

***CONTROLINC***<sup>®</sup>

***NETWORK MASTER***

***OPERATIONS***

***MANUAL***



**EIM CONTROLS**

**Model M124N**



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## **1.0 Introduction**

EIM Controlinc Network Masters are the master of EIM Controlinc valve actuator networks. 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 setpoint, 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 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.

### **1.1.1 EIM Controlinc 320A or 320B Quick Startup Guide**

### **1.1.2 FACTS Engineering 205 Basic CoProcessor User's Manual**

### **1.1.3 FACTS Extended BASIC Reference Manual**

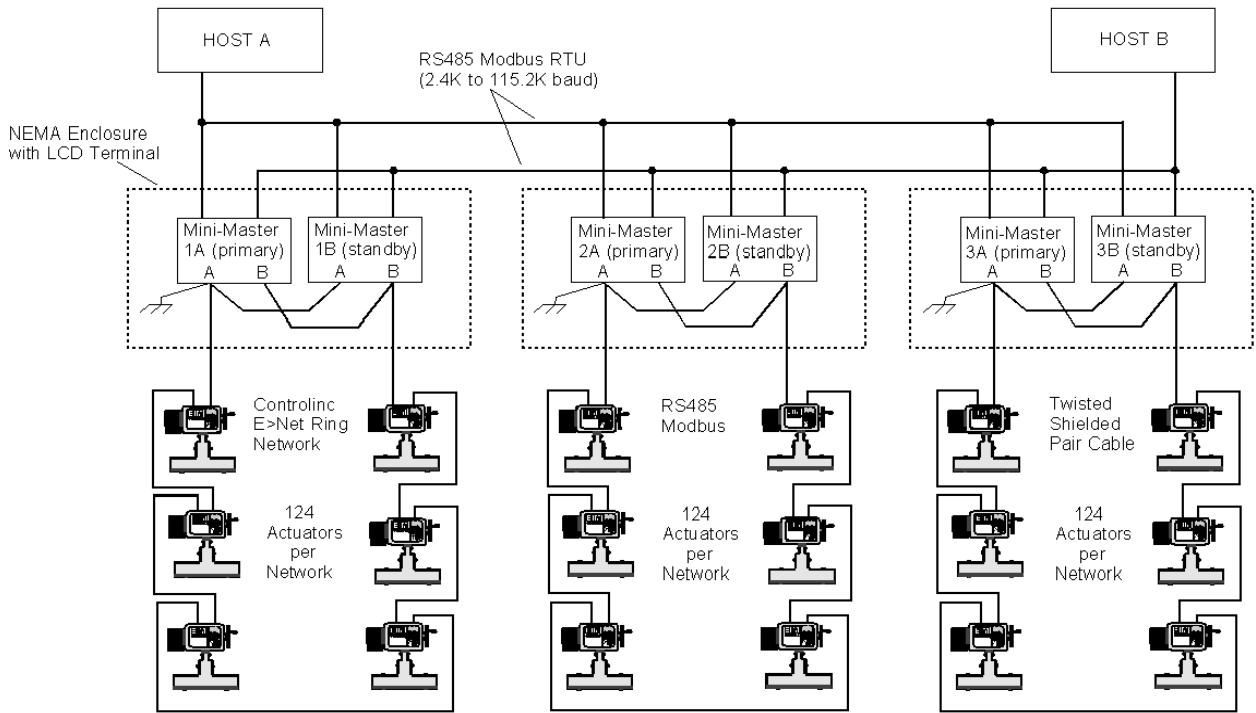
### **1.1.4 Direct Logic DL205 User Manual**

All documents and system software are provided with the system on CDROM.

## 1.2 System Configuration

Controlinc Network Master Model M124N contains redundant valve actuator network masters in a single enclosure. M124N supports one Controlinc E>Net ring network with up to 124 valve actuators. The system uses standard RS-485 and Modbus RTU protocol. 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 1-1 shows the specific system configuration of the supplied system. Version 1.0 and later communicate with Controlinc Model 320A valve actuators with Version 1.0 or later firmware 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. Each chassis consists of two Modbus Slave modules located in Slots 3 and 4. These slave modules communicate with a 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 M124N 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 screen and keypad provide 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 terminal for maintenance purposes. The LCD terminal 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.

## Model M124N Valve Actuator Control System

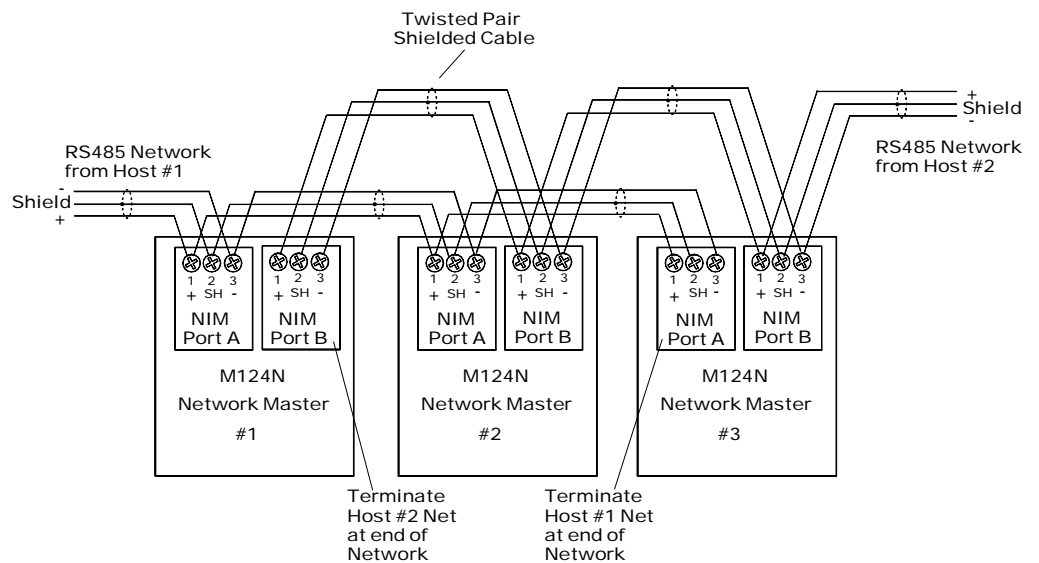


M124N\_S1

**Figure 1-1**

**Figure 1-2**

### Redundant Host RS485 Bus Network Wiring



### 1.3 General System Specifications

#### 1.3.1 Environmental

Storage temperature:	-20C to 70C
Ambient operating temperature:	0C to 55C
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 VAC @ 50/60 Hz (100-240 VAC) (other options available)
Total current @ nominal voltage:	0.65 Amps (includes LCD panel)
Maximum inrush current:	60 Amps
Total power consumption:	25 VA nominal (includes LCD)
Isolation resistance:	>10 MegOhms @ 500 VDC
Dielectric withstand voltage:	1500 VAC @ 1 minute

