Writing Discrete Commands to Valve Actuators

Discrete commands are written to a single valve actuator as coils (bit) data using Modbus Function Code 05 or Function Code 15. Commands may also be written to multiple valve actuators by writing a single holding register using Function Code 06 or to multiple holding registers using Function Code 16. Emergency Shut Down to all valve actuators (ESD) is accomplished by writing seven (7) to Modbus Register 40575. This will cause ESD to be broadcast to all valve actuator addresses. Writing a zero to register 40575 ends the ESD function. Each valve actuator will respond to four commands as shown in Table 9. The four bits associated with each valve is in sequence with the valve actuator network address. When writing to holding registers, data is written to four valve actuators. Writing zeros to any location has no affect on operation. Each command is a positive one (set coil) and the coil is automatically reset when the command is executed. Only one coil per valve may be written at any one time. Writing multiple coils to a single valve will cause no action, i.e. it is treated as a no-op.

Table 9. Writing Commands to Valves using Function Code 05 or 15

Modbus Address	Comman and Valve Network Address
0001	Open - Valve at address 001
0002	Stop - Valve at address 001
0003	Close - Valve at address 001
0004	ESD - Valve at address 001
0005	Open - Valve at address 002
0006	Stop - Valve at address 002
0007	Close - Valve at address 002
0008	ESD - Valve at address 002
0009	Open - Valve at address 003
00010	Stop - Valve at address 003
00011	Close - Valve at address 003
00012	ESD - Valve at address 003
00013	Open - Valve at address 004
00014	Stop - Valve at address 004
00015	Close - Valve at address 004
00016	ESD - Valve at address 004

Discrete command holding registers contain four commands per valve for four valves per 16-bit register. A single register may be written to command four valves by using the Modbus Function Code 06. Multiple registers may be written using Function Code 16. Command holding registers begin at Modbus address 40512. A total of 63 registers are used for the command coils. The last valve network address in register 40574 is valve address 250. Each actuator is configured to respond to the ESD command in either of three ways; go closed, go open, or stay put. Each actuator can also control an ESD relay, which may be wired to control the actuator, external equipment or to override some internal function. See Section 1.1 for instructions on setting ESD functions of the valve actuator.

4.5 Writing Analog Valve Position Setpoint (Function Codes 06 and 16)

If the valve is a modulating or positioning unit (except device types 0 and 1), the position setpoint may be written to the valve as an unsigned 16-bit integer from 0 to 4095 using Modbus Function Codes 06 or 16. Setpoint of each valve is in sequence with network address. Any Emerson actuator with Controlinc, except device types 0 and 1, may be a positioner or modulating unit. The actuator, depending on the command issued by the master, automatically sets the operating mode.

4.6 Reading Auxiliary Analog Inputs Using Function Code 03

Device types 4 and 5 have two auxiliary analog inputs for data acquisition of other equipment such as pressure or temperature transducers. The two inputs for each actuator are identified as AIN2 and AIN3. The analog data is returned as unscaled 12-bit unsigned integers with a value between 0 and 4095. The host is required to scale the values to engineering units for display to the Man Machine Interface (MMI). The values are scaled by (real time value/4095 *full scale engineering units). Data for auxiliary analog inputs AIN2 is in sequence with network address starting at Modbus register 40826. Up to 250 values may be acquired. The last register for the 250th unit is 42075. Data for auxiliary analog inputs AIN3 is in sequence with network address starting at address 42076. Up to 250 values may be acquired. The last register for the 250th unit is 42325.

4.6.1 Reading Torque Analog Input Using Function Code 03

Device types 4 and 5 may have an optional analog input for relative torque measurement. The torque data is scaled as 0 to 4095 for 0 to 100% of the analog value read from register 15 labeled AIN#1. The user must provide scaling at the host for conversion to actual torque based on the actuator model and spring pack. Torque data range is provided on the data sheet supplied with each actuator. Torque data may be used for detection of valve problems by measuring and storing an initial maximum opening torque and then comparing the current reading to the stored initial maximum torque reading. If the current reading exceeds the initial maximum torque reading by a predetermined amount (limit), then a valve maintenance alarm or message may be generated. The analog torque reading is in sequence with network address starting at Modbus register 42076. Up to 250 values may be acquired. The last register for the 250th unit is 42325.

4.7 Reading and Writing Auxiliary Analog Outputs

All device types, except type 0 and 1, have an option to add one 4 to 20 mA analog output. The host may write to the output by writing to a Modbus register in sequence with network address starting at register 41326. Up to 250 analog outputs may be written. The last register for the 250th unit is 41575. Data must be written to the actuators as 12-bit analog data with a range of 0 to 4095 corresponding to 4 to 20 mA. The data is written to the actuators using Modbus Function Code 06 or 16. The analog output may be read back from the actuator using Function Code 03.

4.8 Reading User Discrete Inputs

Each Controlinc equipped actuator has two isolated discrete inputs available to the User. These are Inputs 13 (User Input #1) and 14 (User Input #2) in the discrete input memory map. Inputs 0 to 15 are the raw hardware discrete inputs and are de-bounced by software. None of the inputs are software generated. The Network Master reads all discrete inputs (0 to 15) of device types 1, 3 and 5 and places these into contiguous data base locations corresponding to network address of the actuator. Inputs of each actuator are shown in Table 10. The host, using Function Codes 02, 03, and 04, may access these inputs. When using Function Code 02, the inputs are addressed from 14065 to 18064 with 16 inputs per actuator as shown in Table 10 for up to 250 actuators. When using Function Code 03, the discrete inputs are addressed from register 41576 (valve #1) to 41825 (valve #250). When using Function Code 04, the discrete inputs are addressed from register 30256 (valve #1) to 30505 (valve #250). Inputs (bits) of each valve actuator within the 40000 and 30000 registers are in the same sequence as shown in Table 10.

Table 10. Discrete Inputs for Valve at Network Address #1 Using Function Code 02

Modbus Address	Valve Status	Description
10001	Open Limit Switch	Valve Fully Open
10002	Close Limit Switch	Valve Fully Closed
10003	Auxiliary Open Contact	Aux. contact of starter
10004	Auxiliary Close Contact	Aux. contact of starter
10005	Manual Mode	Selector Swt in Local
10006	Auto Mode	Selector Swt in Remote
10007	Open Torque Alarm	Open Torque Swt Tripped
10008	Close Torque Alarm	Close Torque Swt Tripped
10009	Power Monitor Alarm	Loss of Control Voltage
10010	Motor Overload Alarm	Overload Relay Tripped
10011	Phase Monitor Alarm	3-Phase power reversed
10012	Local ESD Alarm	Local ESD input activated
10013	VFC Fault Alarm	VFC alarm input activated
10014	User Discrete Input #1	Isolated user wired input
10015	User Discrete Input #2	Isolated user wired input
10016	On-board execute button	Used by 320A or B only

4.9 Writing User Relay Outputs (MRTU Support)

Device types 1, 3 and 5 have two User Relay Outputs, which may be controlled by the host. The outputs are Coils 04 (User Relay #1) and 05 (User Relay #2) in the Controlinc Coil Map (0 to 15). The Network Master may read and write all 16 coils but masks all coils except 00, 01, 04 and 05. If the user attempts to write to any other coils, the command will be ignored. The user should not write to coils 00 (close) or 01 (open) if the device is a valve actuator. Write these coils only if the device is an MRTU.

The database of the Network Master is configured for 16 coils per actuator for 250 actuators in sequence with valve address. The User Relays may be controlled using Function Codes 05, 15, 06 or 16. If Function Codes 05 or 15 are used the coils are addressed from coil 05089 to 09088 with 16 coils per actuator. For example, writing to the relays of valve number one, write to coil 05093 for User Relay #1 and 05094 for User Relay #2. User Relays of each consecutive valve are offset by 16. For example, User Relay #1 of valve number two would be coil 05109 (5093+16). Coils 00 (close) and 01 (open) are masked by the network master when the selector switch is in "Remote" mode. This prevents the host from overwriting these coils in the valve actuator when under control by the Controlinc card in the actuator.

4.10 System Status Word

The system status word is the status of the Network Master. This word is located in Modbus register 40254. The system status word may be read using Modbus Function Code 02 or 03 in the same manor as reading valve status. Bit locations for Function Code 02 are shown in Table 11. Only the first least significant twelve bits are defined.

The four most significant bits are reserved for future functions and are set to zeros. If Bit 8 is set (true) then the chassis is the primary network master. If Bit 9 is set (true) then the chassis is the secondary network master. Bit assignments are shown in Table 11.

Table 11. System Status Word Bit Map

Bit	Status Definition	Note	CR	FC02
0	Primary Watchdog Timer Alarm	-	20	14049
1	Secondary Watchdog Timer Alarm	-	21	14050
2	Primary Failed Write Command Alarm	C (FW)	22	14051
3	Secondary Failed Write Command Alarm	C (FW)	23	14052
4	Primary Master in Hot Standby Mode	C (HM)	24	14053
5	Secondary Master in Hot Standby Mode	C (HM)	25	14054
6	Primary Network Fault Alarm	C (NF)	26	14055
7	Secondary Network Fault Alarm	C (NF)	27	14056
8	Primary Network Master Active	C (AM)	30	14057
9	Secondary Network Master Active	C (AM)	31	14058
10	Primary Host Link Failed Alarm	-	32	14059
11	Secondary Host Link Failed Alarm	-	33	14060
12	DXL Grant primary master access to network	-	34	14061
13	DXL Grant secondary master access to network	-	35	14062
14	DXL Fail Alarm	-	36	14063
15	Switch Active Master to Hot Standby and Standby to Active	-	37	14064

Primary and Secondary Host Link Failed alarms shown in Table 11 are determined by queries received from the Modbus host computer (DCS) using function codes 01, 02, 03, 04 or 08. If a query is not received from the host in about five to six seconds, then this alarm is set. Host link alarms are exchanged between the primary and secondary network masters. These alarms are also used to help determine which master takes control of the network.

