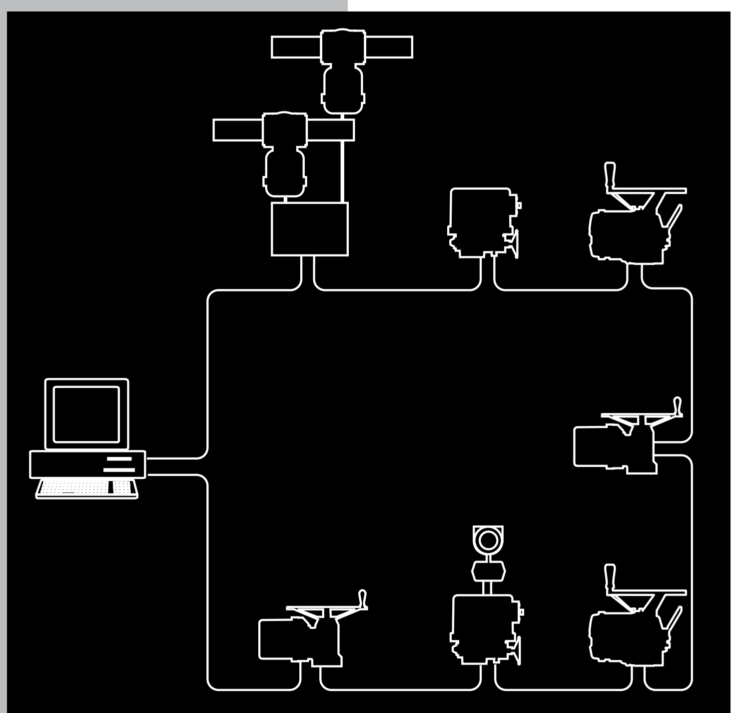
DDC-100
Direct-to-Host
Programming Guide

FCD LMAIM4019-00
(Replaces 435-23009)



FLOWSERVE

Network Control Systems

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1 Introduction

1.1 Premise

This Programming Guide was written for the user who is connecting Flowserve Limitorque DDC-100 Network-compatible valve actuators directly to a control system Host computer. These guidelines provide the information that is necessary to control and monitor the valve actuators through a serial data communications network.

Your safety and satisfaction are very important to Flowserve. Please follow all instructions carefully and pay special attention to safety.

1.2 Emphasis

The following methods will be used to emphasize text throughout this manual:

c **WARNING: Refers to personal safety. This alerts the reader to potential danger or harm. Failure to follow the advice in warning notices could result in personal injury or death.**

a **CAUTION:** Directs attention to general precautions, which, if not followed, could result in personal injury and/or equipment damage.

NOTE: Highlights information critical to the understanding or use of these products.

Bold text highlights other important information that is critical to system components.

CAPITALIZED text stresses attention to the details of the procedure.

Underlined text emphasizes crucial words in sentences that could be misunderstood if the word is not recognized.

The purpose of these emphasized blocks of text is to alert the reader to possible hazards associated with the equipment and the precautions that can be taken to reduce the risk of personal injury and damage to the equipment.

Read and become familiar with the material in these guidelines before attempting installation, operation, or maintenance of the equipment. Failure to observe precautions could result in serious bodily injury, damage to the equipment, or operational difficulty.

1.3 Audience

These guidelines were written to help you successfully connect Limitorque valve actuators directly to a control system Host computer. You do not have to be an expert in electronics or digital controls to utilize this manual. However, this manual assumes that you have a working understanding of valve actuators and a fundamental understanding of control system programming.

The following manuals should be available before attempting to connect the valve actuators to the control system:

1) **Accutronix Installation and Operation for MX-DDC Field Unit Manual**
   Bulletin LMAIM1329

2) **DDC-100 UEC Field Unit (Modbus®) Installation and Operation Manual**
   Bulletin LMAIM4029

3) **DDC-100 UEC Field Unit Wiring and Startup Guidelines**
   Bulletin LMAIM4022

4) **DDC-100 UEC Field Unit Installation and Commissioning Manual**
   Bulletin LMAIM4030

5) **Modicon Modbus Protocol Reference Guide PI-MODBUS-300 Rev. G**
   available from Modicon

6) **Valve actuator installation manual for the specific model(s) to be installed.**

An understanding of valve actuators and digital control systems is beneficial to all system users. Flowserve assistance and training is available to help you operate your system at top efficiency. It is recommended that you read this entire manual before attempting to install the valve actuators in your control system.

2 Direct-to-Host Valve Control

In this document, Direct-to-Host valve control is defined as the use of a customer-supplied (possibly pre-existing) Host control system (PLC, DCS, PC, etc.) to directly control the actuation of valves that are equipped with DDC-100 Network-compatible field units. The field units are micro-processor-based devices that can communicate with the Host and respond to Host commands for valve motion and status. The DDC-100 Network uses the EIA RS-485 standard for the physical layer and the A.E.G. Modicon Modbus protocol for the command structure.

The Direct-to-Host solution to valve actuation systems provides distinct advantages for many users. These benefits range from maximizing system design flexibility to utilizing existing plant equipment for valve actuator control. The customer can emphasize selecting the best equipment and software that closely matches the application's requirements. This solution allows the user to add valve control while avoiding the need to incorporate new control equipment into the facility. Direct-to-Host functionality is accomplished through the use of open architecture control and communications in the valve actuator controls that economically accommodate widely available interfaces for existing SCADA, PLC, or personal computers.

2.1 Advantages of Direct-to-Host Control

- Freedom to design a valve actuator system to interface directly with customer-preferred supervisory equipment with open-market availability and off-the-shelf components.
- Maximizes valve actuator system flexibility by utilizing the industry standard protocol of Modbus, complemented with the EIA RS-485 electrical standard.
- Increases control room equipment utilization while incorporating a cost savings to the customer through the elimination of unnecessary hardware.
- Supports the use of control system components familiar to the user and eliminates the requirement to learn third-party interfaces.
- Strengthens control system architecture with components readily available on the open market.
- Encourages parts replacement and support programs favorable to the user.
- Promotes direct downloading of valve actuator data to the supervisory control system without intervening proprietary hardware or protocols.

- Provides a safe and reliable communications path between the supervisory control system and valve actuator network. This eliminates an unnecessary single point of failure that would exist if the valve control network required a gateway device.
- Enhances the operational relationship between the customer and the customer's preferred system integrator.

2.2 Deliverables for Successful Direct-to-Host Implementations

Each Direct-to-Host installation requires coordination to ensure that every supplier understands their deliverable responsibilities. When suppliers understand particular obligations and perform the tasks in an orderly and timely fashion, the DDC-100 Network installation process will progress very smoothly. Appendix A outlines a "typical" chart detailing areas of responsibility or supplier deliverables for installing a DDC-100 system. This appendix is a guideline and may vary from project to project.

3 Field Unit Monitoring and Control

Flowserve Limitorque valve actuators that are DDC-100 Network compatible can be controlled and monitored by sending queries and receiving responses over a serial data network. The DDC-100 Network uses the non-proprietary Modbus message protocol and EIA RS-485 standard for the physical communication link.

Table 3.1 – Field Unit Communication Parameters

Parameter	Options	Default
Message Framing	RTU, ASCII	RTU
Baud Rate	1200, 2400, 4800, 9600, 19,200	9600
Data Bits	8	8
Stop Bits	1	1
Parity	None	None
Error Checking	CRC-16 (RTU), LRC (ASCII)	CRC-16 (RTU)
Field Unit Address Range 1–250	Configurable	Configurable

3.1 Use of Coils and Registers for Monitoring and Control

The material in this section is a brief tutorial and general discussion of the use of Modbus queries and responses to control valve actuators. The detailed discussion of the commands will be given in Section 3.2.

The Modbus communications protocol allows for working with two types of information—coils (or bits) and registers (or 16-bit words). Coils are either ON (1) or OFF (0) and are used in direct relation to relays (that have coils). For example, in a typical actuator, Coil 1 is energized to CLOSE the actuator and Coil 2 is energized to OPEN the actuator. Register information is used for control functions that do not involve coils. An example would be to write a command value to energize the open or close coil or move the actuator to a position of 0 to 100% of open.

Queries are used to send requests from the Modbus master (Host) to the Modbus slave (DDC-100 Field Unit), and the slave must respond with an appropriate response or an error message.

The Modbus function codes that are supported in the DDC-100 Network are a subset of the complete Modbus function codes and are listed below:

01 **Read Coil Status** Reads the ON/OFF status of discrete outputs (coils) in the field units.

02 **Read Input Status** Reads the ON/OFF status of discrete inputs in the field units.

03 **Read Holding Registers** Reads the binary contents of holding registers in the field units.

04 **Read Input Registers** Reads the binary contents of the input registers in the field units.

05 **Force Single Coil** Forces a single coil to either the ON or OFF state.

06 **Preset Single Register** Presets a value into a single-holding register.

08 **Diagnostics** Provides communication tests and checks for internal error conditions in the field units.

15 **Force Multiple Coils** Forces multiple coils to either the ON or OFF state.

16 **Preset Multiple Registers** Presets a value into multiple holding registers.

NOTE: All data in Modbus messages are referenced to zero. The first occurrence of a data item is addressed as item number zero. This includes Coils, Inputs, and Registers. For example, coils 1-8 would be addressed as 0-7, inputs 1-16 would be addressed as 0-15, and registers 1-16 would be addressed as 0-15.

3.2 Modbus

The Modbus protocol was developed by A.E.G. Modicon for communicating to various networked devices. The relationship between these devices and a central controller is called a master-slave relationship in which the master (Host device) initiates all communications. The slave devices (field units in the actuators) respond to the queries from the master. Modbus only permits one master to communicate at any given time (simultaneous communication is prohibited) for assuring process control integrity.

The controlling device (master) must conform to the Modbus protocol as defined in the Modicon Modbus Protocol Reference Guide PI-MODBUS-300 Rev. G and support Modbus function codes 01 through 06, 08, 15 and 16. These function codes are a subset of the complete protocol and are defined in Table 3.2.

Table 3.2 – Modbus Function Codes Supported

Function Code	Name	Bit/Register Addressing	Extended Addressing Range
01	Read Coil Status	Bit	0,000 - 9,999
02	Read Input Status	Bit	10,000 - 19,999
03	Read Holding Register	Register	40,000 - 49,999
04	Read Input Register	Register	30,000 - 39,999
05	Force Single Coil	Bit	0,000 - 9,999
06	Preset Single Register	Register	40,000 - 49,999
08	Diagnostics	N/A	N/A
15	Force Multiple Coils	Bit	0,000 - 9,999
16	Preset Multiple Registers	Register	40,000 - 49,999

Note: MX-DDC does not support Modbus function code 02.
Modbus function codes 15 and 16 are supported in:
UEC-3-DDC Modbus Firmware 2.00 and greater
MX-DDC Firmware 02/01.00 and greater

The choice of which query to use in a particular situation can significantly affect the efficiency of the network. As an example, consider the situation where the Host requires the status of the coils, the status of the digital inputs, the status of the faults, and the status of the timers and analog channels. This information can be obtained by using the 01 - Read Coil Status query, the 02 - Read Input Status query, and 04 - Read Input Register query. To obtain this information, the Host would have to send three separate queries, and the field unit would have to respond to each query separately. A more efficient way to accomplish this same request for information would be through the use of the 03 - Read Holding Register query. The Host would issue the 03 query (specifying the registers to read), and the field unit would respond with one response that would contain all of the requested information. The latter approach would generate considerably less network traffic than the former approach, improving network capacity and response times.

In the strict sense, all transmissions from the Modbus master are called commands. In this manual, a request for information, however, may be referred to as a query. Usually the term query will only be used in conjunction with function codes (01), (02), (03), (04), and (08), which typically request data. Commands are used in conjunction with function codes (05), (06), (15) and (16), which typically initiate field unit action.

Examples

- The coil known as “coil 1” in the field unit is addressed as coil 0000 in the data address field of a Modbus message.
- Digital input 129 decimal is addressed as digital input 0080 hex (128 decimal).
- Holding register 40001 is addressed as register 0000 in the data address field of the message. The function code field already specifies “holding register” operation. Therefore the reference “4XXXX” is implicit.
- Holding register 40009 is addressed as register 0008 hex (8 decimal).

3.2.1 Modbus Function Code 01 (Read Coil Status)

This function code is used to read the coil status in the DDC-100 Field Unit. There are nine coils available to be read on DDC-100 Field Units as shown in Table 3.3. For the MX/DDC or UEC-3-DDC Field Unit, Coil 1 indicates CLOSE contactor and is interlocked with Coil 2, Coil 2 indicates OPEN contactor and is interlocked with Coil 1. When the I/O Module is used in non-MOV (motor-operated valve) mode, relays 1 through 6 or coils 3 through 8 are available for user configuration.