#### 1.3.3 LCD panel specifications

- Display type: 2-Lines x 16-Character LCD, LED Status lights
- Enclosure: NEMA 4 (IP65)
- Input voltage: 8-32 VDC
- Power consumption: 5 VA @ 24VDC
- Operating temp: 0 to 50C

#### 1.3.4 M124 PLC Port 2 Setup for Database Exchange Link (DxL)

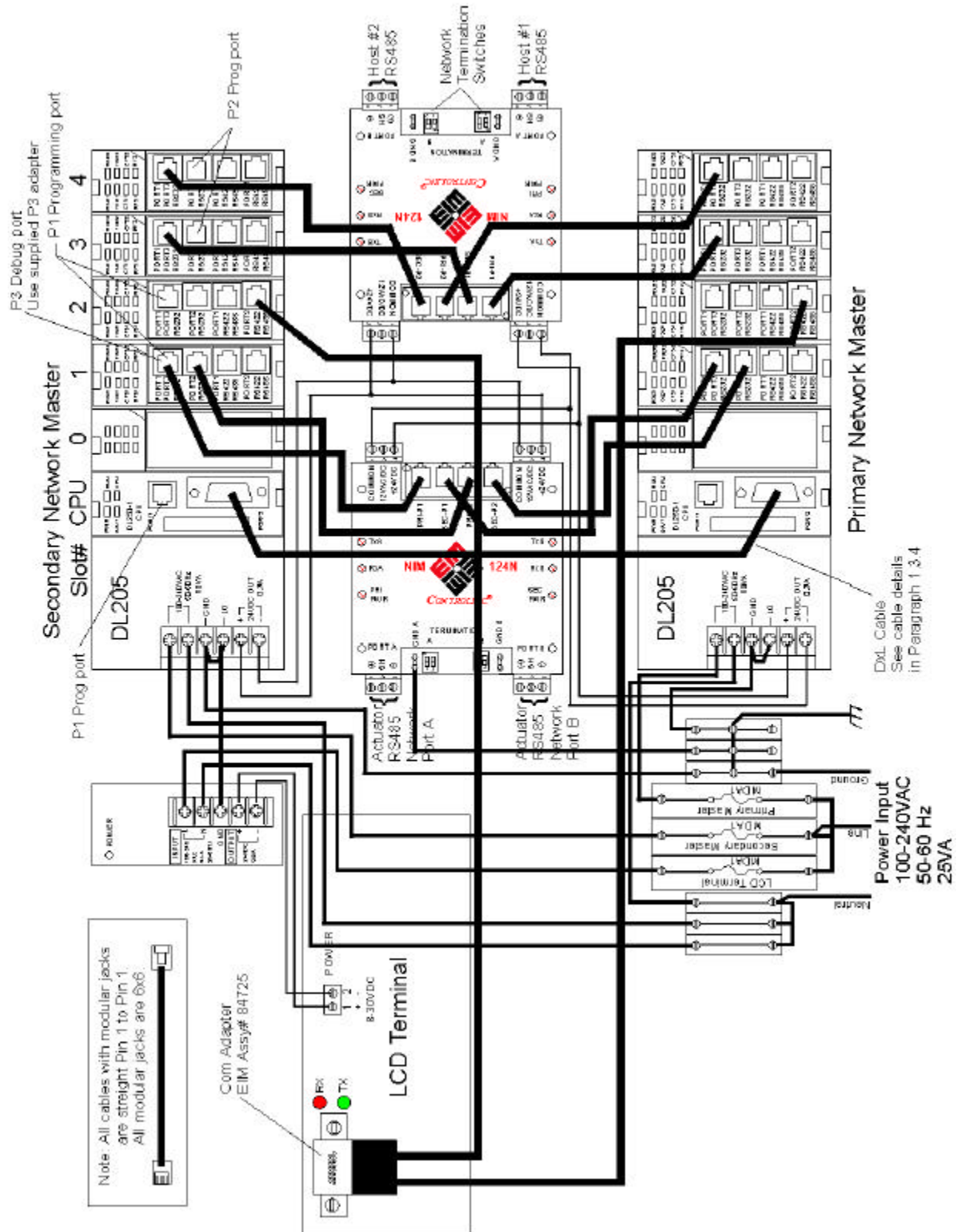
<u>Primary Master</u>	<u>Secondary Master</u>
DirectNet	DirectNet
Base Timeout x 1	Base Timeout x 1
RTS/CTS 0mS, 0mS	RTS/CTS 0mS, 0mS
Station Address 2	Station Address 1
38400,1,Odd,Hex	38400,1,Odd,Hex

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

<u>Primary</u>	<u>Secondary</u>
<u>Pin/Wire</u>	<u>Pin/Wire</u>
2 Red -----	3 Red
3 Wht -----	2 Wht
7 Grn -----	7 Grn
8 Blk -----	8 Blk



Figure 1-3 M124N Internal Wiring







**1.4 Parts List**

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

<b>Qty</b>	<b>Part Number</b>	<b>OEM**</b>	<b>Description</b>
2	D2-06B-1	DL	Six slot base (chassis) /Power Supply (120VAC)
2	D2-250	DL	DL205-250 PLC CPU
8	F2-CP128	FE	Overdrive CoProcessor with 128K RAM, 26MHz clock
1	OP-1500	OM	LCD Keypad operator panel
2	NIM124I	EIM	Dual channel Network Interface Module, Panel Mount
1	FPO-PSA1	NAiS	100-240V, 50/60Hz to 24VDC power supply for LCD

**Support Equipment, Software and Documentation**

F2CABKIT	FE	Universal cable kit (for programming and test only)
ABM-Com-V1.45	FE	Windows software utilities for CoProcessor modules
M124N-V1.11	EIM	Application software back-up disk
D2-USER-M	DL	DL405 PLC User Manual
F2-CP-M	FE	CoProcessor User Manual with Programming Manual
M124N-M	EIM	Controlinc Network Master Operations Manual
OP-1510-M	OM	Operator panel manual