The host communication status and associated network fail over is discussed in the Theory of Operation Section of this manual. The host(s) must repeatedly transmit queries to both primary and secondary masters within 5 seconds between transmissions to prevent the masters from detecting a faulty link from the host(s). The network master will not respond to any queries while in hot standby.

4.11 Combined System Alarms

In addition to the system alarms located in the system status word at Modbus register 40254, there are four combined system alarms located at Modbus register 40251 as shown in Table 12. The system is in alarm when this register is non-zero and the alarm is cleared when this register in zero. Bit 0 is a combined alarm for bits 1 to 3 in register 40251, meaning this bit is set when any one of the other system alarms is set. Bit 1 is set when any valve actuator on the loop is in alarm. This is a combination of all actuator Unit alarms. Bit 2 is set when the Primary master is in alarm. This is a combination of Bits 0, 2, 6 and 14 of the system status word shown in Table 11. This alarm is also set when the Primary master is powered down. Bit 3 is set when the Secondary master is in alarm. This is a combination of Bits 1, 3, 7 and 14 of the system status word shown in Table 11. This alarm is also set when the secondary master is powered down.

Table 12. Combined System Alarms (Modbus Register 40251)

Bit	Alarm Definition
0	System Alarm (Combined system alarm, set when any one of Bits 1,2, or 3 is set)
1	Actuator Unit Alarm (Set when any valve actuator unit alarm is set)
2	Primary Master Alarm (Set when any primary master alarm is set)
3	Secondary Master Alarm (Set when any secondary master alarm is set)
4 to 15	Reserved for future enhancements

4.12 Network Fault Location

If the field network is connected in a ring configuration, the Network Master automatically detects and locates a single line fault. Location of the fault may be displayed by the LCD touch panel or the MMI as two network addresses. The two network addresses between which the fault is located is available in Modbus register 40252 (Network Fault Low Address) and register 40253 (Network Fault High Address).

By reading these two locations, the SCADA or DCS host may display to the MMI the location of the fault when a Network Fault system alarm bit is set. It is important for the address scan list be properly configured as described under system configuration, Section 3.6 of this manual in order for fault location to function properly.

4.13 M250 Global Database and Modbus Holding Register Map

Table 12 is supplied for the benefit of the software engineer and is not required for system configuration. The system automatically allocates memory for the database as shown. All communication modules, masters and slaves, located in Slots 1-5 of the I/O rack share the same database located in the memory of the main processor. Table 13 is supplied for system configuration. For more detail on system configuration, see Section 3 of this manual. All communication modules may be configured from any one of the Modbus slave ports normally connected to a host. The LCD touch panel may be used to configure the network masters.

Refer to Table 13 for database location of Network Master configuration written by the LCD touch panel.

NOTE:

Network Address Scan List defaults to addresses 1 to 250 in sequence.
Device Type List defaults to all type 2.
All communication ports default to RS232, 9600, N, 8, 1.
All modules default to Normal Run Mode.

Table 13. M250 Global Database for Bettis RTS and XTE3000/ Biffi ICON3000 Actuators and Modus Register Assignments for Valve Data (All Actuator Data is in Sequence with Valve Actuator Network Address)

Parameter		Octal	Decimal	Hex	Modbus	
Valve Status and Alarms (250 words)	Begin	1400	0768	300	40001	RO
	End	1771	1017	3F9	40250	
System Alarms	-	1772	1018	3FA	40251	RO
Network Fault Low Address	-	1773	1019	3FB	40252	RO
Network Fault High Address	-	1774	1020	3FC	40253	RO
System Status Word (1 word)	-	1775	1021	3FD	40254	RO
Swap Primary and Hot Standby	-	1776	1022	3FE	40255	R/W
Valve Position Feedback (250 words)	Begin	1777	1023	3FF	40256	RO
	End	2370	1272	4F8	40505	
Net Fault Index Low	-	2371	1273	4F9	40506	RO
Net Fault Index High	-	2372	1274	4FA	40507	RO
Discrete Valve Commands (63 words)	Begin	2377	1279	4FF	40512	R/W
	End	2475	1341	53D	40574	
ESD to all Valve Actuators	-	2476	1342	53E	40575	R/W
Valve Position Setpoint (250 words)	Begin	2477	1343	53F	40576	R/W
	End	3070	1592	638	40825	
User Analog Input #1 (250 words)	Begin	3071	1593	639	40826	RO
	End	3462	1842	732	41075	
User Analog Input #2 (250 words) -N/A TO XTE3000/ICON3000	Begin	3463	1843	733	41076	RO
	End	4054	2092	82C	41325	
Analog Output (250 words) -N/A TO XTE3000/ICON3000	Begin	4055	2093	82D	41326	R/W
	End	4446	2342	926	41575	
User Discrete Inputs (Valve inputs 0 to 15) (250 words)	Begin	4447	2343	927	41576	RO
	End	5040	2592	A20	41825	
User Discrete Outputs (Valve outputs 0 to 15) (250 words) -N/A TO XTE3000/ICON3000	Begin	5041	2593	A21	C 5089	R/W
	End	5432	2842	B20	C 9088	
Valve Torque (raw analog) (250 words)	Begin	5433	2843	B21	42076	RO
	End	6024	3092	C14	42325	
EHO, XTE, RTS Extended Status and Alarms cont. (250 words)	Begin	10000	4096	1000	43329	RO
	End	10371	4345	10F9	43578	
EHO Extended Close Attempt (250 words) -N/A TO XTE3000/ICON3000	Begin	10372	4346	10FA	43579	RO
	End	10763	4595	11F3	43828	

⚠ WARNING

Writing 7 to Register 40575 will cause all actuators to execute ESD.
Writing zero to Register 40575 will disable (end) ESD.

Table 14. M250 Network Master Configuration (Writing to RO Registers is Allowed but will be Over-Written by the Controller) (All Registers are 16-bit Unsigned Integers) (1)

Configuration Slot/Parameter	Configuration Options, Default Settings shown in [Brackets]		PLC Octal	PLC Hex	Modbus Register	
Network Address Scan List (250 words)	Physical sequence of Actuators on Network	Begin	6025	C15	42326	R/W
		End	6416	D0B	42575	
Device Type List (124 words)	Type of each Slave Device on Valve Actuator Network	Begin	6417	D0F	42576	R/W
		End	7010	E08	42825	
Main CPU S/W Version	Software Version Number of RLL. Data written to this register will be over-written by the CPU on power up	Begin	7011	E09	42826	RO
System Reset	Writing non-zero value will cause the system to reset. This register is zeroed after reset	End	7012	E0A	42827	R/W
Slot 1 (Net Master)	Valve Actuator Network Master		-			
Software Version	Module S/W Version Number Written by Module in Slot 1		7013	E0B	42828	RO
Diagnostic Mode	[0=Normal Run Mode] Non-Zero=Diagnostic Mode		7014	E0C	42829	R/W
Number of Field Network Devices	[250] Total number of slave devices connected to network		7015	E0D	42830	R/W
Baud rate of Valve Actuator Network	Enter whole number/100. Example: 48, 96, 192, 384 [96]		7016	E0E	42831	R/W
Receiver Time-Out	Enter time in milliseconds (50 mS)		7017	E0F	42832	R/W
Enable/Disable Report-By-Exception	0=Disable report by exception (RBE) [Non-Zero=Enable RBE]		7020	E10	42833	R/W
Reserved	Data written ignored		7021	E11	42834	R/W
Reserved	Data written ignored		7022	E12	42835	R/W
Enable Program Mode	Writing a non-zero value to this register allows the module to be programmed from Port 1		7023	E13	42836	R/W
Reload Default Scan List and Device Types	Writing zero to this register reloads sequential scan list from 1 to 250 and all device types as 2. Do not write a non-zero value. The master writes 0x5A5A to this register after defaults are loaded		7024	E14	42837	R/W

Table 15. M250 Network Master Configuration (Writing to RO Registers is Allowed but will be Over-Written by the Controller) (All Registers are 16-bit Unsigned Integers) (2)

Configuration Slot/Parameter	Configuration Options, Default Settings Shown in [Brackets]		PLC Octal	PLC Hex	Modbus Register	
Slot 2 (LCD Terminal)	**LCD Panel and Control Passcode**		-			
Software Version	Module S/W Version Number Written by Module in Slot 2		7025	E15	42838	RO
Diagnostic Mode	[0=Normal Run Mode] Non-Zero=Diagnostic Mode		7026	E16	42839	R/W
LCD Slave Address	Enter whole number from 1 to 254. [Default=5]		7027	E17	42840	R/W
LCD Baud rate	Enter whole number/100. Example: 96, 192, 384, 1152 etc.		7030	E18	42841	R/W
LCD Slave Parity	[0=None], 1=Odd, 2=Even		7031	E19	42842	R/W
Port Hardware Mode	[0=RS232], Non-Zero=RS422/485		7032	E1A	42843	R/W
Reserved for Future Expansion	Data written to these registers are ignored	Begin	7033	E1B	42844	R/W
		End	7034	E1C	42845	
LCD Control Passcode	[0=Passcode Disabled] Write integer between 0 and 998		7035	E1D	42846	R/W
Slot 3 (Host Port 1)	**Modbus Slave Configuration**		-			
Software Version	Module S/W Version Number Written by Module in Slot 3		7036	E1E	42847	RO
Diagnostic Mode	[0=Normal Run Mode] Non-Zero=Diagnostic Mode		7037	E1F	42848	R/W
Modbus Slave Address	Enter whole number from 1 to 254 [Default=5]		7040	E20	42849	R/W
Modbus Slave Baud rate	Enter whole number/100. Example: 96, 192, 384, 1152 etc.		7041	E21	42850	R/W
Modbus Slave Parity	[0=None], 1=Odd, 2=Even		7042	E22	42851	R/W
Port Hardware Mode	[0=RS232], Non-Zero=RS422/485		7043	E23	42852	R/W
Reserved for Future Expansion	Data written to these registers are ignored	Begin	7044	E24	42853	R/W
		End	7047	E27	42856	
Slot 4 (Host Port 2)	**Modbus Slave Configuration**		-			
Software Version	Module S/W Version Number Written by Module in Slot 4		7050	E28	42857	RO
Diagnostic Mode	[0=Normal Run Mode] Non-Zero=Diagnostic Mode		7051	E29	42858	R/W
Modbus Slave Address	Enter whole number from 1 to 254 [Default=5]		7052	E2A	42859	R/W
Modbus Slave Baud rate	Enter whole number/100. Example: 96, 192, 384, 1152 etc.		7053	E2B	42860	R/W
Modbus Slave Parity	[0=None], 1=Odd, 2=Even		7054	E2C	42861	R/W
Port Hardware Mode	[0=RS232], Non-Zero=RS422/485		7055	E2D	42862	R/W
Reserved for Future Expansion	Data written to these registers are ignored	Begin	7056	E2E	42863	R/W
		End	7061	E31	42866	