Table 3.3 – DDC-100 Coil Assignments, Modbus Function Code 01 Usage for Digital Outputs

Coil Number	Bit Number	MX/DDC	UEC-3-DDC	DDC-100 Clamshell	I/O Module
1	00	Close / Stop	Close / Stop	Close / Stop	Do Not Use
2	01	Open / Stop	Open / Stop	Close / Stop	Do Not Use
3	02	AS-1	Lockout or Relay #3	Lockout or Relay #3	Relay #3
4	03	AS-2	Do Not Use	Relay #4	Relay #4
5	04	AS-3	Do Not Use	Relay #5	Relay #5
6	05	AS-4	Relay #6	Relay #6	Relay #6
7	06	AR-1 (Opt)	Do Not Use	Do Not Use	Relay #21
8	07	AR-2 (Opt)	Do Not Use	Do Not Use	Relay #12
9	08	AR-3 (Opt)	Do Not Use	Do Not Use	Do Not Use

Note 1: Relay #2 is physical Relay K2.

Note 2: Relay #1 is physical Relay K1.

Example

Poll field unit number 3 for 8 coils starting at coil 1.

Query 0301000000083C2E

Response 03010118503A

Message Breakdown

Query		Response	
03	Slave (Field Unit) Address	03	Slave (Field Unit) Address
01	Function	01	Function
00	Starting Address Hi	01	Byte Count
00	Starting Address Lo	18 1	Data (Coils 8 - 1)
00	No. of Points Hi	503A	Error Check (CRC)
08	No. of Points Lo		
3C2E	Error Check (CRC)		

Note 1: 18h equals 00011000 or coils 4 and 5 are ON.

3.2.2 Modbus Function Code 02 (Read Input Status)

This function code is used to read the discrete input status bits in the DDC-100 Field Unit. The use of this function code will provide the user with the input status bits that are used to develop holding registers 9 through 13. The status bit inputs are contained in locations 10129-10208 for each DDC-100 Field Unit and are defined in Table 3.4.

Table 3.4 – Status Bit Definitions

Bit Number	Modbus Bit Address	UEC-3-DDC and DDC-100 Clamshell	I/O Module
129	128	Opened	Not Used
130	129	Closed	Not Used
131	130	Stopped	Not Used
132	131	Opening	Not Used
133	132	Closing	Not Used
134	133	Valve jammed	Not Used
135	134	Actuator switched to local mode	Not Used
136	135	Combined fault	Not Used

Table 3.4 – Status Bit Definitions (continued)

Bit Number	Modbus Bit Address	UEC-3-DDC and DDC-100 Clamshell	I/O Module
137	136	Over-temperature fault	Not Used
138	137	Actuator failing to de-energize	Not Used
139	138	Channel A fault	Channel A fault
140	139	Channel B fault	Channel B fault
141	140	Open torque switch fault	Not Used
142	141	Close torque switch fault	Not Used
143	142	Valve operated manually fault	Not Used
144	143	Phase error	Not Used
145	144	Input “open verify” is not active after open command is initiated	Not Used
146	145	Input “close verify” is not active after close command is initiated	Not Used
147	146	Input “open verify” is active after open command is de-energized	Not Used
148	147	Input “close verify” is active after close command is de-energized	Not Used
149	148	“Ph_det” (Phase Detect) input is active. One or more phases is missing	Not Used
150	149	“Ph_seq” (Phase Sequence) input is active. Reverse phase sequence is occurring	Not Used
151	150	Valve manually moved from mid-travel to open	Not Used
152	151	Valve manually moved from open to mid-travel	Not Used
153	152	Valve manually moved from mid-travel to close	
154	153	Valve manually moved from close to mid-travel	Not Used
155	154	Network emergency shutdown (ESD) is active	Not Used
156	155	Local emergency shutdown is active	Not Used
157	156	Field unit microprocessor has reset since the last poll	Not Used
158	157	Wrong rotation	Not Used
159	158	Opening in local mode	Not Used
160	159	Closing in local mode	Not Used
161	160	Close contactor (interlocked)	Not Used
162	161	Open contactor (interlocked)	Not Used
163	162	Lockout or user, Relay 3	Relay 3
164	163	Local pushbutton switch LED (UEC-3) Relay 4 (Clamshell)	Relay 4
165	164	Local pushbutton switch LED (UEC-3) Relay 5 (Clamshell)	Relay 5
166	165	User, Relay 6	Relay 6
167	166	Close contactor (non-interlocked)	Relay 2 (K2)
168	167	Open contactor (non-interlocked)	Relay 1 (K1)
169	168	Field unit software vs. ID	Field unit software vs. ID
170	169	Field unit software vs. ID	Field unit software vs. ID
171-176	170-175	Field unit software vs. ID	Field unit software vs. ID
177	176	Remote switch	User Input 8
178	177	Thermal overload	User Input 9

Table 3.4 – Status Bit Definitions (continued)

Bit Number	Modbus Bit Address	UEC-3-DDC and DDC-100 Clamshell	I/O Module
179	178	Open torque switch	User Input 10
180	179	Open limit switch	User Input 11
181	180	Close torque switch	User Input 12
182	181	Close limit switch	User Input 13
183	182	Aux. Open Input	User Input 14
184	183	Aux. Close Input	User Input 15
185	184	User Input 0	User Input 0
186	185	User Input 1	User Input 1
187	186	User Input 2	User Input 2
188	187	User Input 3	User Input 3
189	188	User Input 4	User Input 4
190	189	User Input 5	User Input 5
191	190	Input 6	User Input 6
192	191	Input 7	User Input 7
193	192	Analog Input 1 lost	Analog Input 1 lost
194	193	Analog Input 2 lost	Analog Input 2 lost
195	194	Analog Input 3 lost	Analog Input 3 lost
196	195	Analog Input 4 lost	Analog Input 4 lost
197	196	Network Channels A/B timed out	Network Channels A/B timed out
198	197	Reserved	Reserved
199	198	Reserved	Reserved
200	199	Reserved	Reserved
201	200	Reserved	Reserved
202	201	Reserved	Reserved
203	202	Reserved	Reserved
204	203	Reserved	Reserved
205	204	Lost Phase Input	User Input 18
206	205	Phase Reverse Input	User Input 19
207	206	Input 8	User Input 16
208	207	Input 9	User Input 17

Example

Poll field unit number 22 for 16 inputs starting at input 129 with the actuator opening.

Query 1602008000107B09

Response 1602020108CDED

Message Breakdown

Query		Response	
16	Slave (Field Unit) Address	16	Slave (Field Unit) Address
02	Function	02	Function
00	Starting Address Hi	02	Byte Count
80	Starting Address Lo	01[1]	Data (Inputs 10136 - 10129)
00	No. of Points Hi	08[2]	Data (Inputs 10144 - 10137)
10	No. of Points Lo	CDED	Error Check (CRC)
7B09	Error Check (CRC)		

Note 1: 01h equals 0000 0001 (actuator open input bit is ON).

Note 2: 08h equals 0000 1000 (actuator Channel B Fail bit is ON).

3.2.3 Modbus Function Code 03 (Read Holding Register)

This function code is used to read the binary contents of holding registers in the DDC-100 Field Unit. This function code is typically used during the network polling cycle. A network poll should consist of field unit registers 9 (Status) and 10 (Fault) as a minimum. Holding register 8 should also be polled when the actuator is configured for the analog feedback option or position control. See Table 3.5 for a complete listing of the holding registers.

Table 3.5 – Field Unit Register Definitions

Register Number	Register Name	MX/DDC Meaning	UEC-3-DDC Meaning
1	Command	Registers 1 and 2 are write-only registers used for Modbus Function Code 06	Registers 1 and 2 are write-only registers used for Modbus Function Code 06
2	Argument	Registers 1 and 2 are write-only registers used for Modbus Function Code 06	Registers 1 and 2 are write-only registers used for Modbus Function Code 06
3	Analog Output	APT Scaled Output Value (Default 0-100)	N/A
4	Analog Output	ATT Scaled Output Value1 (Default 0-100)	Average Torque (version 2.00 and greater)
5	Analog Input	Main Power Value (Volts)	Analog Input 4
6	Analog Input	Analog Input 1 (Default 0-100) User 4-20 mA Input (Heavy Smoothing)	Analog Input 3
7	Analog Input	Analog Input 2 (Default 0-100) User 4-20 mA Input	Analog Input 2
8	Position	Valve Position, Scaled Value (Default 0-100) (0-100, 2-255, 0-4095)2	Valve Position, Scaled Value (Default 0-100) OR Analog Input 1
9	Status Register (Field Units as MOV - Motor-Operated Valve)	**16 Bits of Field Unit Status**	**16 Bits of Field Unit Status**
		Bit 0 Opened	**Bit 0** Opened
		Bit 1 Closed	**Bit 1** Closed
		Bit 2 Stopped	**Bit 2** Stopped
		Bit 3 Opening	**Bit 3** Opening
		Bit 4 Closing	**Bit 4** Closing
		Bit 5 Valve jammed	**Bit 5** Valve jammed
		Bit 6 Actuator switched to local mode1	**Bit 6** Actuator switched to local mode
		Bit 7 Combined fault3	**Bit 7** Combined fault3
		Bit 8 Over-temperature fault	**Bit 8** Over-temperature fault
		Bit 9 Future Implementation	**Bit 9** Actuator failing to de-energize
		Bit 10 Network Channel A fault4	**Bit 10** Network Channel A fault
		Bit 11 Network Channel B fault4	**Bit 11** Network Channel B fault
		Bit 12 Open torque switch fault	**Bit 12** Open torque switch fault
		Bit 13 Close torque switch fault	**Bit 13** Close torque switch fault
		Bit 14 Valve-operated manually fault	**Bit 14** Valve-operated manually fault
		Bit 15 Phase error	**Bit 15** Phase error
9	Status Register I/O Module only (Non-Valve Service)	N/A	**16 Bits of Field Unit Status**
			Bits 0-9 Not Used
			Bit 10 Network Channel A fault
			Bit 11 Network Channel B Fault
			Bits 12-15 Not Used

Table 3.5 – Field Unit Register Definitions (continued)

Register Number	Register Name	MX/DDC Meaning	UEC-3-DDC Meaning
10	Fault Register (Not Used for I/O Module)	**16 Bits of Field Status**	**16 Bits of Field Status**
		Bits 0-3 Not Used	**Bit 0** Input “open verify” is not active after open command is initiated
		Bit 4 One or more phases are missing	**Bit 1** Input “close verify” is not active after close command is initiated
		Bit 5 Reverse phase sequence is occurring	**Bit 2** Input “open verify” is active after open command is de-energized
		Bits 6-9 Not Used	**Bit 3** Input “close verify” is active after close command is de-energized
		Bit 10 Network emergency shutdown is active	**Bit 4** “Ph_det” input is active. One or more phases are missing
		Bit 11 Local PB emergency shutdown is active	**Bit 5** “Ph_seq” input is active. Reverse phase sequence is occurring
		Bit 12 MX microprocessor has reset since the last poll	**Bit 6** Valve manually moved from mid-travel to open
		Bit 13 Local Stop	**Bit 7** Valve manually moved from open to mid-travel
		Bit 14 Opening in local mode	**Bit 8** Valve manually moved from mid-travel to close
		Bit 15 Closing in local mode	**Bit 9** Valve manually moved from close to mid-travel
			Bit 10 Network emergency shutdown is active
			Bit 11 Local emergency shutdown is active
			Bit 12 Field Unit microprocessor has reset since the last poll
			Bit 13 Wrong rotation
			Bit 14 Opening in local mode
			Bit 15 Closing in local mode

Table 3.5 – Field Unit Register Definitions (continued)

Register Number	Register Name	MX/DDC Meaning	UEC-3-DDC Meaning
11	Digital Outputs	Value of 16 Digital Outputs	**Value of 16 Digital Outputs**
		Bit 0 Close contactor (interlocked)	**Bit 0** Close contactor (interlocked), I/O Module as MOV (Motor-Operated Valve)
		Bit 1 Open contactor (interlocked)	**Bit 1** Open contactor (interlocked), I/O Module as MOV
		Bit 2 AS-1	**Bit 2** Lockout or User Relay 3
		Bit 3 AS-2	**Bit 3** UEC-3-DDC Local push-button switch LED, Relay 4 Clamshell and I/O Module
		Bit 4 AS-3	**Bit 4** UEC-3-DDC Local push-button switch LED, Relay 5 Clamshell and I/O Module
		Bit 5 AS-4	**Bit 5** Relay 6 Clamshell and I/O Module
		Bit 6 AR-1 (Opt)	**Bit 6** Relay 2 (K2), I/O Module (non-interlocked)
		Bit 7 AR-2 (Opt)	**Bit 7** Relay 1 (K1), I/O Module (non-interlocked)
		Bit 8 AR-3 (Opt)	**Bits 8-15** Field Unit Software vs. ID
		Bit 9 Network Relay	
		Bits 10-15 Not Used	
12	Digital Inputs 1	**Value of 16 Digital Inputs**	**Value of 16 Digital Inputs**
		Bit 0 Remote Switch	**Bit 0** Remote Switch, I/O Module Input 8
		Bit 1 Thermal Overload	**Bit 1** Thermal Overload, I/O Module Input 9
		Bit 2 Open Torque Switch	**Bit 2** Open Torque Switch, I/O Module Input 10
		Bit 3 Open Limit Switch	**Bit 3** Open Limit Switch, I/O Module Input 11
		Bit 4 Close Torque Switch	**Bit 4** Close Torque Switch, I/O Module Input 12
		Bit 5 Close Limit Switch	**Bit 5** Close Limit Switch, I/O Module Input 13
		Bit 6 Not Used	**Bit 6** Aux. Open Input, I/O Module Input 14
		Bit 7 Not Used	**Bit 7** Aux. Close Input, I/O Module Input 15
		Bit 8 User Input 0, terminal 21	**Bit 8** User Input 0, I/O Module Input 0
		Bit 9 User Input 1, terminal 10	**Bit 9** User Input 1, I/O Module Input 1
		Bit 10 User Input 2, terminal 9	**Bit 10** User Input 2, I/O Module Input 2
		Bit 11 User Input 3, terminal 6	**Bit 11** User Input 3, I/O Module Input 3
		Bit 12 User Input 4, terminal 7	**Bit 12** User Input 4, I/O Module Input 4
		Bit 13 User Input 5, terminal 5	**Bit 13** User Input 5, I/O Module Input 5
		Bit 14 Opt User Input 6, terminal 23	**Bit 14** Input 6, I/O Module Input 6
		Bit 15 Opt User Input 7, terminal 24	**Bit 15** Input 7, I/O Module Input 7