**OEM\*\*** means Original Equipment Manufacture

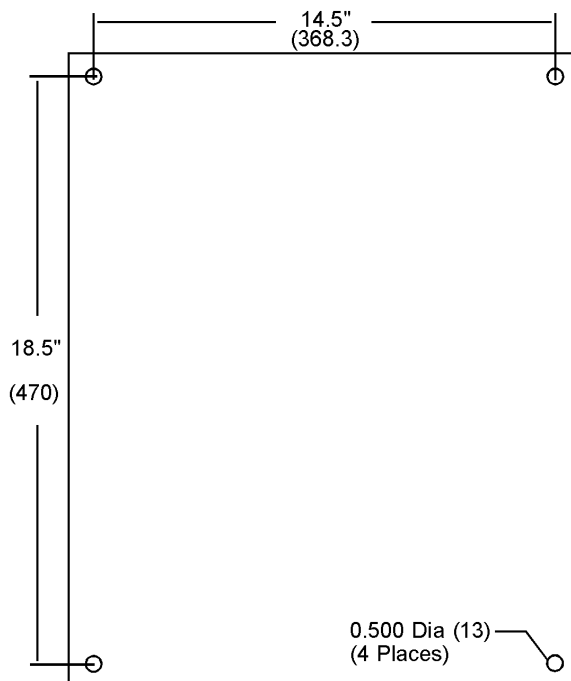
- DL = Direct Logic
- FE = FACTS Engineering
- EIM = EIM Company Inc.
- OP = OptiMate

## 2.0 Installation

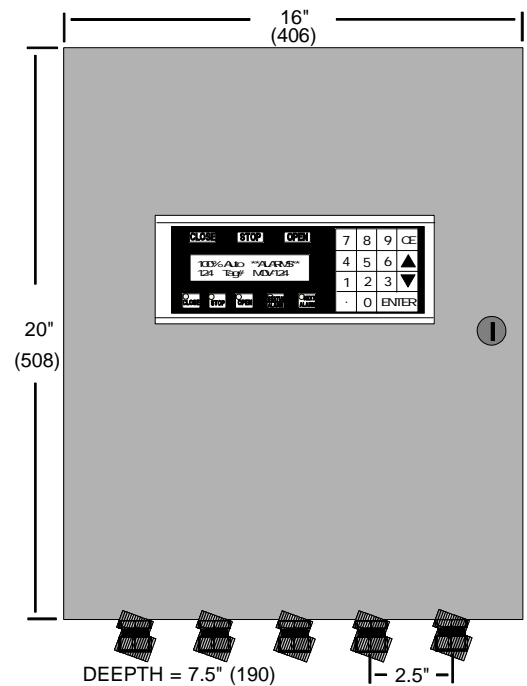
If the system is supplied from the factory in an NEMA enclosure, no internal wiring is required except for connecting power and field network wiring. The next three paragraphs (2.1, 2.2 and 2.3) discuss mounting, power input and field network wire connections to the NIM.

### 2.1 Mounting

The enclosure is rated for NAMA 4/12 and IP65/IP55. Dimensions of the enclosure are shown in Figure 2-1. Mounting dimensions are shown in Figure 2-2. 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" 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 2-1**



- (5) Cable entries are provided for:
- (1) Power Cable
  - (2) Field RS-485 Network Cables
  - (2) Host RS-485 Network Cables

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

**Figure 2-2**

### NEMA Box Mounting

## 2.2 Power Input

The system operates from 120VAC, 50/60Hz 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 (6.3x32mm, 1Amp) in the DIN-rail mounted fuse blocks. Each chassis and the LCD terminal are independently fused. Each NIM is powered from redundant 24VDC power supplies from the two chassis power supplies. The LCD terminal is powered from an independent 24VDC power supply. All other modules within the unit are powered over the base back plane from the associated main chassis power supply.

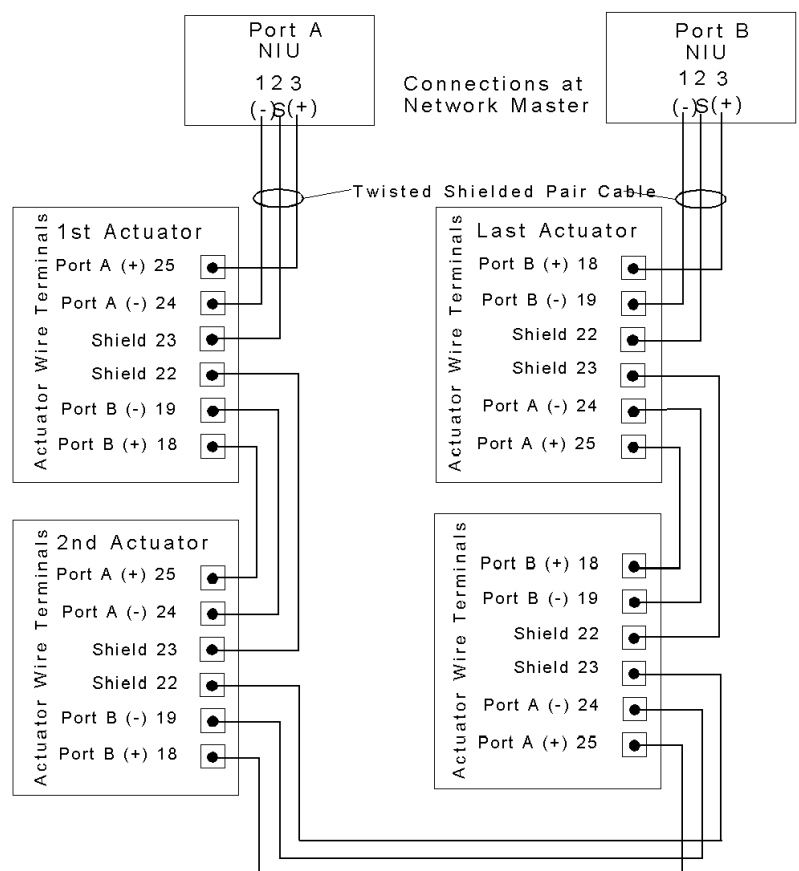
## 2.3 Field Network Wiring

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 2-3. The networks must be connected to

Port A and Port B of the valve actuators as shown in the wiring diagram of the Controlinc 320A manual. Controlinc 320A 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 2-3**

Controlinc 320A Ring Network Wiring (typical)