Section 5: Theory of Operation

This section describes systems with redundant network masters. If your system does not have redundant masters, references to redundant chassis or modules do not apply. The system normally has two Network Master chassis running identical software. System configuration and the Network Master's ability to access the field network determine mode of operation of each chassis. Either of the network masters may take control of the field network. The following paragraphs explain how the system functions from an application software point of view. This will provide a better understanding of how the system functions. The Network Masters may be referred to as modules.

5.1 Valve Actuator Network Connections

In order to better understand how the Network Masters, operate, the user needs to understand what goes on at the network and actuator level. Each Controlinc equipped valve actuator has a network Port A and Port B connection. When a message is received on either port, it is conditioned by hardware and transmitted at the other port. If a message is received on Port A, it is transmitted at Port B. If a message is received at Port B, it is transmitted at Port A.

Messages on the network are conditioned and transmitted in both directions without intervention of microprocessor software. As the message passes through the actuator, it is received by the microprocessor of the valve actuator. If the message address matches the actuator address, the command is processed and the valve actuator responds to the host command. When the actuator responds, it transmits on both Ports A and B. Thus, both communication channels of the network master receive messages returned from the field. Both redundant Network Masters receive all messages from the network from both ends of a ring.

5.2 Power-up Initialization

The M250N system supports one Network Master module per chassis but may support a variable number of slave modules. At power up, the Network Master module configures itself based on information read from the global database as written to the system via Modbus registers 41574 through 41584. Each communication module in the rack reads the number of slaves configured for the network from memory location 0x927 (Modbus register 41577).

The master module uses the number of slaves to allocate memory and build a scan list obtained from a master scan list starting at memory location 0x82B, Modbus register 41325. The module then reads the device type list starting at memory location 0x8A7 (Modbus register 41449). The module reads its network baud rate from memory location 0x928 (Modbus register 41578). This is the baud rate for network Ports 1 and 2 of the module. The module reads its receiver time out from memory location 0x929 (Modbus register 41579). This is the amount of time in milliseconds it will wait for a response from a slave before flagging the slave response as bad and going on to the next slave address. The module reads the RBE enable from memory location 0x92A, Modbus register 41580. If the value in this location is greater then zero, then the master will use Report-By-Exception (RBE) in the polling process. If the value is zero, then RBE is disabled.The module reads its network baud rate from memory location 0x928 (Modbus register 41578). This is the baud rate for network Ports 1 and 2 of the module. The module reads its receiver time out from memory location 0x929 (Modbus register 41579). This is the amount of time in milliseconds it will wait for a response from a slave before flagging the slave response as bad and going on to the next slave address. The module reads the RBE enable from memory location 0x92A, Modbus register 41580. If the value in this location is greater then zero, then the master will use Report-By-Exception (RBE) in the polling process. If the value is zero, then RBE is disabled.

The module reads the Diagnostic Mode from memory location 0x926 (Modbus register 41576). If the value in this register is greater than zero, the module transmits ASCII debug messages to Port 3 at 9600, N, 8, 1. Transmitting these debug messages significantly slows down the normal process. It is advisable to always write a zero to this register to enable normal run mode after diagnostics is complete. While in diagnostic mode, the module will transmit to Port 3 selected Modbus messages sent to and received from the network ports. It will also transmit other useful diagnostic messages to Port 3, such as error messages. The module reads the Program Mode from memory location 0x92D (Modbus register 41583). If the value in this register is greater than zero, the module will enable Port 1 as the programming port, disable "LOCKOUT," and enable entry of Control C at Port 1. This mode allows the processor to be halted by entering Control C. The program may be edited on line or a new program downloaded at Port 1.

One of the two redundant chassis is configured at the factory as the "primary" chassis and the other is configured as the "secondary" chassis. The secondary chassis normally powers up in the Hot Standby mode. The secondary master module/chassis delays two seconds after power-up to allow the primary module/chassis to take control of the network. If the system is installed with a Hot Standby system, this forces the Hot Standby unit (secondary module/chassis) to remain in the Hot Standby mode so long as the primary master is communicating on the same network to which it is connected.

5.3 Hot Standby Fail-Over

After power up, both masters listen to the network to which they are connected for 500 mS. If no activity is detected (quiet line), the module checks status of the host links to both chassis. If the other chassis is not present, then the first chassis will proceed to take control of its network if it has a good host link. If network activity is detected during this process, the timer is reset to 200 mS and the whole process begins again. If a master transmission is detected while listening to the line, the message is discarded, and the listening process is restarted. If at any time during the listening process, a master module detects a quiet line, it will begin the polling process and thus take over the network but only if a good host link is detected. In the case of redundant host links, if all host links are bad, it checks the status of the host links to the other chassis. If the other chassis has a good host link then the listen mode will be repeated, allowing the other chassis with a good host link to take control. During the polling process, if another master's message is received, the module will go into Hot Standby mode and begin listening to the network again.

This process requires less than 1 second, where the normal listening process takes up to 2 seconds to fail over. If the master detects all host links have failed, it checks the status of the host link of the other chassis. If the other chassis has a good host link, then listen mode will be entered, else the polling process will continue. Each module resets its own watchdog timer when valid data is received from the network. On every poll cycle, each module checks the status of its own watchdog timer. If the watchdog timer times out, the module goes to the listen mode and turns the network over to the Hot Standby chassis. Each module counts the number of no responses from the slave units. If the number of no responses exceeds the number of connected devices plus ten, without receiving good data, then the module goes into listen mode and releases the network to the Hot Standby chassis. Normal fail over time is 800 mS for problems other than host link failures. Fail over time for host link failures is up to six seconds from the time the host stops polling the master.

5.3.1 Modbus Host Link and Fail-Over

Each time the host transmits a query to the network master using function code 01, 02, 03, 04 or 08, the host link timer is reset. If a host query is not received within 5 to 6 seconds, the master sets the Host Link Failed Alarm in the system status word. Both chassis monitor status of redundant host links to both chassis. If the redundant links to the master that has control of the network fails, then the system will fail over to the chassis that has a good host link. If either of the two modules goes into Hot Standby mode, Modbus communication transmissions to the host system are inhibited. This insures that the host is acquiring data from the system that has control of the network. If both chassis have good host links or if both chassis have bad host links, then the master that has control of the network will retain control.

5.4 Network Fault Detection

If the module gains access to the network, it then performs a network test. It transmits a message from Port A and verifies that the message is received through the network at Port B. It then transmits a message from Port B and verifies that the message is received through the network at Port A. If the message is not received on either port after three attempts, it then sets the network fault alarm. It then polls from Port A around the ring in the order of slave addresses from the scan list for the total number of actuators configured. The module records the last address that responded as the fault location low address. The module polls the network from Port B by polling from the last configured address in the scan list and decrements to the first address in the scan list. The module records the last address to respond as the location of the network fault high address.

The network fault is located between the low address and high address. These addresses are available to the host in Modbus registers 40252 and 40253. If a module gains access to the network but does not receive any valid data from the connected slaves, it also sets a network fault alarm. Each time the module finishes 5 complete poll cycles of all network addresses, it repeats the network fault test described above. Network fault conditions reported in the system status word and the location of the fault should be alarmed to the system operator MMI (HMI) so that the fault can be corrected. If a network fault is detected, the module polls the accessible addresses around the ring in one direction from Port A and then polls around the ring in the opposite direction from Port B. This allows the master to access all actuators on both sides of the network fault. Under network fault conditions, the module polls one address from the scan list greater than the last address to respond, i.e. it polls one address past the fault location. If the address beyond the fault responds, the network fault alarm is reset, and the normal polling process resumes.

5.5 Polling Process

The module gets slave addresses from a scan list located in the global data starting at memory location 0x82B and progress upward for the next slave to poll. The scan list is actually loaded into the network master module from the database at power up. If a valid address is the next address in the poll sequence, the slave is polled and received data stored in the global database by address sequence, not scan list sequence. If a slave does not return data for three poll cycles, the module sets the COM alarm bit for that slave address.

Valve actuator status includes one COM alarm bit (14th bit). This com alarm bit is set only when both network paths have failed, meaning both Port A and Port B of the module lost access to the actuator. The COM alarm bit is reset when either port gains access to the actuator.