Table 3.5 – Field Unit Register Definitions (continued)

Register Number	Register Name	MX/DDC Meaning	UEC-3-DDC Meaning
13	Digital Inputs 2	Value of 16 Digital Inputs	**Value of 16 Digital Inputs**
		Bit 0 Not Used	**Bit 0** Analog Input 1 lost
		Bit 1 Not Used	**Bit 1** Analog Input 2 lost
		Bit 2 Analog input 1 lost	**Bit 2** Analog Input 3 lost
		Bit 3 Analog input 2 lost	**Bit 3** Analog Input 4 lost
		Bit 4 Network Channels A/B timed out	**Bit 4** Network Channels A/B timed out
		Bit 5 Not Used	**Bit 5** Reserved
		Bit 6 DDC board present	**Bit 6** Reserved
		Bit 7 I/O option board present	**Bit 7** Reserved
		Bit 8 Not Used	**Bit 8** Reserved
		Bit 9 Not Used	**Bit 9** Reserved
		Bit 10 Not Used	**Bit 10** Reserved
		Bit 11 Not Used	**Bit 11** Reserved
		Bit 12 Phase lost	**Bit 12** Phase lost input, I/O Module Input 18
		Bit 13 Phase reverse	**Bit 13** Phase reverse input, I/O Module Input 19
		Bit 14 Opt User Input 8, terminal 25	**Bit 14** Input 8, I/O Module Input 16
		Bit 15 Not Used	
		Bit 15 Input 9, I/O Module Input 17	
14	Timers and Analog Channels	Bits 0-15 – Not Used	**Value of 16 Bits**
			Bit 0 Analog Channel 1 Low
			Bit 1 Analog Channel 2 Low
			Bit 2 Analog Channel 3 Low
			Bit 3 Analog Channel 4 Low
			Bit 4 Analog Channel 1 High
			Bit 5 Analog Channel 2 High
			Bit 6 Analog Channel 3 High
			Bit 7 Analog Channel 4 High
			Bit 8 Open reversal time-out
			Bit 9 Close reversal time-out
			Bit 10 Jammed valve time-out
			Bit 11 Network Channel A time-out
			Bit 12 Network Channel B time-out
			Bit 13 User 1 time-out
			Bit 14 User 2 time-out
			Bit 15 User 3 time-out

Table 3.5 – Field Unit Register Definitions (continued)

Register Number	Register Name	MX/DDC Meaning	UEC-3-DDC Meaning
15	User Faults	Bits 1-15 – Not Used	**Value of 16 Bits** **Bit 0** User Fault 0 **Bit 1** User Fault 1 **Bit 2** User Fault 2 **Bit 3** User Fault 3 **Bit 4** User Fault 4 **Bit 5** User Fault 5 **Bit 6** User Fault 6 **Bit 7** User Fault 7 **Bit 8** User Fault 8 **Bit 9** User Fault 9 **Bits 10-15** Reserved
16	Current State	Bits 0-15 – Not Used	**Value of 16 Bits** **Bit 0** Waiting to Open **Bit 1** Waiting to Close **Bit 2** Running Backward **Bit 3** Invalid Configuration **Bit 4** Reverse Switches **Bit 5** OK to Modulate **Bits 6-15** Reserved
17	Field Unit Holding Register	Special Applications Only	Special Applications Only
18	Field Unit Holding Register	Special Applications Only	Special Applications Only
19	Field Unit Holding Register	Special Applications Only	Special Applications Only
20	Field Unit Holding Register	Special Applications Only	Special Applications Only
21	Field Unit Holding Register	Special Applications Only	Special Applications Only
22	Field Unit Holding Register	Special Applications Only	Special Applications Only
23	Field Unit Holding Register	Special Applications Only	Special Applications Only
24-44	Reserved	Special Applications Only	Special Applications Only
45-47	Not Named	Special Applications Only	Special Applications Only
48	TP_START_ POSITION	Special Applications Only	Special Applications Only
49	TP_STOP_POSI-TION	Special Applications Only	Special Applications Only
50	TP_SAMPLE	Special Applications Only	Special Applications Only
51	TP_MID_T_HIGH	Special Applications Only	Special Applications Only
52	TP_MID_T_POS	Special Applications Only	Special Applications Only

Table 3.5 – Field Unit Register Definitions (continued)

Register Number	Register Name	MX/DDC Meaning	UEC-3-DDC Meaning
53	TP_MID_T_AV_ VAL	Special Applications Only	Special Applications Only
54	TP_STOP_VAL	Special Applications Only	Special Applications Only
55	TP_BEFORE MID_T_HIGH_	Special Applications Only	Special Applications Only
56	TP_AFTER MID_T_HIGH	Special Applications Only	Special Applications Only

Note 1: Torque will be expressed proportionally as a reference only from 40-100% inclusive. Initial indication may read 0% until torque exceeds 40% minimum.

Note 2: Default value is scaled 0-100 of span. Changes made to "Scale Analog" affect Analog registers (3, 4, 6, 7, 8) and "move-to" commands.

Note 3: Combined Fault bit is a value of 1 or true when bit 5 or 8 or 9 or 15 or (bits 10 and 11) is a value of 1 or true.

Note 4: Channel A is physical connection A1. Channel B is physical connection A2.

MX/DDC actuators shipped prior to 2nd QTR, 1999, have the following definition for Register 9 bit 6. When this bit has a value of 1 or true, the actuator selector switch is in LOCAL mode. This bit does not indicate STOP or REMOTE. The actuator selector switch in REMOTE (available for network control) is indicated by Register 12 bit 00 having a value of 1 or true. Register 9 bit 6 value 0 (zero) or false AND Register 12 bit 00 value 0 (zero) or false indicates selector switch is in the STOP position.

MX/DDC actuators shipped after 2nd QTR, 1999, have the following definition of Register 9 bit 6. When this bit has a value of 1 or true, the actuator is in LOCAL or STOP (unavailable for network control). The actuator selector switch in REMOTE (available for network control) is indicated by Register 12 bit 00 having value of 1 or true.

IMPORTANT: Verify Host program when installing an MX/DDC actuator shipped after 2nd QTR, 1999, on a network commissioned before 2nd QTR, 1999, for indication of selector switch values. Proper selector switch indication at the Host will ensure safe conditions at the facility.

Example

Poll field unit number 125 for 3 registers starting at register 8 with the actuator stopped between the limits and in local mode.

Query 7D0300070003BFF6

Response 7D0306003D084400003E07

Message Breakdown

Query		Response	
7D	Slave (Field Unit) Address	7D	Slave (Field Unit) Address
03	Function	03	Function
00	Starting Address Hi	06	Byte Count
07	Starting Address Lo	00	Data Hi (Register 40008)
00	No. of Points Hi	3D[1]	Data Lo (Register 40008)
03	No. of Points Lo	08	Data Hi (Register 40009)
BFF6	Error Check (CRC)	44[2]	Data Lo (Register 40009)
		00	Data Hi (Register 40010)
		00	Data Lo (Register 40010)
		3E07	Error Check (CRC)

Note 1: 003Dh equals 61 Decimal (actuator Analog Input 1 in percent format).

Note 2: 0844h equals 2116 Decimal or 0000 1000 0100 0100 Binary (actuator stopped between limits, local mode, and Channel B Fail bit is ON).

3.2.4 Modbus Function Code 04 (Read Input Register)

This function code is used to read the binary contents of input registers in the DDC-100 Field Unit. The typical use of this function code is to read the analog input registers. If the field unit is configured for scaled analog data, the register information will be returned as a percent from 0 to 100 (see NOTE below). The first analog input register (Analog 4) will start at register 30005 through (Analog 1) Input Register 30008.

This function code may also be used to read the information available in registers 9 through 16.

NOTE: Limitorque field units can be configured to report analog data in several formats. See the appropriate field unit manual for details.

Example
Poll field unit number 70 for 4 registers starting at register 5 (Analog Input Registers 1-4).

(This example assumes that the field unit is configured for scaled analog data.)

Query 460400040004BF7F

Response 460408FFFFFFFF002B001EDBA8

Message Breakdown

Query		Response	
46	Slave (Field Unit) Address	46	Slave (Field Unit) Address
04	Function	04	Function
00	Starting Address Hi	08	Byte Count
04	Starting Address Lo	FF	Data Hi (Register 40005)
00	No. of Points Hi	FF[1]	Data Lo (Register 40005)
04	No. of Points Lo	FF	Data Hi (Register 40006)
BF7F	Error Check (CRC)	FF[2]	Data Lo (Register 40006)
		00	Data Hi (Register 40007)
		2B[3]	Data Lo (Register 40007)
		00	Data Hi (Register 40008)
		1E[4]	Data Lo (Register 40008)
		DBA8	Error Check (CRC)

Note 1: FFFFh equals 65535 Decimal (actuator Analog Input 4 value).

Note 2: FFFFh equals 65535 Decimal (actuator Analog Input 3 value).

Note 3: 002Bh equals 43 Decimal (actuator Analog Input 2 value).

Note 4: 001Eh equals 30 Decimal (actuator Analog Input 1 in percent format).

3.2.5 Modbus Function Code 05 (Force Single Coil)

This function code is used to force a single coil in the DDC-100 Field Unit. Forcing the individual coil either ON (1) or OFF (0) will energize or de-energize a coil (digital output) in the field unit. Coil 1 in the field unit closes the actuator and Coil 2 opens the actuator. If the actuator is opening or closing, changing the status of coil 1 or 2 from a value of 1 to 0 will stop the actuator (the coil will automatically be set to zero when the actuator reaches the full open or full close position).

Available digital outputs for DDC-100 Field Units are listed in Table 3.6. Force-coil commands should be issued only once for the desired field unit control. Repeated issuance of an acknowledged command will degrade network performance.

NOTE: See Bulletin LMAIM1329, Accutronix Installation and Operation for MX-DDC Field Unit to configure AS and AR Relays for DDC control.

Table 3.6 – DDC-100 Coil Assignments Modbus Function Code 05 Usage for Digital Outputs

Coil Number	Bit Number	MX/DDC	UEC-3-DDC	DDC-100 Clamshell	I/O Module
1	00	Close / Stop	Close / Stop	Close / Stop	Do Not Use
2	01	Open / Stop	Open / Stop	Open / Stop	Do Not Use
3	02	AS-1	Lockout or Relay #3	Lockout or Relay #3	Relay #3
4	03	AS-2	Do Not Use	Relay #4	Relay #4
5	04	AS-3	Do Not Use	Relay #5	Relay #5
6	05	AS-4	Relay #6	Relay #6	Relay #6
7	06	AR-1 (Opt)	Do Not Use	Do Not Use	Relay #21
8	07	AR-2 (Opt)	Do Not Use	Do Not Use	Relay #12
9	08	AR-3 (Opt)	Do Not Use	Do Not Use	Do Not Use

Note 1: Relay #2 is physical Relay K2.

Note 2: Relay #1 is physical Relay K1.

The normal response to the (05) command is an echo of the command.

Example of force coil command
Force coil 1 of field unit 49 ON. This will CLOSE the valve controlled by field unit 49.

Query 31050000FF0089CA

Response 31050000FF0089CA

Message Breakdown

Query		Response	
31	Slave (Field Unit) Address	31	Slave (Field Unit) Address
05	Function	05	Function
00	Coil Address Hi	00	Coil Address Hi
001	Coil Address Lo	00	Coil Address Lo
FF	Force Data Hi	FF	Force Data Hi
002	Force Data Lo	00	Force Data Lo
89CA	Error Check (CRC)	89CA	Error Check (CRC)

Note 1: 0000h equals Coil Address 00000001 (field unit coil 1).
0001h equals Coil Address 00000010 (field unit coil 2).