Net320A1.GED

### 2.3.1 Network Grounding

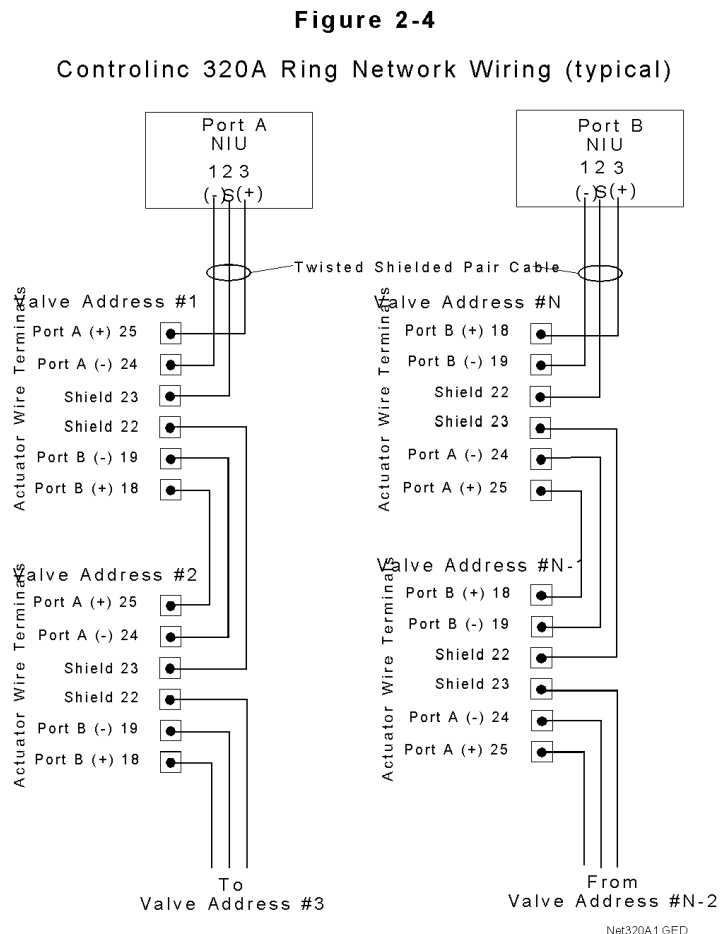
The shield or drain wire of the network must be earth grounded at only one point per network segment. This single ground point may be at any location in the system where a good earth ground can be obtained. This may be Port B of each actuator if desired. If the network shield is connected to the internal 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 22 and 23 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). Turning ON S5 and S6 of SW4 of the Controlinc 320A module terminates each valve actuator. See Figure 4 of the Controlinc 320A Quick Startup Guide for location of DIP switches.

### 2.4 Modbus Host Cables

It is necessary for the user to connect cables between the Modbus Host computer and the Modbus slave NIM. If RS232 is used, components of the cable kit (F2-CBLKIT) may be used during system integration and test but should be replaced by a quality shielded cable when the system is put in service. Two cables are required if redundant Modbus slave modules are installed. The system may be configured for communications at baud rates from 1200 to



115,200 baud. Default configuration of all slave modules is 9600 baud, 8-bit data, no parity and one stop bit. The Modbus communications link may be configured for RS-232, RS422 (4-wire), or RS485 (2-wire). The system is normally configured at the factory to the customer-specified settings. The supplied system is configured for RS232 and the ports are converted to isolated RS485, 2-wire by the supplied NIM124I module.

### **3.0 Configuring the System**

The user should read this entire section before attempting to configure the system. It may also be helpful to read Theory of Operation Section 5.0 of this manual for a better understanding of the system before attempting system configuration. Configuration data and associated Modbus registers are shown in Table 4-11 in Section 4.0 of this manual. The system is configured from any Modbus host capable of reading and writing up to 290 configuration registers in the range of 41325 through 41614 shown in Table 4-11. It is recommended that EIM's Configuration and Control Utility (CCU) version 3.2.9 or later be used for configuring the system. 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. Refer to the following paragraphs of this section for location and value of configuration parameters to be edited.

**Notice:** When configuration changes are made the affected module will automatically reset and reinitialize 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**

Unlike previous network master systems supplied by EIM, the software development environment is not required to configure the system. 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.

### **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 4-11. Software versions are reported as a three-digit number with an implied decimal point between the first as second most significant digits. Software version numbers are displayed by the CCU.

### **3.2 Selecting Diagnostic/Programming Mode**

Each module may be independently configured for Diagnostic/Programming mode by writing a non-zero value to the “Diagnostic Mode” register. When Diagnostic Mode is selected, network communication messages are output (printed) in ASCII format to Port 3 of the module. While in Diagnostic Mode, the module may be interrupted and allow user to gain access to the program. Programs may be uploaded and down loaded via Port 1 of modules in Slots 1 and 2 and Port 2 of Modbus Slave modules in Slots 3 and 4. You must write zero to the Diagnostic Mode register to return the module to the Normal Run Mode.

### **3.3 Chassis Identification and Hot Standby**

The chassis near the bottom of the enclosure is the Primary chassis. The chassis near the top 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 4-9 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 swap roles of active and hot standby at any time a fault condition of one chassis exists. The two chassis may be forced to swap roles of active and hot standby mode by writing a non-zero value to Modbus Register 40249. 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 4-11. The module must be configured for RS232 if a NIIM is used for connecting the Host RS-485 networks. Modbus slave address, baud rate, and parity may be configured by writing to the associated configuration register shown in Table 4-11.

### **3.5 Configuring the Field Network**

Editing the values loaded to Modbus registers 41577 through 41580 as shown in Table 4-11 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 41577.

#### **3.5.2 Configuring Field Network Baud Rate**

Editing the constant written to Modbus register 41578 as shown in Table 4-11 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 41579 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 10mS) 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 41580 will disable RBE. Writing a non-zero value to register 41580 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 41325 through 41448 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 124 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 16-31). Remaining data acquired is listed below.

<u>Device</u>	<u>Data Acquired</u>
Type 0	Valve position (0-100% in 1% increments)
Type 1	Valve position (0-100% in 1% increments) Coils (0-15) Inputs (0-15)
Type 2	Valve position (0-4095) Position setpoint (0-4095) Analog output (0-4095)
Type 3	Valve position (0-4095) Position setpoint (0-4095) Analog output (0-4095) Coils (0-15) Inputs (0-15)
Type 4	Valve position (0-4095) Position setpoint (0-4095) Analog output (0-4095) Valve torque (0-4095) User analog input #1 (0-4095) User analog input #2 (0-4095)
Type 5	Valve position (0-4095) Position setpoint (0-4095) Analog output (0-4095) Valve torque (0-4095) User analog input #1 (0-4095) User analog input #2 (0-4095) Coils (0-15) Inputs (0-15)

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 41449 through 41572 or the number of registers equal to the number of devices on the network. If the system reload default settings, all devices will be set as Device Type 2.



## **4.0 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 4-1 is the address map for valve actuators up to a maximum of 124. 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 (0-4095) value written to the valve actuator using the 06 or 16 function codes. All registers are unsigned 16-bit integers.

#### **IMPORTANT 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 4-1 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 4-1 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 4-1 would be 00 Hex in the Modbus message.