5.6 Report-by-Exception

The system uses Modbus Function Code 07 for report-by-exception (RBE). The module normally polls all devices with Function Code 07. If the valve actuator did not have any status, alarms, or analog valve changes since the last master’s request it returns zero in the Function 07-processor status field. If data changed since the last poll, the valve actuator responses with a 0xFF in the processor status field. The valve actuator is actually performing the RBE process, distributing the RBE processing time among the salve devices. If zero is returned, the master module has no data to process into the database.

It simply goes on to the next slave address in the scan list. If 0xFF is returned, indicating an exception, the module polls the actuator using Function Code 03. All data is requested in one block and processed into the database when received. This RBE process speeds up the system throughput by a factor of four to six times due to the small amount of data being transferred over the network. Throughput is also increased due to the fact that no data is processed into the database (the most time-consuming event) until data has changed. To ensure the host system always has an accurate database, the valve actuators force an exception every 200 poll cycles.

5.7 Priority Scan

When a master module receives a command from the host and commands an actuator to move, the actuator's address is put in priority scan. If a valve transition opening or closing status is received from an actuator, its address is put in priority scan. The module polls the valves in priority scan first and then polls the next slave in the master scan list. It continues this pattern of interlace scanning of moving valves between non-moving valves.

The interlace-scanning process insures fast update of moving valves to the host system. An unlimited number of slave addresses may be in priority scan at any one time. Slave addresses are removed from priority scan as soon as their opening or closing transition bit is cleared or if they go into communications alarm.

5.8 Writing Discrete Commands to Valve Actuators

The host system writes discrete valve commands to the Modbus slave module that in turn stores the commands in the global database and sets an interrupt to the central CPU. The CPU writes the commands to the Network Master module.

The CPU write to the master module generates an interrupt to the module. The interrupt causes immediate processing of the commands. If a module does not accept the data written by the CPU within two seconds, a Write Command Alarm bit is set in the system status word for the faulty module. Each module decodes the commands and determines which slave address is to receive the command. If the slave address is not in the scan list, the module ignores the command.

If the slave is in the scan list the command is transmitted to the slave and the module waits for an acknowledgment. If an acknowledgment is not received within the receiver time-out period, the command is retransmitted up to three times on Port A and three times on Port B. If the slave does not return an acknowledgment after three transmission attempts on both Ports A and B, its COM alarm bit is set. The host may write commands for multiple valves at the same time. The module will decode each command in the order of the slave address and transmit each in turn. After each command is transmitted to an actuator, the module zeros the discrete command in the global database. Database values stored for analog setpoint, analog output, and user discrete outputs are not zeroed.

The host may read back these types of output data at any time. Each time a new command is written, the commanded actuator’s address is put in priority scan.

5.9 Writing Position Setpoint

When the host writes a valve position setpoint to the master, the module compares the new setpoint with the setpoint returned by the valve actuator. If a difference is detected, the new setpoint is transmitted to the valve actuator. The module requires an acknowledgment from the actuator. If an acknowledgment is not received after three attempts on both Ports A and B, the COM alarm bit for the actuator is set. Each time a new setpoint is written to a valve actuator, the address is put in priority scan. If the address is configured as device type 0 or 1, then the master will not attempt to write valve position setpoint.

5.10 Writing Analog Outputs

When the host writes an analog output to an actuator, the module compares the command output to the received analog output from the actuator. If a difference is detected, it writes the new analog value to the actuator. Like all writes, the module will attempt three times on both Ports A and B if an acknowledgment is not received. If the address is configured as device type 0 or 1, then the master will not attempt to write the analog output.

5.11 Writing User Relay Outputs

When the host writes to a coil corresponding to either User Relay #1 or User Relay #2 or both, the module compares the status of the coils received from the actuator. If a difference is detected, the module writes the new coil output (on or off) to the actuator. The module will make three attempts to write a coil to the actuator on both Ports A and B if an acknowledgment is not received.

The module only will write discrete outputs to device types 1, 3 and 5.

5.12 Writing ESD Command

When the host writes an Emergency Shut Down (ESD) command to the system by writing a 7 to register 40575, an ESD command is immediately transmitted to all valve actuators that are currently active on the network. A broadcast address is not used because the module requires confirmation that each actuator received the ESD command. It will retransmit the ESD command to any one device up to three times. This insures that all actuators receive the ESD command; if not received, an alarm bit is set for the actuators that do not acknowledge the command.

Section 6: Software Source Code

Source code for the main CPU, LCD Panel, Modbus slaves and Network Master module is supplied with the system on CD ROM. The software is supplied as a back-up copy and should not be copied. Emerson reserves all rights in accordance with Copyright laws.

Thus, it must not be printed or copied. The software files may be used only for downloading to a replacement module.

6.1 Host Database Configuration Aid

An excel spreadsheet is also supplied on the CD ROM under “Memory Maps” directory. This spreadsheet is an aid used for configuring the host database. Load the excel file to a computer with windows then open the spreadsheet. To use the spreadsheet, simply enter the valve actuator network address in the designated “address” box and then hit the enter key. Locate the parameter to be read or written by the host.

The corresponding Modbus address according to desired function code is listed for the specified valve or MRTU under the Network Master column.

Section 7: LCD Touch Panel Backup Terminal Operation

Touch Panel display may be used to monitor system and actuators health and for valve control.

7.1 Home Screen

Refer to Figure 11 for a view of the Home Screen Information and for Main Menu Screen, see Figure 12.

Figure 11. Home Screen Information

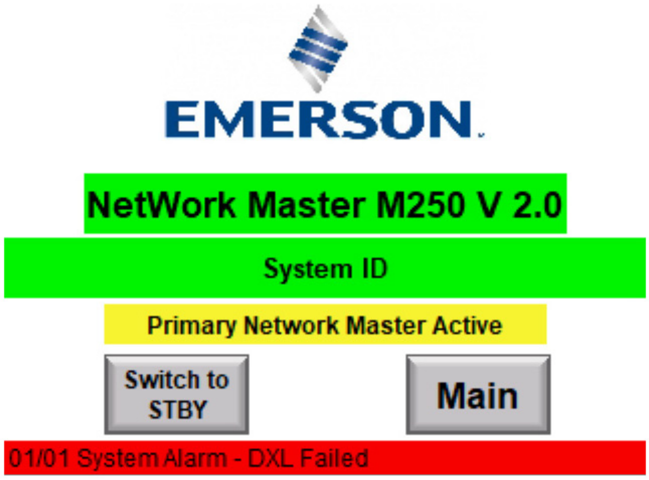
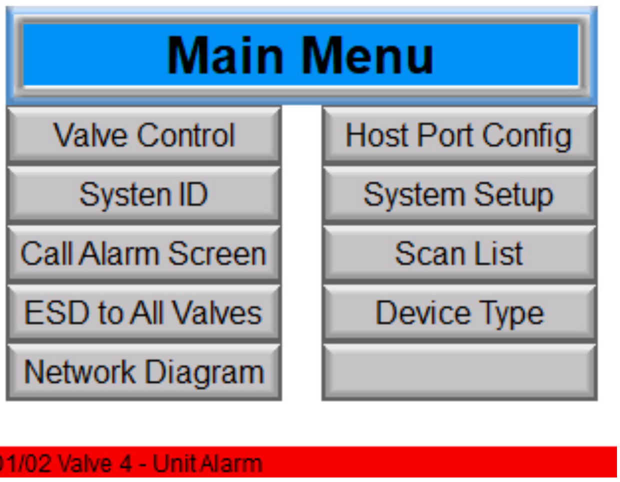


Figure 12. Main Menu Screen

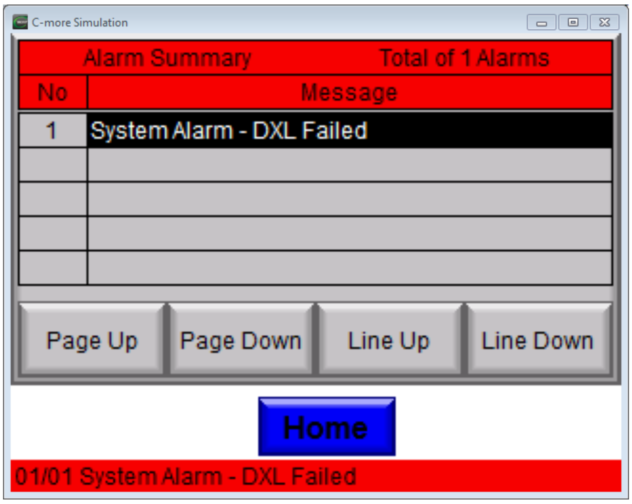


7.1.1 Alarm Display

The alarm display page will display lists of alarms that valve currently has an alarm and including system alarms.

Refer to Figure 13.

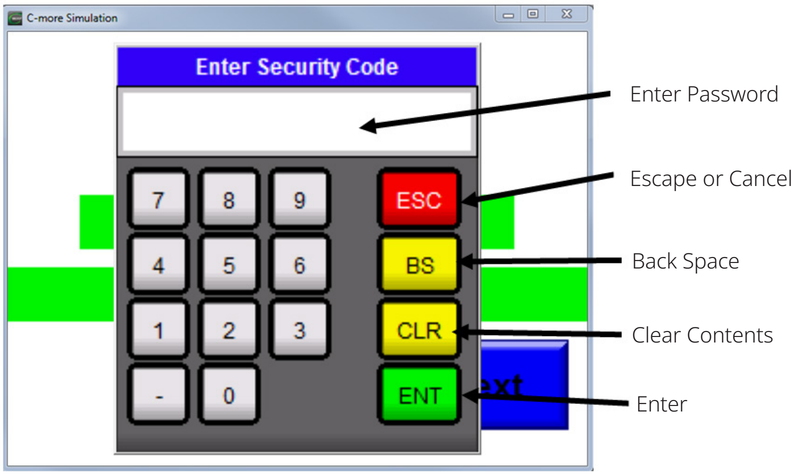
Figure 13. Alarm Display Screen



7.1.2 Security Codes Screen

Refer to Figure 14 to view a Security Code Screen. This is where Password Protection screen will prompted when it required a security code.