Note 2: FF00h requests the coil to be ON. (0000h requests the coil to be OFF)

3.2.6 Modbus Function Code 06 (Preset Single Register)

This function code is used to preset a single register in the field unit. The function code is typically used to command the DDC-100 Field Unit by writing values to the 40001 and 40002 registers. A predetermined value may be used to open/stop/close the actuator, move the actuator to a preset position, activate/deactivate network ESD, reset the field unit, etc.

The Modbus function code 06 is also used to command a throttling actuator to "move-to" a position of 0-100% of open. The field unit will compare the new position value with the current position and open or close the valve to meet the new position requirement. This is a two-step command: the first step is to write the desired position value to the field unit register 40002, then write the value of 6656 to field unit register 40001. This sequence of commands loads the desired position, then instructs the field unit to execute the command.

For UEC-3-DDC field units containing Modbus Firmware 2.00 or greater and MX-DDC field units containing Firmware 02/01.00 or greater, the "move-to" command may be executed with a one-step command.

Modbus function code 06 command values for controlling the DDC-100 Field Unit are given in Table 3.7. Each command should be issued only one time for the desired field unit control. Repeated issuance of an acknowledged command will degrade network performance.

The normal response to the (06) command is an echo of the command.

NOTE:

1) Only use values listed in table 3.7 For field unit register 40001.
2) Field Unit Register 40002 should only be used for "move-to" position input.
3) The Host MUST issue "move-to" commands in the proper sequence. Failure to issue this two-step command in the correct sequence will result in the field unit waiting for the proper command sequence execution before performing the "move-to" function.
4) The "move-to" command should only be used with field units that include the position control option.
5) Do not write to Field Unit Registers 5-16.

Table 3.7 – Modbus 06 Command and Field Unit Holding Register 40001

Host Commands to Field Unit Register 1	Value (dec.)	MX-DDC	UEC-3-DDC	DDC-100 Clamshell	I/O Module
Null Command	0	Yes	Yes	Yes	Yes
Open	256	Yes	Yes	Yes	Do Not Use
Stop	512	Yes	Yes	Yes	Do Not Use
Close	768	Yes	Yes	Yes	Do Not Use
Start Network ESD	1280	Yes	Yes	Yes	Do Not Use
Stop Network ESD	1536	Yes	Yes	Yes	Do Not Use
Engage Relay #1	2304	Yes (AS-1)	Do Not Use	Do Not Use	Yes, K21
Engage Relay #2	2560	Yes (AS-2)	Do Not Use	Do Not Use	Yes, K12
Engage Relay #3	2816	Yes (AS-3)	Yes	Yes	Yes
Engage Relay #4	3072	Yes (AS-4)	Do Not Use	Yes	Yes
Engage Relay #5	3328	Yes (AR-1)	Do Not Use	Yes	Yes
Engage Relay #6	3584	Yes (AR-2)	Yes	Yes	Yes
Engage Relay #7	3840	Yes (AR-3)	Do Not Use	Do Not Use	Do Not Use
Disengage Relay #1	4352	Yes (AS-1)	Do Not Use	Do Not Use	Yes, K21
Disengage Relay #2	4608	Yes (AS-2)	Do Not Use	Do Not Use	Yes, K12
Disengage Relay #3	4864	Yes (AS-3)	Yes	Yes	Yes
Disengage Relay #4	5120	Yes (AS-4)	Do Not Use	Yes	Yes
Disengage Relay #5	5376	Yes (AR-1)	Do Not Use	Yes	Yes
Disengage Relay #6	5632	Yes (AR-2)	Yes	Yes	Yes
Disengage Relay #7	5888	Yes (AR-3)	Do Not Use	Do Not Use	Do Not Use
Move-To (enable)	6656	Yes	Yes	Yes	Do Not Use

Note 1: Engage and disengage Relay #1 control physical Relay K2.

Note 2: Engage and disengage Relay #2 control physical Relay K1.

Do Not Use–This command is not intended for use in this configuration.

Other registers may also be preset to control or change other functions but care must always be taken to properly change these values. An improper value written to a register can cause undesirable actions from the DDC-100 Field Unit.

NOTE: Null Command–The field unit takes no action when this command is received. This command is typically used by a Host to reset the Host output register when required.

Example of Field Unit Command

Write the command to open an actuator (actuator open) to field unit number 179. This corresponds to writing the value 256 into field unit register 40001.

Query: B306000001009388

Response: B306000001009388

Message Breakdown

Query		Response	
B3	Slave (Field Unit) Address	B3	Slave (Field Unit) Address
06	Function	06	Function
00	Register Address Hi	00	Register Address Hi
001	Register Address Lo	00	Register Address Lo
01	Force Data Hi	01	Preset Data Hi
002	Force Data Lo	00	Preset Data Lo
9388	Error Check (CRC)	9388	Error Check (CRC)

Note 1: 0000h equals Register Address 40001 (field unit register 1, command register).

Note 2: 0100h requests the register to be preset with 256 Decimal (engage open contactor).

Example of "Move-To" Command

Move an actuator at address 179 to 42% of open by first writing the value of 42 to the field unit 40002 register. After receiving a response from the field unit, write the value of 6656 to the field unit 40001 register. The actuator will then move to a position of 42% of open.

First Command

Query: B3060001002A4207

Response: B3060001002A4207

First Command Message Breakdown

Query		Response	
B3	Slave (Field Unit) Address	B3	Slave (Field Unit) Address
06	Function	06	Function
00	Register Address Hi	00	Register Address Hi
011	Register Address Lo	01	Register Address Lo
00	Force Data Hi	00	Preset Data Hi
2A2	Force Data Lo	2A	Preset Data Lo
4207	Error Check (CRC)	4207	Error Check (CRC)

Note 1: 001h equals Register Address 40002 (field unit register 2, argument register).

Note 2: 002Ah equals 42.

Second Command
Query B30600001A009978

Response B30600001A009978

Second Command Message Breakdown

Query		Response	
B3	Slave (Field Unit) Address	B3	Slave (Field Unit) Address
06	Function	06	Function
00	Register Address Hi	00	Register Address Hi
00[1]	Register Address Lo	00	Register Address Lo
1A	Force Data Hi	1A	Preset Data Hi
00[2]	Force Data Lo	00	Preset Data Lo
9978	Error Check (CRC)	9978	Error Check (CRC)

Note 1: 0000h equals Register Address 40001 (field unit register 1, command register).

Note 2: 1A00h equals 6656.

Example of single register write "move-to" command
This command allows a Host to issue the "move-to" command with a single write utilizing the Modbus function code 06. Register 1 will be used to complete this command.

Rules for utilizing this command:

- Field unit scaling must be configured for 0-100.
- To use the hexadecimal method of determining a single write "move-to" command, 0x4B is always placed into the Hi Byte of Register 1.
- The desired position value is always placed into the Lo Byte of Register 1.

To move the actuator to a position of 50%, place the value 0x4B in the high byte and the value of 0x32 (50 decimal) into the low byte.

Example:
Hex format: 0x4B32

To use the decimal method of determining a single write "move-to" command, add the desired position value to 19200.

Example:
Desired position: 50%

19200 + 50 = 19250

Example of single write "move-to" command
Move an actuator at address 1 to 50% of open by writing the value of 19250 (0x4B32) to the field unit 40001 register. The actuator will then move to a position of 50% open.

Example
Query: 010600004B323EEF

Response: 010600004B323EEF

Message Breakdown

Query		Response	
01	Slave Address	01	Slave Address
06	Function	06	Function
00	Starting Address Hi	00	Starting Address Hi
00	Starting Address Lo	00	Starting Address Lo
4B	Preset Data Hi	4B	Preset Data Hi
32	Preset Data Lo	32	Preset Data Lo
3EEF	Error Check (LRC or CRC)	3EEF	Error Check (LRC or CRC)

3.2.7 Modbus Function Code 08 (Diagnostics)

This function code provides a series of tests for checking the communication system between the Host and field units (slaves), or for checking various error conditions within the field unit. This function code uses a two-byte subfunction code field in the query to define the type of test to be performed. The field unit echoes both the function code and subfunction code in a normal response. It does not affect the field unit in any way. If this exchange is successful, then the communication is successful.

A listing of the supported diagnostic two-byte subfunction codes is given in Table 3.8.

Example
Request a loopback (return query data) from the field unit at network address 3.

Query 030800000000E1E9

Response 030800000000E1E9

Message Breakdown

Query		Response	
03	Slave (Field Unit) Address	03	Slave (Field Unit) Address
08	Function	08	Function
00	Subfunction Hi	00	Subfunction Hi
00	Subfunction Lo	00	Subfunction Lo
00	Data Hi	00	Data Hi
00	Data Lo	00	Data Lo
E1E9	Error Check (CRC)	E1E9	Error Check (CRC)

Table 3.8 – Diagnostic Codes Supported by the DDC-100 Field Unit

Code	Name
00	Return Query Data
01	Restart Communication Option
02	Return Diagnostic Register1
03	Change ASCII Input Delimiter
04	Force Listen-Only Mode
10 (0A Hex)	Clear Counters and Diagnostics Register
11 (0B Hex)	Return Bus Message Count
12 (0C Hex)	Return Bus Communication Error Count
13 (0D Hex)	Return Bus Exception Error Count
14 (0E Hex)	Return Slave Message Count

Note 1: Contains DDC-100 Field Unit diagnostic information. For engineering use only.

3.2.8 Modbus Function Code 15 (Force Multiple Coils)

This function code allows the user to force multiple coils with a single command and uses the same coil assignments as the function code 05.

It should be noted that the coils are operated from the lowest coil number to the highest. Forcing coil 1 or 2 OFF (0) is considered a stop command, sending a 15 command to force two coils starting with coil 1, with coil 1 ON and coil 2 OFF, would result in the unit stopping, since coil 2 is forced OFF after coil 1 is forced ON.

To prevent inadvertent Stop commands from being issued, it is recommended to force one coil at a time.

Available digital outputs for DDC-100 Field Units are listed in Table 3.6. Force multiple coil commands should be issued only once for the desired field unit control. Repeated issuance of an acknowledged command will degrade network performance.

NOTE: This function code is implemented in UEC-3-DDC Modbus Firmware 2.00 and greater and MX-DDC Firmware 02/01.00 and greater

Example of force coil command
Force coil 1 of field unit 1 ON. This will CLOSE the valve controlled by field unit 1.

Query: 010F000000010101EF57

Response: 010F00000001940B

Message Breakdown

Query		Response	
01	Slave Address	01	Slave Address
0F	Function	0F	Function
00	Coil Address Hi	00	Coil Address Hi
00	Coil Address Lo	00	Coil Address Lo
00	Quantity of Coils Hi	00	Quantity of Coils Hi
01	Quantity of Coils Lo	01	Quantity of Coils Lo
01	Byte Count	940B	Error Check (LRC or CRC)
01	Force Data Lo		
EF57	Error Check (LRC or CRC)		

Note: 000000010101h equals Coil Address 00000001 (field unit coil 1)
000100010101h equals Coil Address 00000010 (field unit coil 2)

3.2.9 Modbus Function Code 16 (Preset Multiple Registers)

This function code is used to preset single or multiple registers in the field unit and uses the same predetermined register values as the function code 06. This function code is typically used to command the DDC-100 Field Unit by writing values to the 40001 and/or 40002 registers.

Modbus function code 16 command values for controlling the DDC-100 Field Unit are given in Table 3.7. Each command should be issued only one time for the desired field unit control. Repeated issuance of an acknowledged command will degrade network performance.

The normal response returns the slave address, function code, starting address, and quantity of registers preset.

NOTE: This function code is implemented in UEC-3-DDC Modbus Firmware 2.00 and greater and MX-DDC Firmware 02/01.00 and greater.

Example of Field Unit Command
Write the command to open an actuator (actuator open) to field unit number 1. This corresponds to writing the value 256 into field unit register 40001.

Query: 011000000001020100A7C0

Response: 01100000000101C9

Message Breakdown

Query		Response	
01	Slave Address	01	Slave Address
10	Function	10	Function
00	Starting Address Hi	00	Starting Address Hi
00	Starting Address Lo	00	Starting Address Lo
00	Number of Registers Hi	00	Number of Registers Hi
01	Number of Registers Lo	01	Number of Registers Lo
02	Byte Count	01C9	Error Check (LRC or CRC)
01	Preset Data Hi		
00	Preset Data Lo		
A7C0	Error Check (LRC or CRC)		

Example of "Move-To" Command
Move an actuator at address 1 to 50% of open by presetting registers 40001 with the value 6656, and register 40002 with the value 50 in a single write command. The actuator will receive this message and move to a position of 50% open.

Query: 011000000002041A0000327562

Response: 011000000000241C8

Message Breakdown

Query		Response	
01	Slave Address	01	Slave Address
10	Function	10	Function
00	Starting Address Hi	00	Starting Address Hi
00	Starting Address Lo	00	Starting Address Lo
00	No. of Registers Hi	00	No. of Registers Hi
02	No. of Registers Lo	02	No. of Registers Lo
04	Byte Count	41C8	Error Check (LRC or CRC)
1A	Preset Data Hi		
00	Preset Data Lo		
00	Preset Data Hi		
32	Preset Data Lo		
7562	Error Check (LRC or CRC)		

Note: The single register write "Move-to" command may also be used with the function code 16. This function code may also utilize the Single Register write "move-to" command.