**TABLE 4-1**
**Memory Map of Valve Data and Commands by Function Code**

<b>Function Code and Valve data/Command</b>	<b>Command Data Type</b>	<b>Begin Reg</b>	<b>Ending Reg</b>	<b>Max Number</b>
01 Discrete valve status	Read Coils (discrete)	01985	03968	1984
01 Discrete Outputs (0-15)	Read Coils (discrete)	03969	05952	1984
02 Discrete valve status	Read Inputs (discrete)	10001	11984	1984
02 Discrete Inputs (raw 0-15)	Read Inputs (discrete)	11985	12108	1984
03 Valve status word	Read Holding Register	40001	40124	124
03 Valve position feedback	Read Holding Register	40256	40379	124
03 Raw torque analog input	Read Holding Register	40401	40524	124
03 Valve position setpoint	Read Holding Register	40576	40699	124
03 Aux. analog input #1	Read Holding Register	40701	40824	124
03 Aux. Analog input #2	Read Holding Register	40825	40948	124
03 Aux. Analog output	Read Holding Register	40951	41074	124
03 Discrete Inputs (raw 0-15)	Read Holding Register	41075	41198	124
03 Discrete Outputs (0-15)	Read Holding Register	41201	41324	124
04 Valve status word	Read Input Register	30001	30124	124
04 Discrete Inputs (raw 0-15)	Read Input Register	31075	31198	124
05 Discrete valve commands	Write Coils (discrete)	00001	01984	1984
05 Discrete Outputs (0-15)	Write Coils (user relays)	03969	05952	1984
15 Discrete valve commands	Write Multiple Coils	00001	01984	1984
15 Discrete Outputs (0-15)	Write Multiple Coils	03969	05952	1984
06 Discrete valve commands	Write Holding Register	40125	40248	124
06 Valve position setpoint	Write Holding Register	40576	40699	124
06 Aux. analog output	Write Holding Register	40951	41074	124
06 Discrete Outputs (0-15)	Write Holding Register	41201	41324	124
16 Discrete valve commands	Write Multiple Registers	40125	40248	124
16 Valve position setpoint	Write Multiple Registers	40576	40699	124
16 Aux. Analog output	Write Multiple Registers	40951	41074	124
16 Discrete Outputs (0-15)	Write Multiple Registers	41201	41324	124

**Note:** User Relays #1 and #2 may be controlled by writing to the valve command registers. See Table 4-7 in Paragraph 4.4. These relays may also be controlled by writing to Discrete Outputs 04 and 05. See Paragraph 4.9.

## 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 4-2 shows the valve status for valve address #1 when using Modbus Function Code 02.

**TABLE 4-2**

**Valve Status Information for Valve at Network Address #1  
For  
Controlinc Model 320A**

<b>Modbus Address</b>	<b>Valve Status</b>	<b>Description</b>
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.

#### 4.2.1 Multiple Valve Status Locations Using Function Code 02

Valve status information shown in Table 4-2 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 124 valves on the network as shown in Table 4-3.

**TABLE 4-3**

#### 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
:		:	:
:	<b>thru</b>	:	<b>thru</b>
:		:	:
122		11937 thru	11952
123		11953 thru	11968
124		11969 thru	11984

#### 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 4-4. The 16 bits of valve status for each valve actuator is the same as that shown in Table 4-2.

**TABLE 4-4**  
**Using Modbus Function Code 03**

<b>Valve Actuator Network Address</b>	<b>Modbus Address</b>
001	40001
002	40002
003	40003
004	40004
005	40005
⋮	⋮
⋮	⋮
⋮	⋮
<b>thru</b>	<b>thru</b>
⋮	⋮
122	40122
123	40123
124	40124

### 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 4-5. The 16 bits of valve status for each valve actuator is the same as that shown in Table 4-2.

**TABLE 4-5**  
**Using Modbus Function Code 04**

Valve Actuator Network Address	Modbus Address
001	30001
002	30002
003	30003
004	30004
005	30005
⋮	⋮
⋮	⋮
⋮	⋮
thru	thru
⋮	⋮
⋮	⋮
122	30122
123	30123
124	30124

### 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 0-100% 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 4-6.

**TABLE 4-6**

#### **Valve Position Feedback and Setpoint using Modbus Function Code 03**

Valve Actuator Network Address	Modbus Address	
	Position	Setpoint
001	40256	40576
002	40257	40577
003	40258	40578
004	40259	40579
005	40260	40580
⋮	⋮	⋮
⋮	thru	⋮
⋮	⋮	thru
⋮	⋮	⋮
122	40278	40697
123	40279	40698
124	40380	40699

### 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 to multiple valve actuators using Function Code 15. Commands may also be written to valve actuators by writing holding registers 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 40250. This will cause ESD to be broadcast to all valve actuator addresses. Writing a zero to register 40250 ends the ESD function. Regardless of “Device Type”, each valve actuator will respond to eight commands as shown in Table 4-7. The four LSBs of each word control the valve actuator. The next higher four bits of each word control the two User Relays. When writing to holding registers, one register is written per valve in sequence of valve addresses. Writing zeros to any location has no affect on operation. Each command is a positive one (set coil) and the coil is automatically reset to zero when the command is executed. Only one coil per valve may be written for valve control at any one time. Writing multiple coils to control a single valve will cause no action, i.e. it is treated as a no-op. Writing two mutually exclusive coils will have no affect on operation.

**TABLE 4-7**
**Writing Commands to Valves using Function Code 05 or 15**

<b>Modbus Address</b>	<b>Command and Valve Network Address</b>
00001	Open - Valve at address 001
00002	Stop - Valve at address 001
00003	Close - Valve at address 001
00004	ESD - Valve at address 001
00005	Turn ON User Relay #1 for valve address 001
00006	Turn OFF User Relay #1 for valve address 001
00007	Turn ON User Relay #2 for valve address 001
00008	Turn OFF User Relay #2 for valve address 001
00009	Reserved
00010	Reserved
00011	Reserved
00012	Reserved
00013	Reserved
00014	Reserved
00015	Reserved
00016	Reserved



Discrete command holding registers contain four commands per valve and four bits for User Relay output control per register. A single register may be written to command one valve by using Modbus Function Code 06. Multiple registers may be written to control multiple valves by using Function Code 16. Command holding registers begin at Modbus address 40125. A total of 124 registers are used for the command coils. Writing a seven (7) to Modbus Register 40250 will cause an ESD command to be sent to all actuators on the network. Each actuator is configured to respond to the ESD command in one of three ways: go closed, go open, or stay put. Each actuator can also control an ESD relay, that may be wired to control the actuator, external equipment or to override some internal function. See Reference 1.1.1 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 Controlinc 320A actuator, 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  $(\text{real time value}/4095 * \text{full scale engineering units})$ . Data for auxiliary analog inputs AIN2 is in sequence with network address starting at Modbus register 40701. Up to 124 values may be acquired. The last register for the 124<sup>th</sup> unit is 40824. Data for auxiliary analog inputs AIN3 is in sequence with network address starting at address 40825. Up to 124 values may be acquired. The last register for the 124<sup>th</sup> unit is 40928.