Figure 14. Security Code Screen

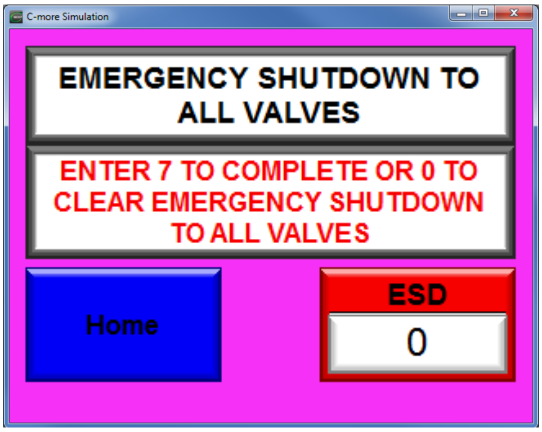


7.1.3 ESD Screen

Emergency Shut Down (ESD) may be sent to all valve by writing 7 cause all actuators to execute ESD. Writing 0 (zero) will disable (end) ESD.

Refer to Figure 15.

Figure 15. ESD Screen

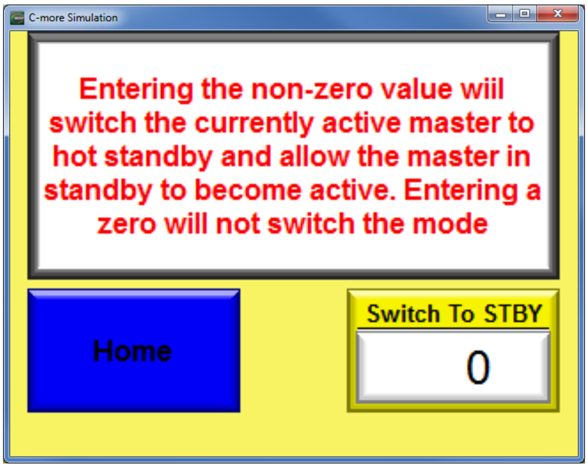


7.1.4 Switch Active Master to Standby Screen

Switching to Hot Standby will cause the active chassis/master to go to hot standby and allow the chassis currently on standby to switch to the active role. This allows the two masters to be toggled between active and standby modes. To switch the active master to hot standby mode, press the "Switch to STBY". Entering a non-zero value from 1 to 999 will switch the currently active master to hot standby and allow the master in standby to become active.

Refer to Figure 16.

Figure 16. Switch Active Master to Standby Screen

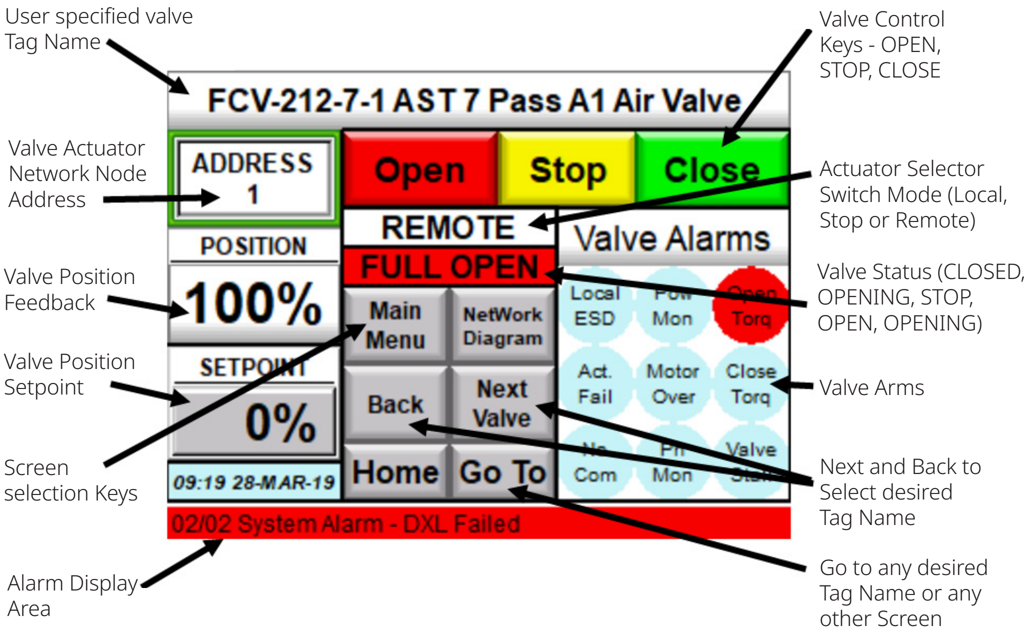


7.2 Valve Control and Status Display

Valve status, and control is displayed by the LCD touch panel. To select the valve tag number by pressing the Next Button or Go to Button. When the desired station address or valve tag number is displayed, the current status of the valve is displayed. The valve status displays the FULL CLOSE (valve closed), STOPPED (valve stopped in mid-travel), or FULL OPEN (valve open). If the valve is in transition, the CLOSING will flash while the valve is closing or the OPEN will flash while the valve is opening. Valve position is updated on the LCD display while the valve is moving. If any alarms occur in the system or actuator alarm, it will be displayed on the bottom.

Refer to Figure 17.

Figure 17. Valve Control and Status Display



7.2.1 Valve Control

Status of the desired valve must be displayed before attempting to control the valve. Select the valve by clicking Next or Goto Button to desired valve address or tag number is displayed. CLOSE, STOP, OPEN valve control button may then be used to control the valve.

Refer to Figure 17.

7.3 Navigation Buttons

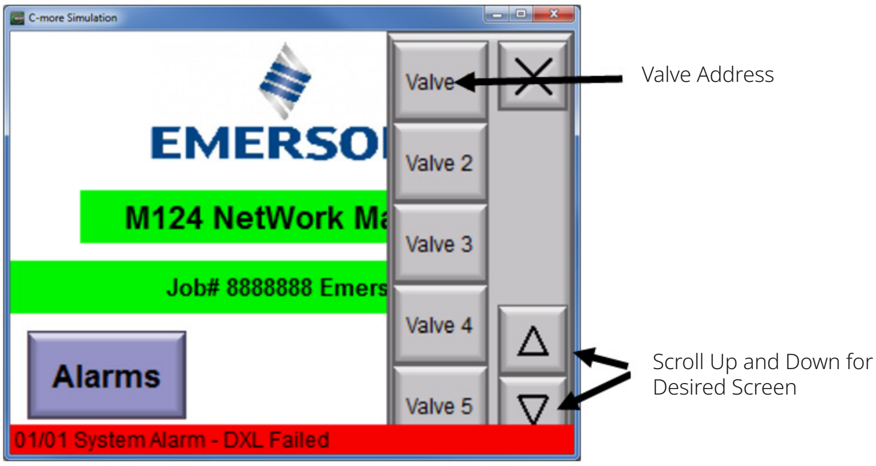
Back Button – This button will allow to go back to one Screen (Valve).

Home Button – This button will take back to Home Screen from anywhere on the screen when there is a Home Button presence.

GoTo Button – This button will allow to jump to any selected valve from the list.

Refer to Figure 18.

Figure 18. Navigation Buttons



Alarms Button – This button will take to Alarms List Screen.

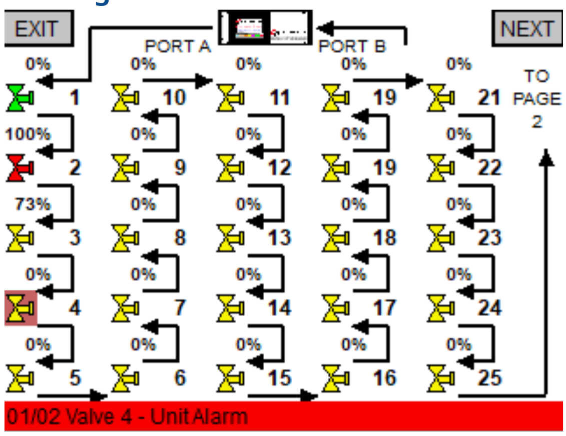
NOTE:
Alarms List Screen only Display Unit Alarm of each Valve when there is an actual Valve Alarm.
To view the Valve alarms please go to Valve Control and Status Screen.
System alarm can also be view on the Alarms List Screen if there is an System Alarms.
The above information can also be seen on the Alarm Bars on the bottom of any Screen.

Next Button – This will allow to go to Next Valve.

7.4 Network Diagrams

Up to 25 valves may be monitored on each of 10 network diagram screens for a total of 250 valves. The valves are shown in the order physically connected to the network. The network node address is displayed to the right of the valve symbol. Valve position (0 to 100%) is shown above each valve. Closed valves are displayed as Green, Open valves are displayed as Red and valves in mid-travel are displayed as Yellow. If the actuator is in alarm, the valve will flash Magenta as shown for the first valve in Figure 19. If a valve is not configured into the system, it will have an address of zero and will be displayed as Yellow. Touch the NEXT key in the upper right corner of the screen to go to the next network diagram page. Touch BACK key to go to the previously displayed page. When on Page 10, touch the EXIT key on the upper right hand corner of Page 10 to return to the Main Menu.