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4 The DDC-100 Network

The Flowserve Limitorque DDC-100 Network is a digital communications network based on non-proprietary hardware and protocols. This network is capable of maintaining up to 250 valve actuators or other devices over a simple shielded, twisted-pair connection. The network consists of a master (Host PLC, Host Computer, Limitorque Master Station, or some other Master-capable device) and a number (up to 250) of field units. The EIA RS-485 standard is used for the physical interface between devices to provide reliable communications over long distances.

Two protocols are supported by Limitorque Field Units—Modbus® and BITBUS®. The protocol must be specified when the units are ordered; however, the protocol may be changed in the field (requires new EPROM). The Modbus protocol was developed by AEG Modicon and the BITBUS protocol was developed by the Intel Corp. Modbus protocol is more widely used, has a simpler implementation, and satisfies most applications that are not extremely time-critical. Therefore, this document addresses only the Modbus protocol. BITBUS protocol information is available upon request.

NOTE: The MX-DDC does not support Bitbus protocol.

The network cable connects the field unit to the Host System. Belden 3074F, 3105A, and 9841 shielded, twisted-pair cable should be used. The use of other cables may result in a reduction of internodal distances or increased error rate. Other individually shielded, twisted-pair cables with electrical properties within 5% of the recommended Belden cables may be used but have not been performance-tested with the DDC-100 Network.

Belden 3074F Specifications

- Total cable length between repeaters or nodes with repeaters: up to 19.2 kbps: 5000' (1.52 km)

For loop mode, this is the total length between operating field units. If a field unit loses power, relays internal to the field unit connect the A1 Channel to the A2 Channel, which effectively doubles the length of the cable (assuming a single field unit fails). If you need to assure operation within specifications in the event of power failure to field units, then this consideration must be added. Example: To assure operation within specification when any two consecutive field units lose power, then the maximum length on cable up to 19.2 kbps: 5000' (1.52 km) per every four field units.

Key Specs
- Resistance/1000 ft = 18 AWG (7x26)
  6.92 ohms each conductor (13.84 ohms for the pair)
- Capacitance/ft = 14 pF (conductor-to-conductor)
- Capacitance/ft = 14 pF (conductor-to-shield)

Belden 3105A Specifications

- Total cable length between repeaters or nodes with repeaters: up to 19.2 kbps: 4500' (1.37 km)

For loop mode, this is the total length between operating field units. If a field unit loses power, relays internal to the field unit connect the A1 Channel to the A2 Channel, which effectively doubles the length of the cable (assuming a single field unit fails). If you need to assure operation within specifications in the event of power failure to field units, then this consideration must be added. Example: To assure operation within specification when any two consecutive field units lose power, then the maximum length on cable up to 19.2 kbps: 4500' (1.37 km) per every four field units.

Key Specs
- Resistance/1000 ft = 22 AWG (7x30)
  14.7 ohms each conductor (29.4 ohms for the pair)
- Capacitance/ft = 11.0 pF (conductor-to-conductor)
- Capacitance/ft = 20.0 pF (conductor-to-shield)

Belden 9841 Specifications

- Total cable length between repeaters or nodes with repeaters: up to 19.2 kbps: 3500' (1 km)

For loop mode, this is the total length between operating field units. If a field unit loses power, relays internal to the field unit connect the A1 Channel to the A2 Channel, which effectively doubles the length of the cable (assuming a single field unit fails). If you need to assure operation within specifications in the event of power failure to field units, then this consideration must be added. Example: To assure operation within specification when any two consecutive field units lose power, then the maximum length on cable up to 19.2 kbps: 3500' (1 km) per every four field units.

Key Specs
- Resistance/1000 ft = 24 AWG (7x32)
  24 ohms each conductor (48 ohms for the pair)
- Capacitance/ft = 12.8 pF (conductor-to-conductor)
- Capacitance/ft = 23 pF (conductor-to-shield)

4.1 Field Unit Network Communication Channels

Before proceeding with discussions of network polling, network error monitoring, and network control, it is necessary to explain some network terminology with respect to field unit communication channels, ports, and hardware features.

All Limitorque DDC-100 Field Units are provided with a dual port network communication channel. This channel is designated Channel A and the ports are designated ports A1 and A2. Both ports are capable of bi-directional serial communications and comply with the EIA RS-485 standard.

In addition, some field units can optionally be ordered or retrofitted with a second dual port network communication channel. This channel is designated Channel B and the ports are designated ports B1 and B2. Channel B is implemented by adding a Granddaughter Board and an additional Network Board to the standard field unit (not available with MX-DDC).

The optional channel, Channel B, is used in network topologies that feature dual redundant communication paths. Please contact Flowserve for further information about dual redundant communication paths with the DDC-100 Network.

4.1.1 Field Unit Network Bypass Relays

Every Limitorque DDC-100 Field Unit is equipped with a set of network bypass relays designed to isolate the individual field unit from the network in the event of a field unit power failure. These normally closed relays are energized on field unit power-up allowing the network data transmissions to enter the field unit repeater circuitry and UART (Universal Asynchronous Receive Transmit circuit). When the field unit power is turned off, these relays close, shorting the signal through the field unit network board so the signal may pass to the next field unit. This isolates the powered-down field unit from the network while allowing the remainder of the network to function normally.

Care must be taken in the design of the DDC-100 network cable routing. This is necessary so maintenance programs or other group power outage conditions do not add more physical cable distance between two functional field units than the RS-485 electrical signal can support.

NOTE: The MX-DDC Field Unit will not energize the network bypass relays until the field unit is fully operational and ready to communicate. UEC-3-DDC Field Units revision 1.57 and greater will “fast start” the UART, preventing network communication disruption during the field unit reboot cycle.

4.1.2 Field Unit Repeater Circuits

Every Limitorque DDC-100 Field Unit communications channel contains a repeater circuit that recenters, reclocks, and amplifies the incoming signal and sends it out the opposite port. The circuit is bi-directional, so it will repeat the received signals from port A1 out A2 or from port A2 out A1. When the optional Granddaughter Board (not available with the MX-DDC) is added, the repeater also recenters, reclocks, and amplifies the incoming signal received from B1 out B2 or from B2 out B1. Although the circuit resends the entire message, there is less than a one-bit time delay before retransmission out the corresponding port.

4.2 Network Topologies

Three network topologies are commonly used and supported by Limitorque—redundant loop, single-ended loop (or half loop), and single-line multi-drop. The recommended cable types for all three topologies are Belden 3074F, Belden 3105A, or Belden 9841. Other individually shielded, twisted-pair cables with electrical properties within 5% of Belden 3074F, Belden 3105A, or Belden 9841 may be used but have not been performance-tested with the DDC-100 Network.

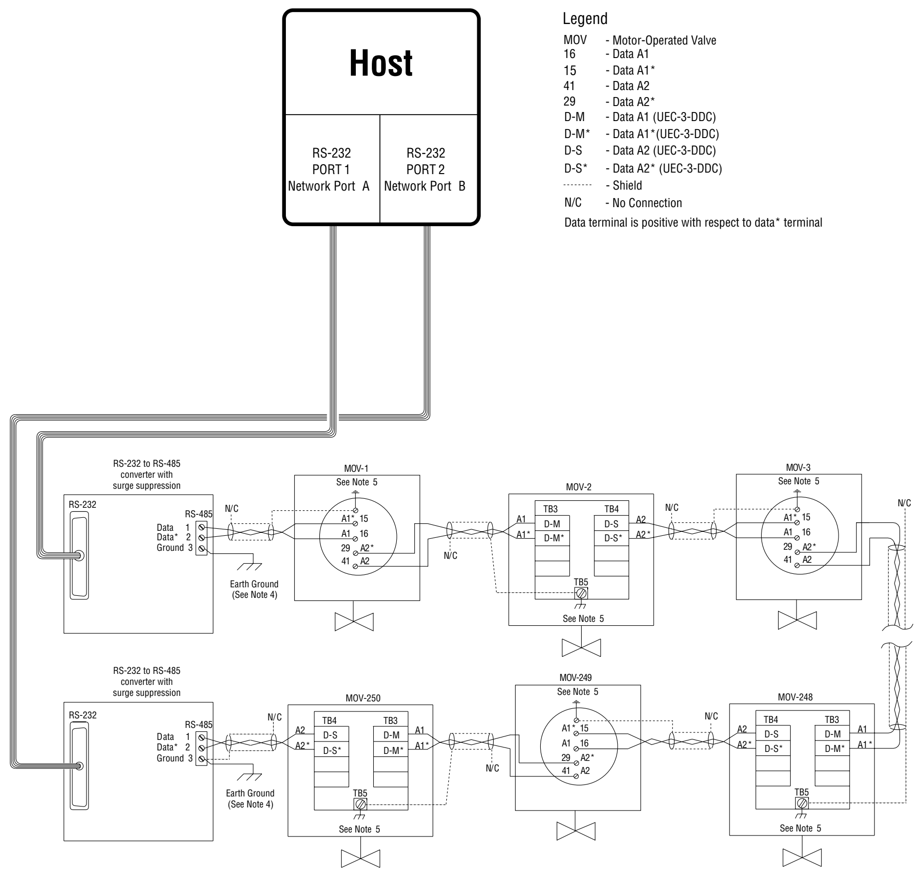
4.2.1 Redundant Loop

The redundant loop topology requires two serial communication ports on the Host device. Because each field unit can be accessed by two ports, redundant access paths are supported. The connections from the serial ports to the field units and between field units are made with shielded, twisted-pair cable in a loop configuration. This topology tolerates a single-line break or short while maintaining communications to all field units. Figure 4.1 shows the redundant loop network topology.

With redundant loop topology, serial data is transmitted from Host port 1 through an RS-232 to RS-485 converter to port A1 of the first field unit. The field unit passes the data that comes in port A1 out through port A2 to the next field unit A1 port. Each subsequent field unit receives data through its A1 port then passes the data out through its A2 port to the next field unit. The looped communication continues in this manner until the last field unit port A2 relays the serial data to port

2 on the Host. The Host is not required to act on the data received at the second port. Note that, because of the bi-directional nature of the serial ports, the direction of data flow can be reversed. Communications can be initiated by port 2 of the Host to port A2 of the first field unit. This data is then transmitted out port A1 to port A2 of the next field unit. The data then continues in this direction until it reaches port 1 of the Host. In either direction, the signal is regenerated in each field unit to permit longer-distance communications with reduced noise sensitivity and improved reliability.

Figure 4.1 – DDC-100 Redundant Loop Network



Notes:

1) Belden 3074F, 3105A, or 9841 shielded cable is recommended.
2) Correct polarity for field unit and network controller connection is necessary for proper operation.
3) Connections shown are typical. The number of MOVs shown may not indicate true system size.
4) Earth ground: ground rod
5) Earth ground: ground rod or lug in actuator if actuator is grounded.

Diagnostic Note:

Polarity and level of the network's data connection can be checked by measuring voltage between data and data* terminals. This voltage should be greater than +200 mVDC with network controller network ports disconnected.

Earth Ground Note:

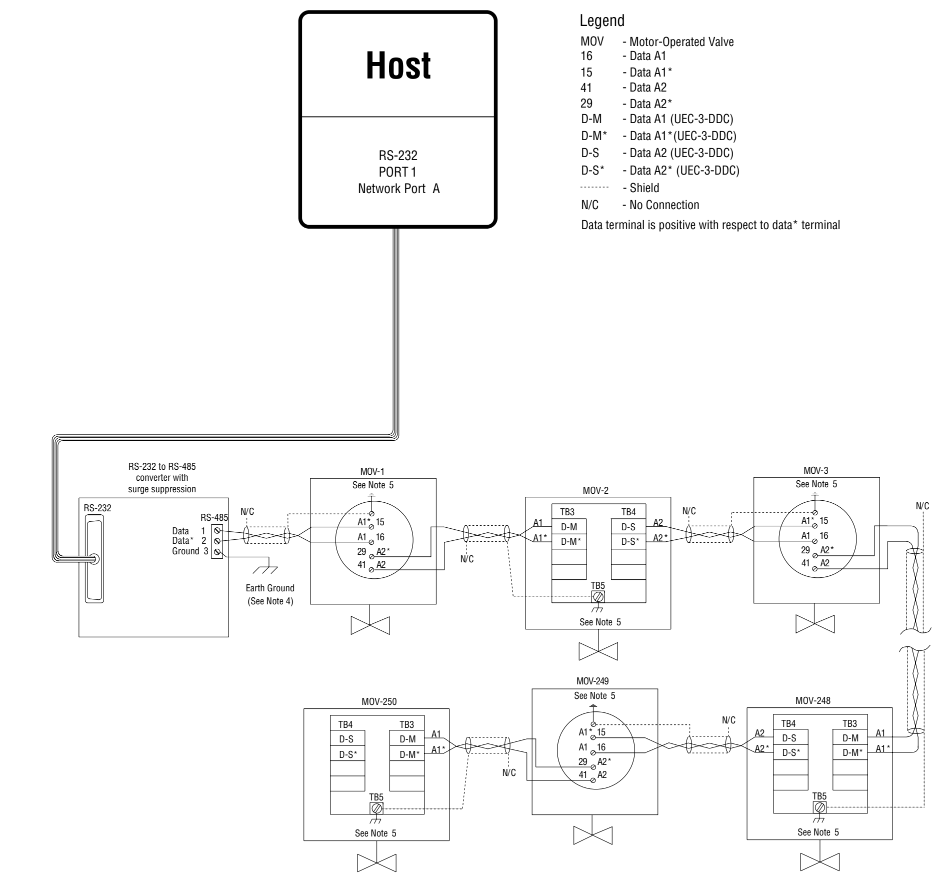
If low impedance earth ground is not available at each actuator, contact engineering for alternative earth ground surge protection strategies.