##### **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 an unscaled raw analog value read from 320A register 15 labeled AIN#1. The range of the value is roughly 0-4095 where zero torque is approximately mid-range (2048). The value decreases for Closing torque and increases for Opening torque. The user must provide scaling and calibration 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. Unscaled 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 raw analog torque reading is in sequence with network address starting at Modbus register 40401. Up to 124 values may be acquired. The last register for the 124<sup>th</sup> unit is 40524.

#### **4.7 Reading and Writing Auxiliary Analog Outputs**

All device types, except type 0 and 1, have an option to add one 4-20mA analog output. The host may write to the output by writing to a Modbus register in sequence with network address starting at register 40951. Up to 124 analog outputs may be written. The last register for the 124<sup>th</sup> unit is 41074. Data must be written to the actuators as 12-bit analog data with a range of 0 to 4095 corresponding to 4-20mA. 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 320A has two isolated discrete inputs available to the User. These are Inputs 13 (User Input #1) and 14 (User Input #2) in the Controlinc 320A discrete input memory map. Inputs 0-15 of the Controlinc 320A 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 (0-15) 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 4-8. The host, using Function Codes 02, 03, and 04, may access these inputs. When using Function Code 02, the inputs are addressed from 11985 to 13968 with 16 inputs per actuator as shown in Table 4-8 for up to 124 actuators. When using Function Code 03, the discrete inputs are addressed from register 41075 (valve #1) to 41198 (valve #124). When using Function Code 04, the discrete inputs are addressed from register 31075 (valve #1) to 31198 (valve #124). Inputs (bits) of each valve actuator within the 40000 and 30000 registers are in the same sequence as shown in Table 4-8.

**TABLE 4-8**

**Discrete Inputs for Valve at Network Address #1 Using Function Code 02  
for  
Controlinc Model 320A**

<b>Modbus Address</b>	<b>Valve Status</b>	<b>Description</b>
14001	Open Limit Switch	Valve Fully Open
14002	Close Limit Switch	Valve Fully Closed
14003	Auxiliary Open Contact	Aux. contact of starter
14004	Auxiliary Close Contact	Aux. contact of starter
14005	Manual Mode	Selector Swt in Local
14006	Auto Mode	Selector Swt in Remote
14007	Open Torque Alarm	Open Torque Swt Tripped
14008	Close Torque Alarm	Close Torque Swt Tripped
14009	Power Monitor Alarm	Loss of Control Voltage
14010	Motor Overload Alarm	Overload Relay Tripped
14011	Phase Monitor Alarm	3-Phase power reversed
14012	Local ESD Alarm	Local ESD input activated
14013	VFC Fault Alarm	VFC alarm input activated
14014	User Discrete Input #1	Isolated user wired input
14015	User Discrete Input #2	Isolated user wired input
14016	On-board execute button	Used by 320A only

#### **4.9 Writing User Relay Outputs (MRTU Support)**

Device types 1,3 and 5 allow four relays to be controlled by the host. The outputs are Coils 00 (Close Relay), 01 (Open Relay), 04 (User Relay #1) and 05 (User Relay #2) in the Controlinc 320A Coil Map (0-15). 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 a Micro Remote Terminal Unit (MRTU). The database of the Network Master is configured for 16 coils per actuator for 124 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 03969 to 05952 with 16 coils per actuator. For example, writing to the relays of valve number one, write to coil 03972 for User Relay #1 and 03973 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 03989 (3973+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. The host may control On/Off state of User Relay#1 and User Relay#2 regardless of device type by writing to the discrete command registers as shown in Table 4-7 as explained in Paragraph 4.4.

#### 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 4-9. 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 4-9.

**Table 4-9  
System Status Word Bit Map**

<b>Bit</b>	<b>Status Definition</b>	<b>Note</b>	<b>CR</b>	<b>FC02</b>
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 & Standby to Active		37	14064

Primary and Secondary Host Link Failed alarms shown in Table 4-9 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 five 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 4-9A. The system is in alarm when this register is non-zero and the alarm is cleared when this register is zero. Bit 0 is a combined alarm for bits 1-3 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 4-9. 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 4-9. This alarm is also set when the Secondary master is powered down.

**Table 4-9A**

**Combined System Alarms  
(Modbus Register 40251)**

<b>Bit</b>	<b>Alarm Definition</b>
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)
4-15	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 terminal 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, Paragraph 3.6 of this manual in order for fault location to function properly.

### **4.13 M124N Global Database and Modbus Holding Register Map**

Table 4-10 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 4-11 is supplied for system configuration. For more detail on system configuration, see Section 3.0 of this manual. All communication modules may be configured from any one of the Modbus slave ports normally connected to a host. EIM Configuration and Control Utility (CCU) Version 3.10 or later may be used to configure the network masters. The CCU software download is available at [www.eim-co.com](http://www.eim-co.com). Any other Modbus host device such as Modview available at Arcom's website [www.arcom.com](http://www.arcom.com) may be used to configure the system.

**Table 4-10**

**M124N Global Database  
And  
Modus Register Assignments for Valve Data**

**(All Actuator Data is in Sequence with Valve Actuator Network Address)**

<b>Parameter</b>		<b>Octal</b>	<b>Decimal</b>	<b>Hex</b>	<b>Modbus</b>	
Valve Status and Alarms (124 words)	Begin	1400	0768	300	40001	RO
	End	1573	0891	37B	40124	
Discrete Valve Commands (124 words)	Begin	1574	0892	37C	40125	R/W
	End	1767	1015	3F7	40248	
Swap Primary and Hot Standby		1770	1016	3F8	40249	R/W
ESD to all Valve Actuators		1771	1017	3F9	40250	R/W
System Alarm		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
System ID, High byte = Char.E, 69 decimal, Low byte = Loop #		1776	1022	3FE	40255	RO
Valve Position Feedback (124 words)	Begin	1777	1023	3FF	40256	RO
	End	2172	1146	47A	40379	
Valve Torque (raw analog) (124 words)	Begin	2220	1168	490	40401	RO
	End	2413	1291	50B	40524	
Valve Position Setpoint (124 words)	Begin	2477	1343	53F	40576	R/W
	End	2672	1466	5BA	40699	
User Analog Input #1 (124 words)	Begin	2674	1468	5BC	40701	RO
	End	3067	1591	637	40824	
User Analog Input #2 (124 words)	Begin	3070	1592	638	40825	RO
	End	3263	1715	6B3	40948	
Analog Output (124 words)	Begin	3266	1718	6B6	40951	R/W
	End	3461	1841	731	41074	
User Discrete Inputs (valve inputs 0-15) (124 words)	Begin	3462	1842	732	41075	RO
	End	3655	1965	7AD	41198	
User Discrete Outputs (valve outputs 0-15) (124 wrds)	Begin	3660	1968	7B0	41201	RO
	End	4053	2091	82B	41324	