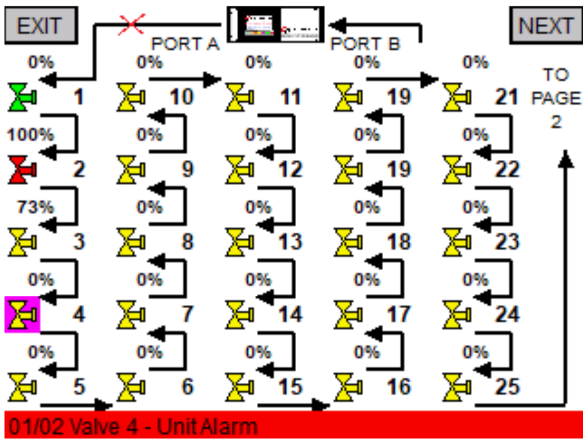
Figure 19. Network Diagrams



7.5 Network Fault Location

When a network fault alarm occurs, the fault location is shown on the wiring diagram. Figure 20 shows an example of a network fault located between the master Port A and the valve actuator.

Figure 20. Network Fault Location

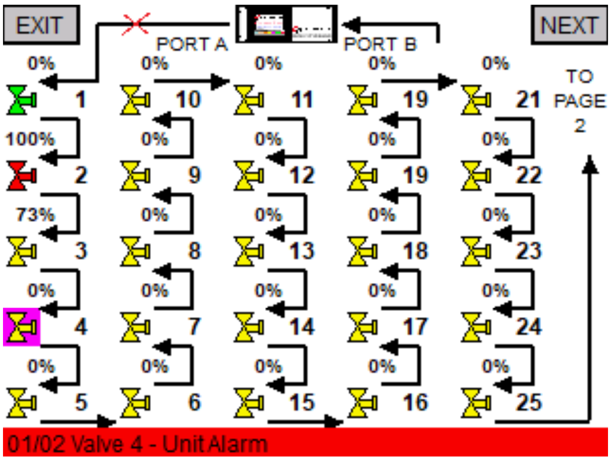


7.6 Alarm Display

When any alarm occurs, the alarm is displayed across the bottom of the screen on all screens except alarm summary and configuration screens. Notice that all operator screens shown in this manual have an alarm displayed across the bottom. If more than one alarm is present, each alarm is displayed for 5 seconds. Alarms are given an alarm number in sequence of occurrence. To view all alarms, return to the Main Menu and select Alarms Display as discussed in Section 7.1.1.

Refer to Figure 21.

Figure 21. Alarm Display



Section 8: System Setup and Configuration Using LCD Touch Panel

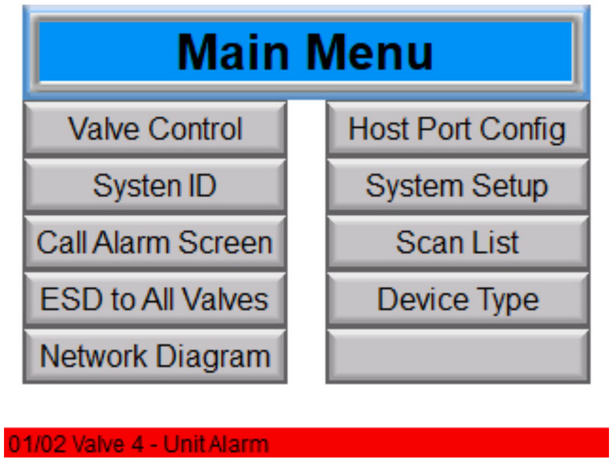
The system is shipped from the factory pre configured per user supplied data. Only minor edits to the system configuration should ever be required. It does not matter which master has control during setup and configuration. Both masters are updated at the same time when a change in configuration is made.

8.1 Main Menu Screen

From the Main Menu, select the desired screen for system setup or configuration from the menu keys on the right side of the screen. Operation screen the left side. Each of the setup and configuration keys/screens will be discussed in the following sections.

Refer Figure 22.

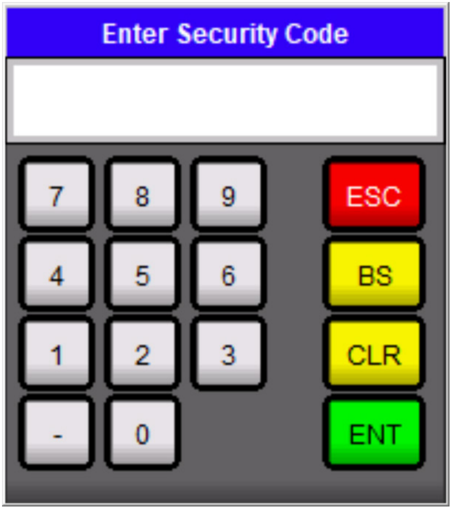
Figure 22. Main Menu Screen



8.2 Security Codes

The system uses security code protection for the system setup screens. Your system may have only an Engineer security code required to protect the system configuration. Other security codes are provided by Emerson at the discretion of the owner. To access the system setup the Engineer security code must be used When any key on the right is touched, the popup window shown in Figure 23 will be displayed. If you do not have a security code, touch "Cancel."

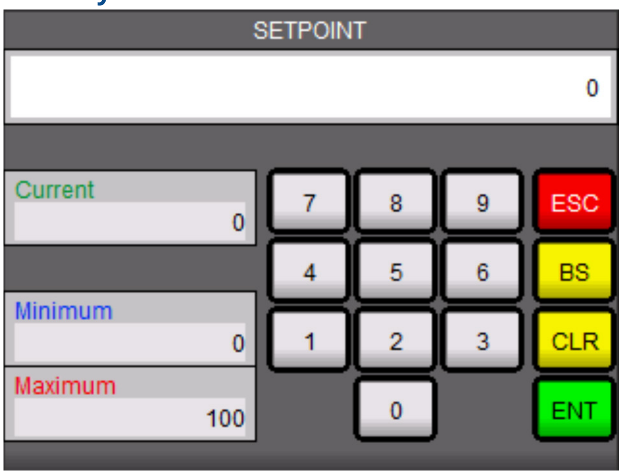
Figure 23. Security Codes



8.3 Data Entry

When data entry is required by the system, a data entry screen like that shown in Figure 24 will be displayed. Only the screen header is different. Enter the desired data and then touch Enter key.

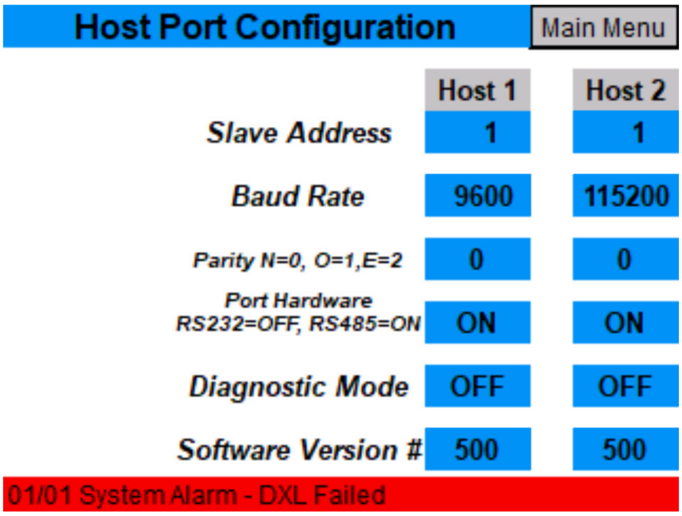
Figure 24. Data Entry Screen



8.4 Host Port Configuration

From the Main Menu, touch the “Host Port Config” key to display the screen shown in Figure 25. These configuration parameters are only for the two Modbus slave port processors in each of the two masters. If optional Ethernet ports are installed, the Ethernet setup parameters are cover in a separate manual. Slave address may be set from 1 to 247. Both ports may be set to the same address since each port is communicating on a different host link. Baud rate is entered as a whole number as baud divided by 100. For example, 19200/100 would be 192. When Diagnostic Mode is selected, the processor will transmit to Port 2 (Debug Port) of the module, Hex ASCII equivalent of all Modbus messages received and transmitted. This will slow down responses to the host because of the time required to transmit the debug messages. The Software Version numbers are displayed values for information only. A decimal point after the most significant digit is implied.

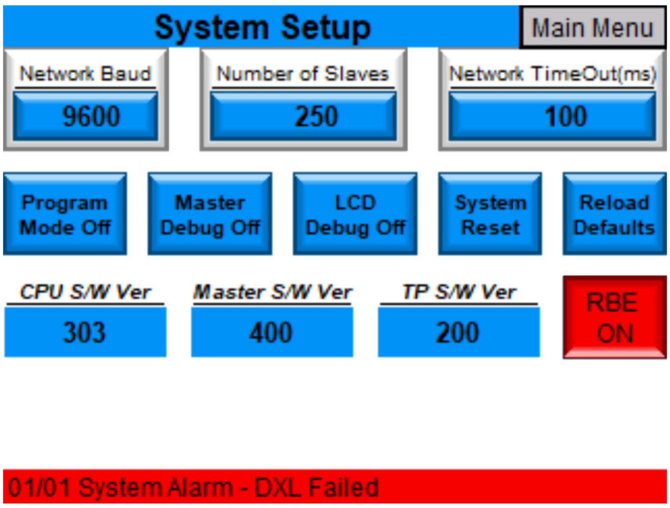
Figure 25. Host Port Configuration



8.5 System Setup

From the Main Menu, touch the "System Setup" key and the screen shown in Figure 26 will be displayed. The Baud Rate key is the baud rate for the valve actuator network. Changing the baud rate requires all actuators on the network to be configured for the same baud rate. Receiver Time out is the time the master will wait on a response from a slave (valve actuator). It is normally set for 50 mS. Setting this time too short can cause collisions on the network and setting it too long waists time when some actuators are not responding, i.e. powered down, etc. The Number of Slaves has to be the highest network node address assigned to any actuator on the network. It does not have to be equal to the number of installed actuators. Activate RBE turns on/off Report-By-Exception. Only Emerson actuators execute RBE for a faster response and improved network performance. Caution must be used when considering using "Reload Defaults". This key is security code protected with the same engineering security code. If this key is used, then all other parameters, including scan list and device types must be reentered. The "System Reset" key must be used to reset the system after configuration changes are made. This has the same effect as cycling power to the system except the LCD touch panel does not have to re initialize.