4.2.2 Single-Ended Loop

The single-ended loop topology is the loop topology described above except that only one end of the loop is connected to the Host as shown in Figure 4.2. The single-ended loop is wired by cabling from the Host port to the first field unit port A1. Port A2 of this field unit is then connected to port A1 of the next field unit. This continues until the last field unit is connected. (If a stub cable is run from port A2 of the last field unit to a planned field unit location, or the last field unit is disconnected, the end of the cable must be terminated with a 120 ohm resistor to prevent unacceptable signal reflections.) The connection of the single-ended loop is identical to the redundant loop except that in the single-ended loop the connection from the last field unit to port 2 of the Host is omitted.

The single-ended loop topology utilizes the field unit repeater circuitry that maximizes the number of field units and distance inherent with the loop topology. The single-ended loop is inherently less reliable than the redundant loop topology because the Host can only reach the field units from one direction. It is, however, more reliable than the single-line multi-drop because a break or a short will only prevent communication with the field units beyond the break or short.

Figure 4.2 – DDC-100 Single-Ended Loop Network



Notes:

1) Belden 3074F, 3105A, or 9841 shielded cable is recommended.
2) Correct polarity for field unit and network controller connection is necessary for proper operation.
3) Connections shown are typical. The number of MOVs shown may not indicate true system size.
4) Earth ground: ground rod
5) Earth ground: ground rod or lug in actuator if actuator is grounded.

Diagnostic Note:

Polarity and level of the network's data connection can be checked by measuring voltage between data and data* terminals. This voltage should be greater than +200 mVDC with network controller network ports disconnected.

Earth Ground Note:

If low impedance earth ground is not available at each actuator, contact engineering for alternative earth ground surge protection strategies.

4.2.3 Single-Line Multi-drop

The single-line multi-drop topology is shown in Figure 4.3. Single-line multi-drop is wired by cabling from the Host and connecting to the first field unit port A1. The cable to the next field unit is attached to the same terminals on the first field unit and then run to port A1 on the second field unit. This continues until the last field unit is connected.

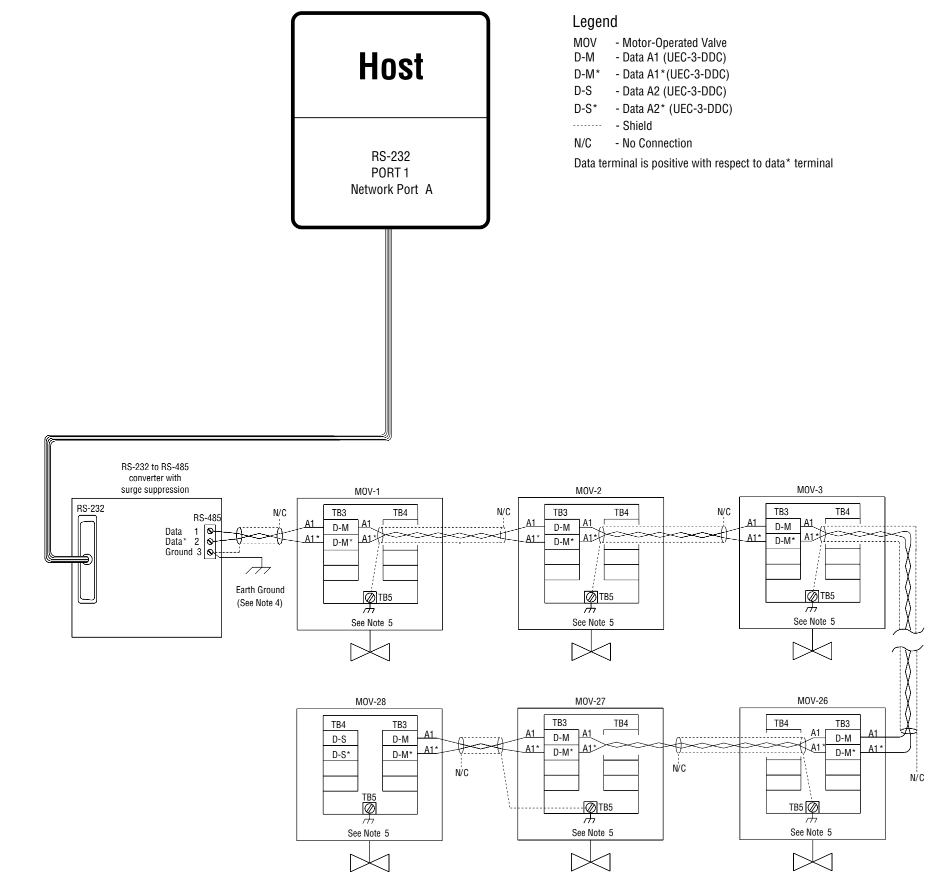
A single-line multi-drop topology can simplify installation (especially when pre-existing wiring is used), but it does not offer the extra reliability of a looped communication path. A line break prevents communication with field units beyond the break, and a line short will cause a loss of communication with all field units.

The maximum number of field units that can be accommodated by the single-line multi-drop network is 28 units and the maximum distance between the Host and the last field unit is 1800 feet (550 m) without the use of repeaters. Note that all Limitorque field units can be wired to act as repeaters by using ports A1 and A2.

Flowserve recommends use of the single-ended loop topology in lieu of single-line, multi-drop for the MX-DDC.

NOTE: The single-line multi-drop topology requires the removal of termination resistors and bias voltage jumpers from all but the last field unit. See the appropriate field unit manual or contact Flowserve for assistance.

Figure 4.3 – DDC-100 Single-Line Multi-Drop Network



Notes:

1) Belden 3074F, 3105A, or 9841 shielded cable is recommended.
2) Correct polarity for field unit and network controller connection is necessary for proper operation.
3) Connections shown are typical. The number of MOVs shown may not indicate true system size.
4) Earth ground: ground rod
5) Earth ground: ground rod or lug in actuator if actuator is grounded.

Diagnostic Note:

Polarity and level of the network's data connection can be checked by measuring voltage between data and data* terminals. This voltage should be greater than +200 mVDC with network controller network ports disconnected.

Earth Ground Note:

If low impedance earth ground is not available at each actuator, contact engineering for alternative earth ground surge protection strategies.

4.3 Network Polling

Network polling is a Host-generated systematic request for information from each field unit on the serial communication network. This systematic process updates the Host Data Table (Poll Table) with each complete network scan. By utilizing this sequential update sequence, the Host can operate more efficiently because the Data Table always contains up-to-date information.

In systems in which there is no up-to-date Data Table, the Host must check the status of a field unit every time it needs to actuate a valve. This check is required to determine if the actuator is capable of movement prior to the issuance of the command to move. The continuous poll process should be enabled at all times to allow peak network performance.

Safeguards are built into the Limitorque field units that operate in the event of a disruption in the polling process. The field unit network watchdog timer will start a field unit reset process if the field unit does not recognize that it has been polled in a specified time interval (default 60 seconds). This field unit reset process is designed to clear any errors in the field unit that may prevent successful communication to a Host device.

Causes of inability to communicate (fail to respond within the watchdog timer interval) can range from faulty network wiring, receipt of garbled or poorly constructed messages, multiple simultaneous Host queries, Host queries faster than field unit responses, or Host shutdown. In a normally functioning actuator network, the field unit reset process will not be activated.

The UEC-3-DDC factory default setting (changeable through field unit Register 112) for the network watchdog timer is 60 seconds. If the field unit is not polled within this time interval, the field unit will reset its UART in an attempt to re-establish communication with the Host. This process of waiting for a poll and UART resets will occur a total of three times. After three cycles, the field unit microprocessor CPU will be reset. The field unit will then remain inactive and wait for network communication without further resetting. If a valid query is received, the network watchdog timer is restarted.

The MX-DDC does not perform a complete field unit reset. After 60 seconds without communication, the MX-DDC Field Unit will set the appropriate bit and indicate a communication loss on Channel A1 (Channel A) or A2 (Channel B) or both.

NOTE: Each field unit reset (UART or CPU) may take 10 to 15 seconds to perform, during which Host communications, queries, and commands are not accepted.

Four other important points concerning network polling

1) The information that is requested from each field unit can be the same for every field unit, or each field unit may be requested to return a unique set of information.

2) When sending commands to the field units, the Host should always wait until a command is acknowledged before sending another command. This will prevent communication collisions on the network.

3) The network can have only one Master device at a time. Simultaneous Masters are not permitted.

4) Host time-out should be greater than 200 ms.

The network scan time for a Modbus Network depends on the number of registers requested from each device and the number of devices attached to the network. Tables 4.1 and 4.2 provide guidelines for calculating average field unit poll times and average network scan times. The Modbus function code 03 was used to obtain this information.

Tables 4.1 and 4.2 do not include Host delay between each poll. Host delays between each poll are variable for each Host. The Host turn-time from receipt of poll to issuance of next poll should be greater than 20 ms and less than 50 ms.

Table 4.1 – Average Field Unit Response Time

Number of	MX-DDC Query Send/	UEC-3-DDC Query Send/
Registers	Receive Time (ms)	Receive Time (ms)
1	40	71
5	50	109
10	62	162

Note 1: Network Protocol - Modbus RTU
Communication Settings - 9600 baud, parity - none, data bits = 8, stop bits = 1
Network Cable - Belden 3074F, 3105A, and 9841

Table 4.2 – Average Network Scan Time (seconds)

Number of Field Units	Scan Time 1 Register per Field Unit		Scan Time 5 Registers per Field Unit		Scan Time 10 Registers per Field Unit	
	MX-DDC	UEC-3-DDC	MX-DDC	UEC-3-DDC	MX-DDC	UEC-3-DDC
10	.40	.94	.50	1.4	.61	1.9
20	.80	1.9	.98	2.8	1.3	3.8
40	1.6	3.9	2.0	5.6	2.5	7.6
50	2.3	5.0	2.9	7	3.8	9.6
100	4.6	11	6	15	6.5	20
200	9.2	24	10	32	13	43
250	11.5	32	12	42	16	56

Note 1: Network Protocol - Modbus RTU
Communication Settings - 9600 baud, parity - none, data bits = 8, stop bits = 1
Network Cable - Belden 3074F, 3105A, and 9841

Example

An MX-DDC Network with 20 field units with 5 registers per field unit being polled will have an average total network scan time of .98 seconds. Host message turn-time per

field unit must be added to this number. (Typical open/close or close/open operating times for motor-operated valves is 30 to 90 seconds.)

4.3.1 Network Communication Errors

In understanding how network communication errors should be handled, a brief discussion defining the difference between field unit communication fault status and Host communication fault status should be helpful. In a typical Limitorque DDC-100 Network, there are two levels of Channel A and Channel B fault.

The first level is the field unit level. In each DDC-100 Field Unit, there are Channel A/B Fault bits located in Register 9, bits 10 and 11 respectively. These bits are set by the field unit as a result of successful communication with the Host over the network.

For UEC-3-DDC and I/O module-based field units, the Channel A bit monitors the standard communication Channel A (ports A1 and A2) for redundant loop communications. The Channel B bit monitors the optional Channel B (ports B1 and B2). Channel B is a second port that is used for dual redundant loop communications.

In a redundant loop network with no faults, the UEC-3-DDC Field Unit will report Channel A with no fault (Reg. 9, bit 10 – contents = 0), but Channel B will indicate a fault condition (Reg. 9, bit 11 – contents = 1). The Channel A fault bit is 0 because the field unit Channel A is active with no faults, while Channel B is 1 because the optional granddaughter board for Channel B is not installed or in use.

For MX-DDC-based field units, the Channel A bit monitors the communication Channel A1 (terminal points 15 and 16) and the Channel B bit monitors communication Channel A2 (terminal points 29 and 41) for redundant loop communications (the MX-DDC does not support dual redundant loop communications).

In a redundant loop network with no faults, the MX-DDC Field Unit will report Channel A with no fault (Reg. 9, bit 10 – contents = 0) and Channel B with no fault (Reg. 9, bit 11 – contents = 0).