**Warning: Writing 7 to Register 40250 will cause all actuators to execute ESD.  
Writing zero to Register 40250 will disable (end) ESD.**



**Table 4-11**
**M124N Network Master Configuration**

**(Writing to RO Registers is allowed but will be over-written by the controller)  
(All Registers are 16-bit Unsigned Integers)**

<b>Configuration Slot/Parameter</b>	<b>Configuration Options, Default settings shown in [brackets]</b>	<b>PLC Octal</b>	<b>PLC Hex</b>	<b>Modbus Register</b>		
Network Address Scan List (124 wrds)	Physical sequence of Actuators on Network	Begin	4054	82C	41325	R/W
		End	4247	8A7	41448	
Device Type List (124 words)	Type of each Slave Device on Valve Actuator Network	Begin	4250	8A8	41449	R/W
		End	4443	923	41572	
<b>Main CPU S/W Version</b>	Software Version Number of RLL. Data written to this register will be over-written by the CPU on powerup		4444	924	41573	RO
System Reset	Writing non-zero value will cause the system to reset. This register is zeroed after reset.		4445	925	41574	R/W
<b>Slot 1 (Net Master)</b>	<b>Valve Actuator Network Master</b>					
Software Version	Module S/W Version Number Written by Module in Slot 1		4446	926	41575	RO
Diagnostic Mode	[0=Normal Run Mode] Non-Zero=Diagnostic Mode		4447	927	41576	R/W
Number of Field Network Devices	[124] Total number of slave devices connected to network		4450	928	41577	R/W
Baud rate of Valve Actuator Network	Enter whole number/100. Example: 48, 96, 192, 384. [96]		4451	929	41578	R/W
Receiver Time-Out	Enter time in milliseconds [50mS]		4452	92A	41579	R/W
Enable/Disable Report-By-Exception	0=Disable report by exception (RBE) [Non-Zero=Enable RBE]		4453	92B	41580	R/W
Reserved	Data written ignored.		4454	92C	41581	R/W
Reserved	Data written ignored.		4455	92D	41582	R/W
Enable Program Mode	Writing a non-zero value to this register allows the module to be programmed from Port 1.		4456	92E	41583	R/W
Reload Default Scan List and Device Types	Writing zero to this register reloads sequential scan list from 1 to 124 and all device types as 2. Do <u>not</u> write a non-zero value. The master writes 0x5A5A to this register after defaults are loaded.		4457	92F	41584	R/W



<b>Slot 2</b> (LCD Terminal)	<b>LCD Panel and Control Passcode</b>					
Software Version	Module S/W Version Number Written by Module in Slot 2		4460	930	41585	RO
Diagnostic Mode	[0=Normal Run Mode] Non-Zero=Diagnostic Mode		4461	931	41586	R/W
LCD Control Passcode	[0=Passcode Disabled]. Write integer between 125 and 998.		4462	932	41587	R/W
Reserved for Future Expansion	Data written to these registers are ignored.	Begin	4463	933	41588	R/W
		End	4471	938	41594	
<b>Slot 3</b> (Host Port 1)	<b>Modbus Slave Configuration</b>					
Software Version	Module S/W Version Number Written by Module in Slot 3		4472	93A	41595	RO
Diagnostic Mode	[0=Normal Run Mode] Non-Zero=Diagnostic Mode		4473	93B	41596	R/W
Modbus Slave Address	Enter whole number from 1 to 254. [Default=5]		4474	93C	41597	R/W
Modbus Slave Baud rate	Enter whole number. Example: 4800, 9600, 19200, etc. [9600]		4475	93D	41598	R/W
Modbus Slave Parity	[0=None], 1=Odd, 2=Even		4476	93E	41599	R/W
Port Hardware Mode	[0=RS232], Non-Zero=RS422/485		4477	93F	41600	R/W
Reserved for Future Expansion	Data written to these registers are ignored.	Begin	4500	940	41601	R/W
		End	4503	943	41604	
<b>Slot 4</b> (Host Port 2)	<b>Modbus Slave Configuration</b>					
Software Version	Module S/W Version Number Written by Module in Slot 4		4504	944	41605	RO
Diagnostic Mode	[0=Normal Run Mode] Non-Zero=Diagnostic Mode		4505	945	41606	R/W
Modbus Slave Address	Enter whole number from 1 to 254. [Default=5]		4506	946	41607	R/W
Modbus Slave Baud rate	Enter whole number. Example: 4800, 9600, 19200, etc. [9600]		4507	947	41608	R/W
Modbus Slave Parity	[0=None], 1=Odd, 2=Even		4510	948	41609	R/W
Port Hardware Mode	[0=RS232], Non-Zero=RS422/485		4511	949	41610	R/W
Reserved for Future Expansion	Data written to these registers are ignored.	Begin	4512	94A	41611	R/W
		End	4515	94D	41614	

**Note:** Network Address Scan List defaults to addresses 1 to 124 in sequence.  
 Device Type List defaults to all type 2.  
 All communication ports default to RS232, 9600,N,8,1.  
 All host ports (Modbus slaves) default to address 5.  
 All modules default to Normal Run Mode.

## **5.0 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 320A 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 M124N 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 than 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 500mS. 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 200mS 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 two 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 failover time is 800mS for problems other than host link failures. Failover 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 form 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 (14<sup>th</sup> 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 40250, 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.