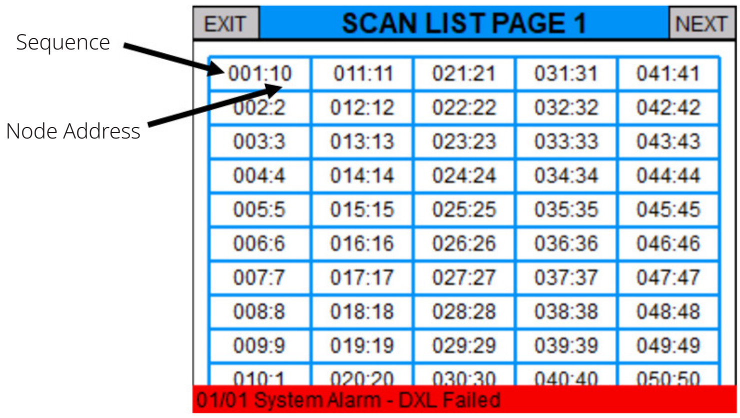
Figure 26. System Setup



8.6 Scan List

From the Main Menu, touch the “Scan List” key and the screen shown in Figure 27 will display. The Scan List is the configuration of the system for the physical location of the actuator node addresses on the network. The list must be in sequence from Port A of the master around the loop to Port B of the master. The number on the left of each key is the sequence number which cannot be edited and the number on the right of each key is the node address for the sequence around the loop based on physical or network wiring location of the actuator in the loop. Any location may have an address of zero. If less than 250 actuators are connected to the network, the next sequence number after the last valve must have a node address of zero. Entering zero for a node address will take that node off scan. If an actuator is not yet installed, a zero may be entered for its location and then actual address entered later. If an actuator is removed from the network or if an actuator is going to be powered down for a long period of time, enter a zero for the node address to take it off scan. There are 50 actuators displayed per page and there are 5 pages for a maximum of 250 actuators.

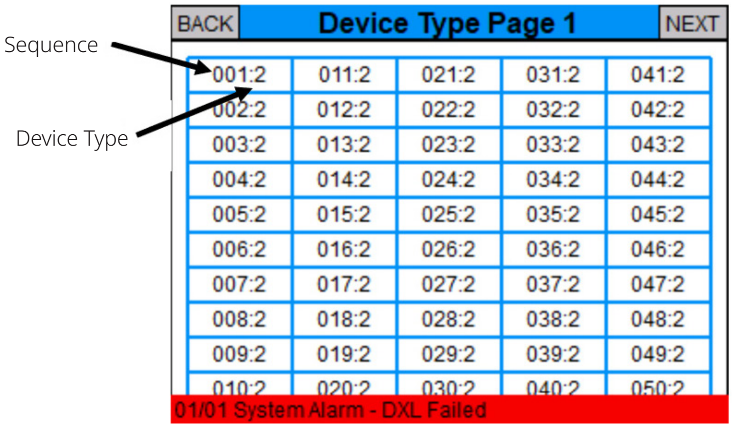
Figure 27. Scan List



8.7 Device Type

From the Main Menu, touch the “Device Type” key and the screen shown in Figure 28 will display. Each Modbus device, including valve actuators, connected to the network must have a device type assigned. Default device type for Emerson valve actuators is device type 2. If some features of the actuator are going to be used, then another device type may be required. The number on the left side of each key is the network node address and cannot be edited. The number on the right of each key is the device type and may be edited by touching the key to display the data entry popup window. There are 50 actuators displayed per page and 5 pages for a total of 250 actuators.

Figure 28. Device Type

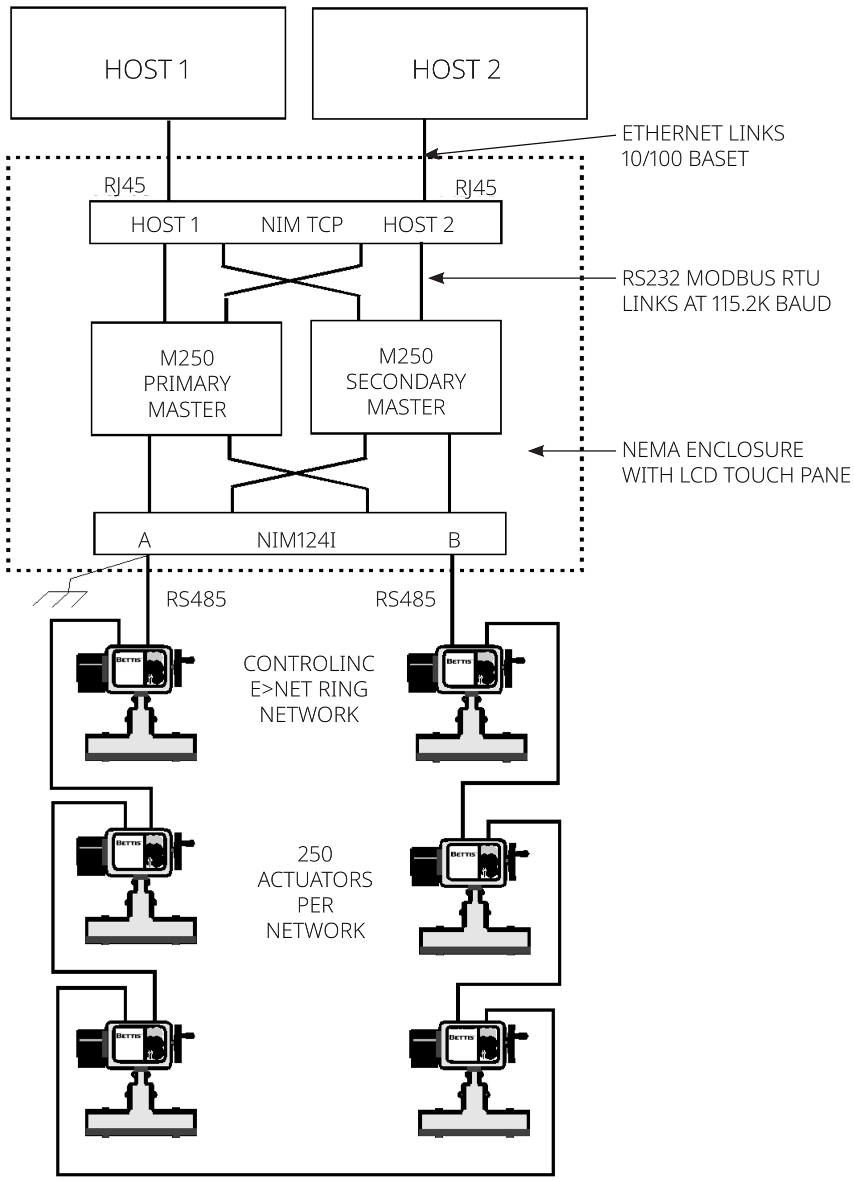


Section 9: Valve Network Topology

9.1 E>Net Ring Network on NEMA BOX or Rack Mount

Refer to Figure 29.

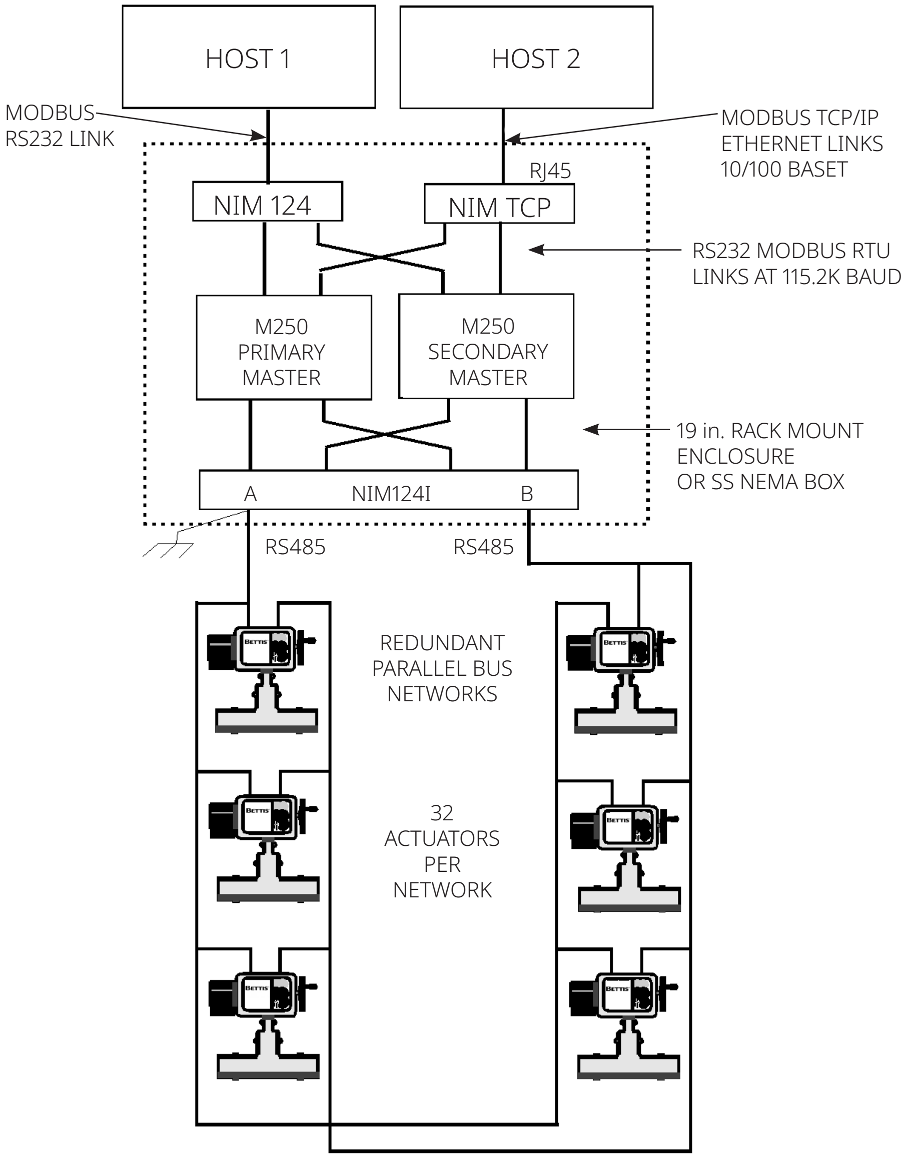
Figure 29.