This level of communication-error reporting is used for local field unit communication diagnostics. Should a Host not be able to communicate with a field unit, the Host will not be able to retrieve this or any other status information to indicate error conditions.

The second level of monitoring Channel A/B fault occurs at the Host and provides communication information for utilization by the Host. When a Host is configured with two network serial ports, one port is designated as Channel A (Port 1) and the other port is designated as Channel B (Port 2).

During the course of polling, the Host will retrieve the field unit status register that contains the field unit-defined status of Channel A/B fault described above. The Host may overwrite the retrieved field unit Channel A/B faults (field unit Register 9 bits 10 and 11) in the Host's memory to indicate communication status between the Host serial ports (A and B) and each field unit.

Channel A and Channel B fault bits may equal a 1 or 0 depending on the Host's requirement of a 1 or 0 to indicate successful communication. This provides an accurate indication of the communication status from both Host Serial ports to each field unit. Typically, this type of communication-fault recording is consistent with Hosts containing "C"-based programs.

An equally effective method for recording the communication status between the Host's two network serial communication ports and networked field units is to create a separate memory location in the Host for recording Channel A/B fault status. This memory location may be configured so a register, say Register X, bits 0 and 1 are field unit 1 Channel A/B fault status, bits 2 and 3 are field unit 2 Channel A/B fault status and so on.

Another permutation of this method is to configure the Host memory so Register X contains the Channel A fault status for the first 16 field units and Register X+1 contains the Channel B fault statuses for the first 16 field units and so on.

It should be remembered that a Host with only one serial communications port will not have the ability to handle redundant loop network communications. Therefore, communication status will be limited to only one channel.

NOTE: In the Direct-to-Host architecture, Channel A and B faults need to be set by the Host. Setting these faults will allow the system integrator to establish field unit time-out, retry, and field unit communication status.

4.3.2 Network Communication Examples

The following write-ups and examples indicate proven polling techniques. The programmer who adheres to these various examples will find their projects easier to implement.

ALL EXAMPLES SHOWN DEPICT A NETWORK IN WHICH THE HOST IS OVERWRITING THE RETRIEVED FIELD UNIT CHANNEL A/B FAULT BIT (FIELD UNIT REGISTER 9, BITS 10 AND 11). The programmer has the choice of overwriting these communication fault bits or creating a separate communication fault table in the Host's memory as detailed in Section 4.3.1, Network Communication Errors.

In Redundant Loop Mode, the Host provides communication redundancy to each configured field unit on the network. The Host monitors the status of the communication path between port 1 and each configured field unit and between port 2 and each configured field unit. Host port 1 communication status between port 1 and the addressed field unit is recorded in the field unit Channel A Fault bit. Host port 2 communication status between port 2 and the addressed field unit is recorded in the field unit Channel B Fault bit. Both Channel A and Channel B Fault bits are located in the field unit Status Register 9, bits 10 and 11 in the Host memory table.

On a fault-free network where all configured field units are communicating, the Host will first poll all field units via port 1, then poll all field units via port 2, back to port 1, and so on. As each field unit is successfully polled, the respective Channel Fault bit is set to 0 in the Host's field unit Status Register. Remember the Host port 1 equals Channel A and the Host port 2 equals Channel B. (See Example 1 in this section.)

If a field unit cannot be reached on a poll, the Host will set the corresponding Channel Fault bit to 1, switch to the other port and attempt to communicate with the same field unit. If communications with the field unit are not successful from the second port, the corresponding Channel Fault bit will be set to 1, and the Host will resume polling on the original port. Once the Host has completed polling all configured field units on the first port, the polling routine will switch to the other port and repeat the above process.

Example

There are five field units on a network (redundant loop topology) and field unit number 3 has been turned off. The Host is currently polling field units through Host port 1 (Channel A). Field unit numbers 1 and 2 respond to the Host port 1 poll. Field unit number 3 does not respond to the port 1 poll causing the Host to set field unit 3 Channel A Fault bit to 1. The Host now changes to port 2 (Channel B) and polls field unit number 3. Field unit number 3 does not respond to the port 2 poll, causing the Host to set the field unit 3 Channel B Fault bit to 1. Next, the Host changes back to port 1 and attempts to poll field unit number 4. This communication attempt is successful and the Host now polls field unit number 5 through Host port 1. Field unit number 5 responds, completing the port 1 poll.

Next, the Host repeats the process through Host port 2 (Channel B). Field units 1 and 2 respond, field unit 3 does not respond, and the Host sets the field unit 3 Channel B Fault bit to 1. The Host changes to port 1 (Channel A) and attempts to communicate with field unit 3. Field unit 3 does not respond. The Host sets the field unit 3 Channel A Fault bit to 1, switches back to port 2, and resumes polling the remainder of the configured field units. Once field units 4 and 5 have been successfully polled via port 2, the Host then switches to port 1 and repeats the polling process. The intermediate alternating port process described above continues until field unit 3 is powered on and the communication fault clears. (See Example 2 in this section.)

Commands for field unit control should interrupt the polling process and be issued through the current poll port. Once the field unit has acknowledged the command, the Host resumes the polling process. In the event of a communication fault between the current poll port and a commanded field unit, the Host should issue the command through the other communication port.

Redundant Loop Network Truth Table Summarizing the results of Examples 1 through 4: Recorded in Host field unit Status Register Bits 10 and 11

Field unit #	Example 1		Example 2		Example 3		Example 4	
	Ch. A	Ch. B	Ch. A	Ch. B	Ch. A	Ch. B	Ch. A	Ch. B
1	0	0	0	0	0	1	0	1
2	0	0	0	0	0	1	0	1
3	0	0	1	1	0	1	0	1
4	0	0	0	0	1	0	0	1
5	0	0	0	0	1	0	0	1

Example 1: No faults

The Host is successfully communicating with each field unit and sets the bits for Channel A and B Fault to 0. A value of 0 in Channel A and B Fault indicates successful communication.

Example 2: A field unit is off-line

The Host is successfully communicating with field units 1, 2, 4, and 5 via both ports. Field unit number 3 is without power that causes the field unit 3 network board bypass relays to de-energize. This de-energization of the bypass relays shorts the signal through the network board and isolates field unit 3 from the DDC-100 Network.

Example 3: A break or short in the redundant loop

The Host is successfully communicating with field units 1, 2, and 3 via port 1, and field units 4 and 5 via port 2. When a field unit doesn't communicate within a predetermined time-out period, the Host sets the corresponding Channel Fault bit to a value of 1. This example indicates a wiring problem between field units 3 and 4. This problem is typically a cable breakage, short, or improperly terminated wire.

Example 4: Loss of 1 of 2 Host Ports
The Host is attempting to communicate with the field units via both ports but is unable to reach any field units via port 2. This typically indicates a broken cable connection at port 2 or at the first field unit from port 2, broken or shorted cable between the Host and the first field unit from port 2, improperly terminated wires, or loss of power to the RS-232/485 converter if attached to the Host port 2.

Non-Looped Network Truth Table via Port 1 (Channel A) Polling Only Summarizing the results of Examples 5 through 7: Recorded in Host field unit Status Register bit 10. Bit 11 Channel B is always 0 as set by the Host

Field unit #	Example 5		Example 6		Example 7	
	Ch. A	Ch. B	Ch. A	Ch. B	Ch. A	Ch. B
1	0	0	0	0	0	0
2	0	0	1	0	0	0
3	0	0	0	0	1	0
4	0	0	0	0	1	0
5	0	0	0	0	1	0

Example 5: No faults
The Host is successfully communicating with each field unit and sets the bit equating to Channel A Fault to 0. A value of 0 in the Channel A Fault bit indicates successful communication.

Example 6: A field unit is off-line
The Host is successfully communicating with field units 1, 3, 4, and 5. Field unit 2 does not respond, causing the Host to set field unit 2 Channel A Fault to 1. In this example, field unit 2 is without power, causing the field unit 2 network board bypass relays to de-energize. This de-energization of the bypass relays shorts the signal through the network board and isolates the field unit from the DDC-100 Network.

Example 7: A break or short in the network
The Host is successfully communicating with field units 1 and 2 but is not able to communicate with field units 3, 4, and 5, causing the Host to set field unit 3, 4, and 5 Channel A Fault to 1. This typically indicates a broken or shorted cable between field unit 2 and 3, a broken cable connection at field units 2 or 3, improperly terminated wires at field unit 2 or 3, or loss of power to field units 3, 4, and 5.

4.4 Network Control

4.4.1 Ladder Logic Routines

The PLC running a ladder logic program is capable of being an integral part of any valve actuator network. All commands for network polling and valve positioning may be generated by the PLC and sent through a Modbus Master communications port to the valve actuator network. This port is typically located on a PLC component or installed on a PLC-compatible third party Modbus interface module. These modules may contain either one or multiple Modbus ports.

Examples of this type of interface include, but are not limited to A-B PLC-5, A-B SLC-500, Square D PLC, Modicon 984, Modicon Quantum, Compact or Micro PLC, Siemens S5 115U, or Simatic TI-545/555.

4.4.2 Software Control Modules (C++ or Visual Basic Program)

The use of Visual Basic or C++ allows the user to totally customize the individual application to meet application specific requirements. The user can create a functional specification that a system integrator can use to write a unique user-interface for polling and commanding the valve actuator network. All Modbus commands for polling or commanding are implemented in a user-developed software driver.

The advantage of this method of control is that any system integrator familiar with process control, Visual Basic, or C++ can write a unique application. This approach provides the user with flexibility to use the software at many sites without repeatedly purchasing site licenses for Modbus driver software or application packages.

4.4.3 Personal Computer with a Graphical User-Interface

A Graphical User-Interface (GUI) software package can be used to communicate directly with the DDC-100 Network without communicating through a dedicated data concentrator. This control of the network requires a Modbus Driver for the GUI that is compatible with the Modbus function codes supported by a DDC-100 Field Unit. The network communication will follow the polling and command rules established by the individual application.

Most GUI Modbus drivers do not toggle the PC RS-232 serial port RTS/DTR line. The Limitorque Self-Steered RS-232/485 converter will enable communication between the PC and the DDC-100 Network.

Examples of GUIs include, but are not limited to, Wonderware InTouch, PCSoft Wizcon, Intellution FixDMACS, and Genesis Iconics.

NOTE: This category of off-the-shelf, PC-based software also includes numerous Supervisory Control and Data Acquisition (SCADA), Human Machine Interface (HMI), and Hybrid real-time system configuration and development software packages.

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5 Interfacing Hardware for the DDC-100 Network

The Flowserve Limitorque DDC-100 Network uses the RS-485 electrical standard for the network communications medium. Because RS-232 ports are standard on most popular Host devices, Limitorque offers two RS-232 to RS-485 converters. These converters contain circuits that electrically isolate the Host, improve noise immunity, and protect it from high-level voltage surges that may be induced into the network.

RS-485 is used for the network electrical standard because it is capable of communicating data at high rates over relatively long distances, and may be used in redundant loop or multi-drop network topologies.

5.1 RS-232 to RS-485 Converters

Limitorque has sourced two models of the RS-232 to RS-485 converters. The primary distinction between these models is self or auto-steering vs. steered as detailed in this section. The models can be distinguished by the part numbers on the case of the converter. The specifications for both models are given in Table 5.1. The dimensions of the converter enclosures are given in Figure 5.1 and the cable to connect the converter to a 25-pin serial port is shown in Figure 5.2.

Table 5.1 – RS-232/RS-485 Converter Specifications

Parameter	Specification
Baud Rate	600 baud to 62.5 kb
Protocols	Modbus, BITBUS
Connectors	RS-232 - DB9 Male
	RS-485 - Detachable five-contact (Steered Converter P/N 61-825-0966-4)
	RS-485 - Detachable three-contact (Self-Steered Converter P/N 61-825-1032-4)
Indicators	PWR1, PWR2, TxD, RxD, RTS/DTR (Steered Converter P/N 61-825-0966-4)
	RS-232 - Power, TxD, RxD
	RS-485 - Power, TxD, RxD
	(Self-Steered Converter P/N 61-825-1032-4)
Surge Protection	In accordance with IEC-801.5 to 1.5 kV
Power	110 - 220 VAC 50/60 Hz, single-phase
	10 W, Switch Selectable
Fuse	250 VAC, .25 A
Operating Temperature Range	0 to 70°C (32 to 158°F)
Operating Humidity	95% Relative (Non-condensing)

The ordering information for the two converter types is given in Tables 5.2 and 5.3.

Table 5.2 – Steered Converter Assembly (P/N 22300-7591)

Description	Part Number	Quantity
Complete converter w/AC power cord	61-825-0966-4	2
Cable, RS-232, DB25M to DB9F, 6 feet long	ESC-AT-PS/2Cable	2
Three-unit bracket for 19" rack mounting	ES5-K1PT-H03B	1
Blank insert panel for three-unit rack	ES5-19216-001B	1

Note 1: Individual assembly components may be purchased from Flowserve.