## **6.0 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. EIM 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**

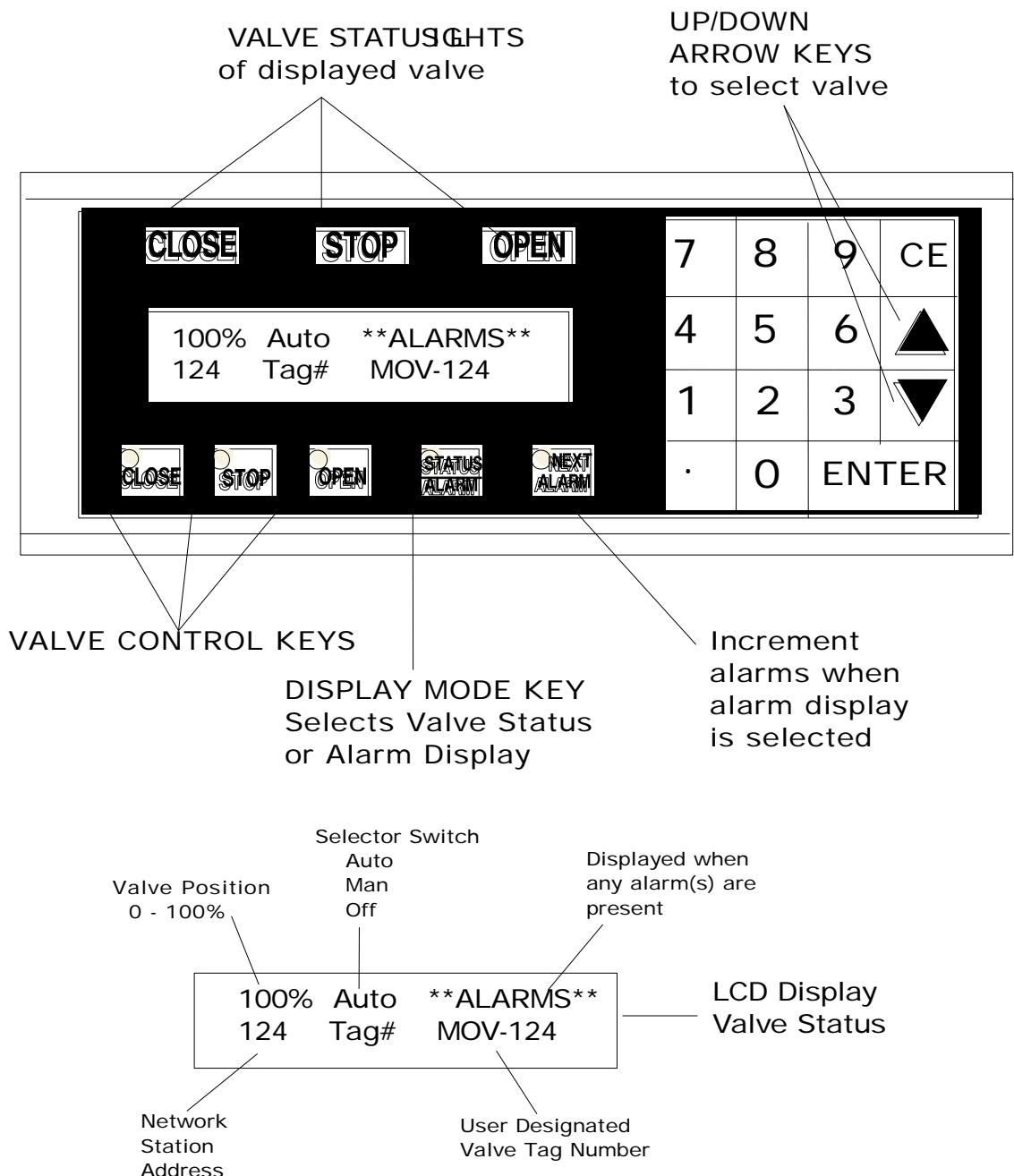
An excel spreadsheet is also supplied on the CD ROM under "Memory Maps" directory. This spreadsheet is an aid used for configuring the host database. Load the excel file to a computer with windows then open the spreadsheet. To use the spreadsheet, simply enter the valve actuator network address in the 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.



## 7.0 LCD Keypad Backup Terminal Operation

Refer to Figure 7-1 for a view of the terminal while reading this section. The numeric keys 0-9, ENTER and CE keys may be used to enter valve actuator addresses for display and control.

Figure 7-1



## **7.1 Display Mode**

The display mode key toggles the display between two modes. When the LED on the display mode key is on, alarm display mode is selected. When the LED on the display mode key is off, valve status/valve control mode is selected. Valves may be controlled only when the valve status/valve control mode is selected.

## **7.2 Valve Status Display**

Valve status is displayed by the LCD display and the valve status lights. To display status of a valve, select the valve tag number by scrolling up or down using the UP and DOWN arrow keys. When the desired station address or valve tag number is displayed, the current status of the valve is displayed. Alternately, the valve address may be selected by pressing the ENTER key and then entering the valve network address using the 0-9 keys and then the ENTER key. The valve status lights display the CLOSE (valve closed), STOP (valve stopped in mid-travel), or OPEN (valve open). If the valve is in transition, the CLOSE light will flash while the valve is closing or the OPEN light 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, **\*\*ALARMS\*\*** will be displayed after the selector switch status. You must select the Alarm Display Mode to view the alarms.

## **7.3 Valve Control**

Status of the desired valve must be displayed before attempting to control the valve. Select the valve by scrolling up or down using the UP and DOWN arrow keys until the desired valve address or tag number is displayed or use the ENTER and 0-9 keys to enter the desired address. The CLOSE, STOP, OPEN valve control keys may then be used to control the valve.

### **7.3.1 ESD Command**

Emergency shutdown (ESD) command may be sent to all valves from the control keys by pressing both CLOSE and NEXT ALARM keys at the same time. When the command is executed, message **\*\*\* ESD \*\*\*** will be displayed.

## **7.4 Alarm Display**

When the **\*\*ALARMS\*\*** message is displayed on the valve status screen, alarms may be viewed by changing to the Alarm Display Mode. Press the STATUS/ALARM key once to select the mode. The first alarm will be displayed. If multiple alarms are active, press the NEXT ALARM key to display the next alarm in the alarm list. After the last alarm is displayed, the system will roll over to the first alarm. To return to the valve status display, press the STATUS/ALARM key once more and the LED will turn off.



## **7.5 Enable/Disable Valve Control**

Valve control from the LCD terminal described in Paragraph 7.3 may be enabled or disabled at the terminal. A passcode is required to enable or disable control. The passcode is controlled by engineering or management and may be changed periodically. To change control modes press the “Enter” key. When the message “Enter Address” is displayed, enter the passcode rather than a valve address. The message “Enable LCD Control?” will be displayed. Entering a zero will disable control. Entering a non-zero value will enable control. The “Enter” key must be used to complete each entry. Unless otherwise instructed, the system is shipped with passcode disabled and the LCD valve control function is enabled at all times. It is necessary for engineering to enable the passcode function after the system is installed. When the passcode is enabled, the passcode must be entered after each power cycle before actuator control is enabled.

## **7.6 Switch Active Master to Hot Standby**

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 “Enter” key. When the message “Enter Address” is displayed, enter 999 rather than a valve address. The message “Switch to Standby?” will be displayed. Entering a zero will not switch the mode. Entering a non-zero value will switch the currently active master to hot standby and allow the master in standby to become active. The “Enter” key must be used to complete each entry.