9.2 Redundant Parallel Bus Networks

Refer to Figure 30.

Figure 30.



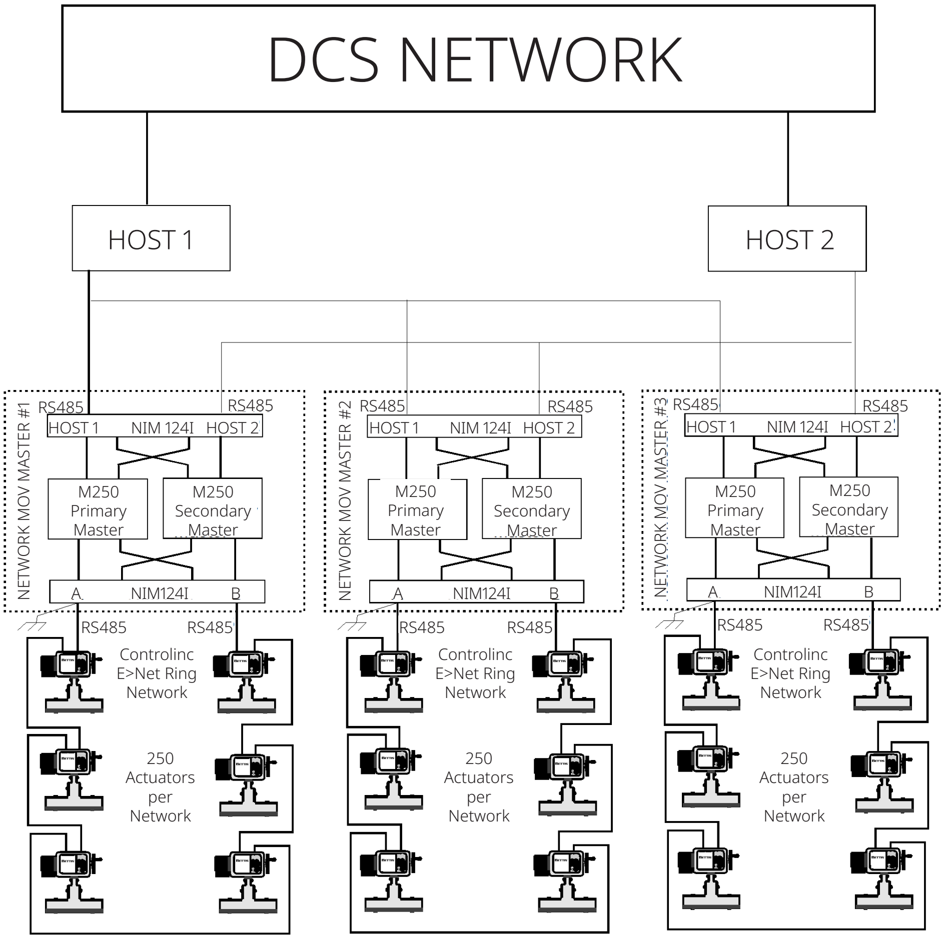
Section 10: Multiple Masters to DCS

10.1 Masters Can Be Distributed Throughout the Plant

Using RS485 Host Interface.
Up to 250 actuators per network.
Up to 124 network masters per system.

Refer to Figure 31.

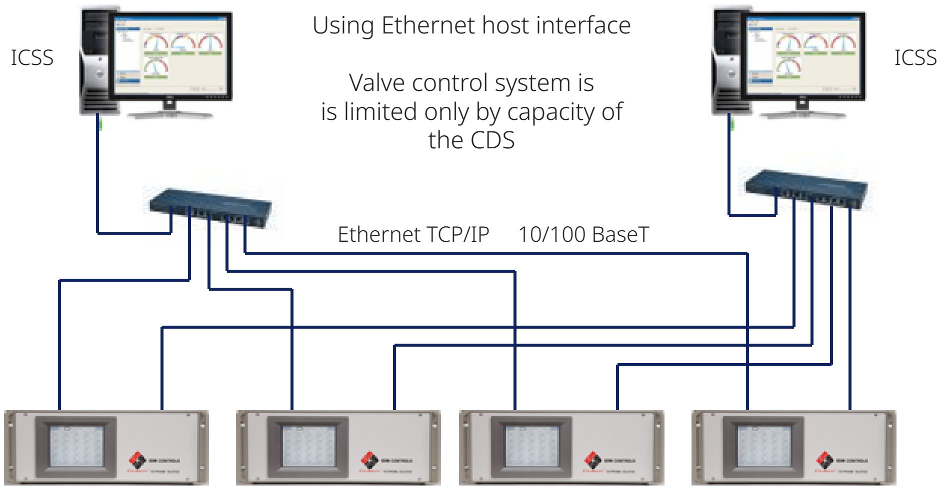
Figure 31.



10.2 Using Ethernet Host Interface

Refer to Figure 32.

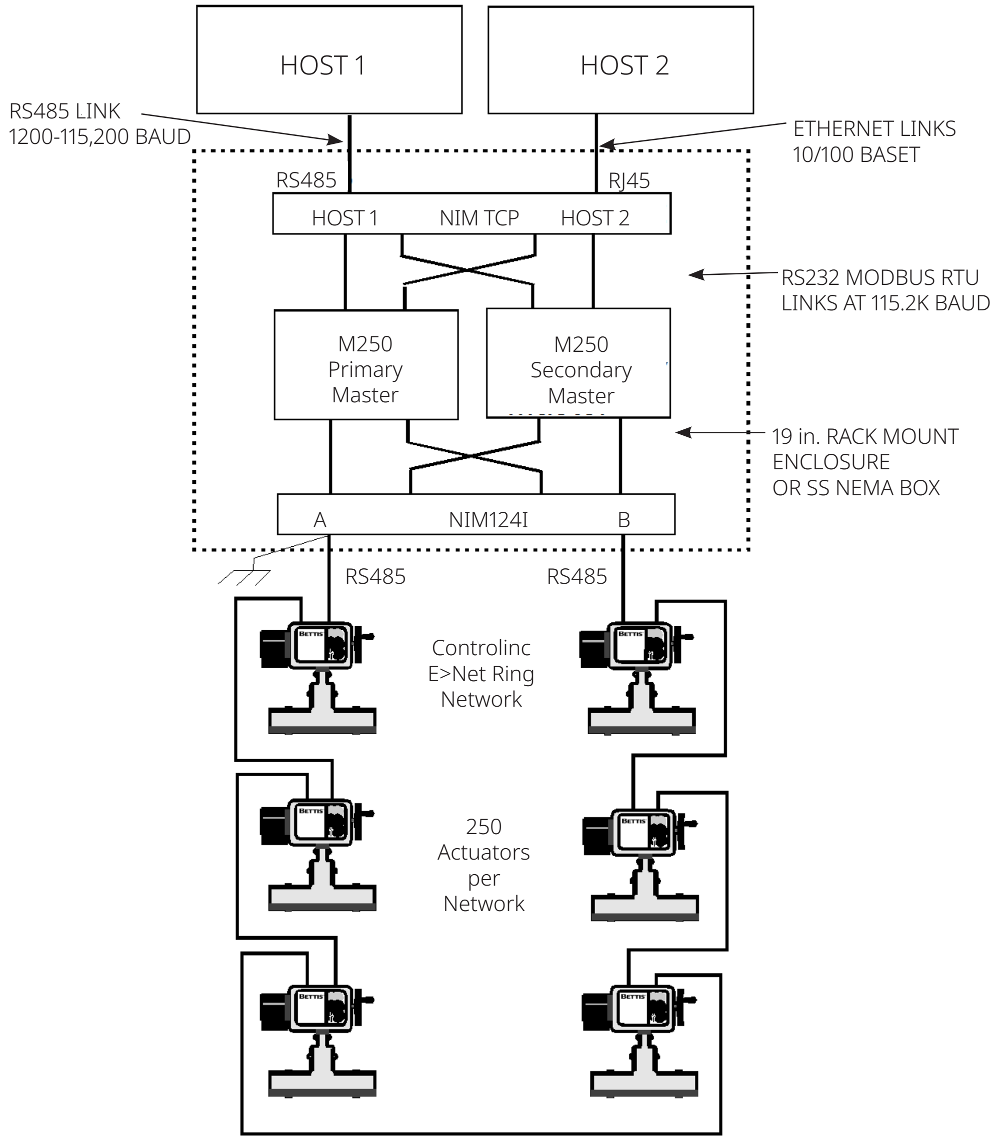
Figure 32.



10.3 Using One RS485 and One Ethernet Modbus TCP/IP Host

Refer to Figure 33.

Figure 33.



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EMERSON