Table 5.3 – Self-Steering Converter Assembly (P/N 22300-7601)

Description	Part Number	Quantity
Complete converter w/AC power cord	61-825-1032-4	2
Cable, RS-232, DB25M to DB9F, 6 feet long	ESC-AT-PS/2Cable	2
Three-unit bracket for 19" rack mounting	ES5-K1PT-H03B	1
Blank insert panel for three-unit rack	ES5-19216-001B	1

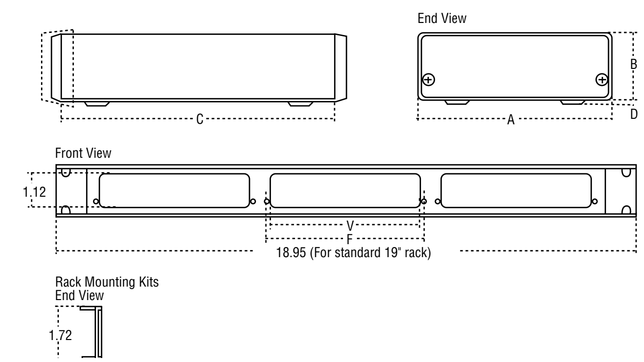
Note 1: Individual assembly components may be purchased from Flowserve.

Converter assemblies 22300-759 and 22300-760 include two DB25M to DB9F modem cables. These cables are appropriate for most Host connections. To determine if these cables are compatible with your Host RS-232 communication port(s), contact your System Integrator.

The System Integrator will review wiring requirements for the Host RS-232 port(s) with the converter-assembly cables. Should the cables not be compatible with the Host RS-232 port, the cables may be altered, a modifying connector installed, or new cables may be purchased at a local cable supplier.

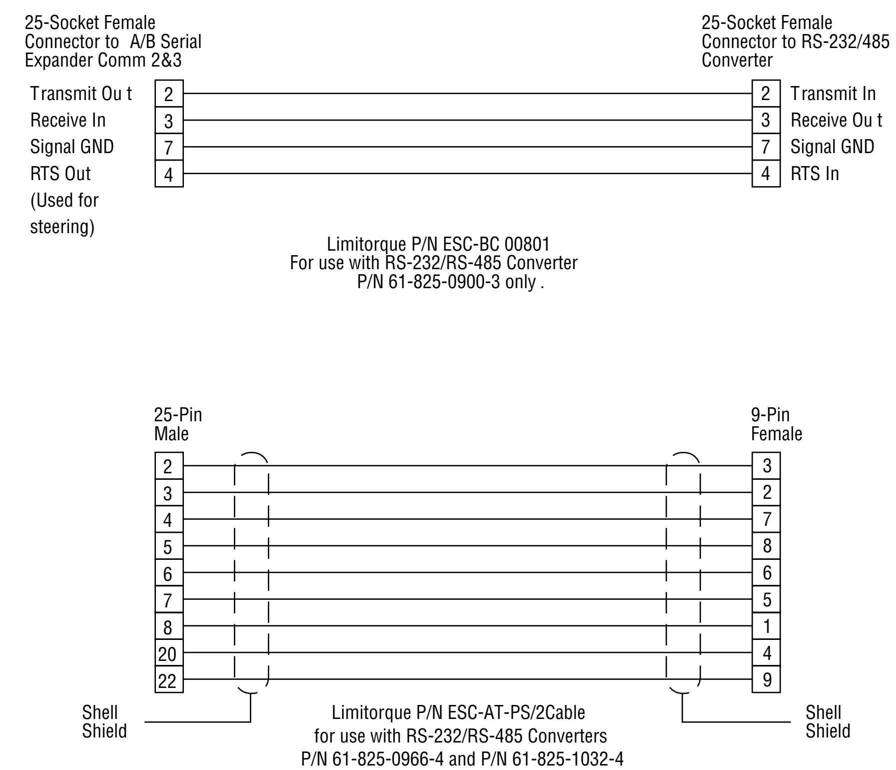
Individual converter part numbers 61-825-0966-4 and 61-825-1032-4 do not include a serial cable for connection to a Host. It is the responsibility of the System Integrator to obtain the correct serial cable based on the Host RS-232 port connector and Limitorque converter RS-232 port connector.

Figure 5.1 – RS-232/RS-485 Converter Dimensions and Rack Mount Kit



	inches	mm
A	5.6	141.5
B	1.5	38.6
C	6.0	152.4
D	0.2	5.3
F	5.2	130.9
V	5.0	128

Figure 5.2 – RS-232/RS-485 Cable Diagram



5.1.1 RS-232/RS-485 Control Line Steered Converter (P/N 61-825-0966-4)

This is the standard converter offered by Flowserve for use with Limitorque networks. This converter provides isolation, surge protection, data rate, and distance capability that is equivalent to the self-steered converter. This converter uses either Host RS-232 port RTS (Request To Send) or DTR (Data Terminal Ready) (DIP switch selectable) signals to steer the RS-485 data direction. This converter also provides a directional steering output for Limitorque's A/B Switch (P/N EEC-90001840).

In the converter, the RS-232 data is converted to TTL signals. The signals drive indicating LEDs and inputs of optical couplers that drive the RS-485 converter circuit. The optical couplers isolate the Host hardware from the RS-485 Network. The RS-485 circuit is bi-directional and must be steered to place it in the transmit or receive mode. This converter requires that the Host serial port driver software must toggle RTS or DTR in order to steer the converter.

There are five LED indicators, one DIP switch, two connectors, and a selector switch to select between 110 and 220 VAC power. The placement of the indicators, switches, and connectors is shown in the photographs of the front and back panels of the converter enclosure in Figure 5.3. All jumpers are located inside the enclosure. The LEDs are labeled with their functions, and the DIP switch, connectors, and jumpers are detailed below:

Figure 5.3 – Front and Back Panels of Steered Converter

Table 5.4 – RS-232/RS-485 Converter (P/N 61-825-0966-4) DIP Switch Functions

Switch	Function	
1	Down	RTS Steering (Default)
	Up	RTS Steering OFF
2	Down	DTR Steering
	Up	DTR Steering OFF (Default)
3	Down	Normal Steering, Transmit when RTS or DTR high (Default)
	Up	Inverted Steering, Transmit when RTS or DTR low
4	Up	(Default)
5	Up	(Default)
6	Up	(Default)
7	Up	(Default)
8	Up	(Default)

Table 5.5 – RS-232/RS-485 Converter (P/N 61-825-0966-4) RS-232 Connector

RS-232 Connector Pin Number	Function
1	Carrier Detect
2	Transmit Data (TxD)[1]
3	Receive Data (RxD)[1]
4	DTR
5	Signal Ground
6	DSR
7	RTS (in)

Note 1: The pin numbers of these signals can be reversed with jumpers inside the converter box (see Table 5.7).

Table 5.6 – RS-232/RS-485 Converter (P/N 61-825-0966-4) RS-485 Connector

RS-485 Connector Pin Number	Function
1	Data
2	Data*[1] ground
3	Earth ground[2]
4	RS-485 RTS steering
5	RS-485 RTS*[1] steering

Note 1: Indicates negative side of signal.

Note 2: Must be connected to earth ground to ensure surge protection.

WARNING: Disconnect the converter from the power source and from the Host and network before removing the cover. Potentially lethal voltages are present inside the enclosure when it is connected to the power source.

Table 5.7 – RS-232/RS-485 Converter (P/N 61-825-0966-4) Jumpers

Jumper[1]	Function
JP1 and JP2	Bias and line termination for RS-485 data lines
	Position 1:2 (ON) adds bias and termination
	Position 2:3 (OFF) removes bias and termination
	Both jumpers must be set to the same position
JP3 and JP4	Bias and line termination for RS-485 steering lines
	Position 1:2 (ON) adds bias and termination
	Position 2:3 (OFF) removes bias and termination
	Both jumpers must be set to the same position
JP5	Reverses RS-232 TxD and RxD lines
	DCE 1:3, 2:4
	DTE 3:5, 4:6 (Default)

Note 1: The jumpers JP1 through JP5 are located inside the converter. The enclosure must be opened for access. The positions for the jumpers are shown in the silkscreen on the PC board.

5.1.2 RS-232/RS-485 Converter with RS-485 Self-Steering (P/N 61-825-1032-4)

This converter provides the same network capabilities as the steered converter, but this converter does not require the RTS or DTR signals from the Host RS-232 port.

There is a patented self-steering circuit in this converter that senses the direction of data, processes the data, and retransmits it via the appropriate output port. The data is processed using a noise elimination circuit ensuring that only valid data is retransmitted. Received data is sent to the self-steering circuit for proper port direction control and signal processing. The data bits are checked, recentered, and reclocked before being directed to the proper output port.

Six LED indicators, two connectors, and a selector switch to select between 110 and 220 VAC power are located on the enclosure. The placement of the indicators, connectors, and the switch is shown in the photographs of the front and back panels in Figure 5.4. All jumpers are located inside the enclosure. The LED indicators are labeled with their functions, and the connectors and jumpers are detailed below:

Figure 5.4 – Front and Back Panels of Self-Steering Converter

Table 5.8 – RS-232/RS-485 Converter (P/N 61-825-1032-4) RS-232 Connector

RS-232 Connector Pin Number	Function
2	Transmit data (TxD)1
3	Receive data (RxD)1
5	Signal ground

Note 1: The pin numbers of these signals can be reversed with jumpers inside the converter box (see Table 5.10).

Table 5.9 – RS-232/RS-485 Converter (P/N 61-825-1032-4) RS-485 Connector

RS-485 Connector Pin Number	Function
1	Data
2	Data*1
3	Earth ground2

Note 1: Indicates negative side of signal.

Note 2: Must be connected to earth ground to assure surge protection.

c **WARNING: Disconnect the converter from the power source and from the Host and network before removing the cover. Potentially lethal voltages are present inside the enclosure when it is connected to the power source.**

Table 5.10 – RS-232/RS-485 Converter (P/N 61-825-1032-4) Jumpers[1]

Jumper	Function	
JP1 and JP2	Bias and termination for RS-485 data lines	
	Position 1:2	Adds bias and termination
	Position 2:3	Disables bias and termination
	Both jumpers must be in the same position	
JP3	BAUD Rate Select	
	Position 0	Not Used
	Position 1	62.5K
	Position 2	38.4K
	Position 3	19.2K
	Position 4	9600
	Position 5	4800
	Position 6	2400
	Position 7	1200
	Position 8	600
	Position 9	N/A
	Position 10	N/A
JP4	Protocol Select	
	Position 1:2	BITBUS
	Position 2:3	Modbus
JP5	Reverses RS-232 TxD and RxD lines	
	DCE 1:2, 3:4	
	DTE 1:3, 2:4	
JP6	XTAL Select.	
	Position 1:2	62.5 Baud
	Position 2:3	Standard Baud
JP7	Asynchronous or HDLC[2]	
	Position 1:2	HDLC
	Position 2:3	Asynchronous
JP8	Filter Ground	
	Position 1:2	Common Ground
	Position 2:3	Isolated Ground

Note 1: The jumpers JP1 through JP8 are located inside the converter. The enclosure must be opened for access. The positions for the jumpers are shown in the silk screen on the PC board.

Note 2: High-Level Data Line Control

5.2 RS-485 Connection Direct to the DDC-100 Field Unit

The RS-232/RS-485 converters that are sourced by Flowserve were specifically designed to comply with the EIA RS-232 and the EIA RS-485 data transmission standards and to protect the DDC-100 Network and the Host device. The successful operation of a large number of installed systems has demonstrated the robustness and reliability of these converters. Flowserve strongly recommends the use of these converters for all DDC-100 applications in which the Host has RS-232 ports available. The use of these converters in most cases will simplify the installation and commissioning of the DDC-100 Network.

If the user wishes to attach a Host device to the DDC-100 Network through other RS-232/RS-485 converters or directly from Host RS-485 ports, the following guidelines must be followed:

1) The Host ports that attach to the DDC-100 Network must adhere to the EIA RS-485 Standard. The DDC-100 Network only uses the DATA, DATA*, and earth ground terminals. The following additional details are provided for interfacing guidance to the Limitorque DDC-100 Network:

    a) The network signal is based on +5 Volts and typical line voltage levels are 0 to 4.5 Volts.

    b) Network biasing for the MX-DDC RS-485 data lines:

        - terminals 15 and 16 (A1) 570 mV
        - terminals 29 and 41 (A2) 280 mV

       Network biasing for the UEC-3-DDC RS-485 data lines:

        - D-M and D-M* (A1) 208 mV
        - D-S and DS* (A2) 208 mV

       Bias voltage is measured without the network attached to the field unit RS-485 communications ports.

    c) DATA is the most positive voltage and DATA* is the least positive voltage level.

    d) When using RS-485 direct (without Limitorque RS-232/RS-485 converter), the user is responsible for ensuring proper surge protection between the network and the Host device.

    e) Each Host port must be resistively terminated with 120 ohms to prevent line reflections.

    f) The DDC-100 Field Units are certified in accordance with IEC 801-5 (EEC-EMC directive 89/336/EEC) to 1.5 kV communication lines.

2) After the Host has finished a transmission that requires a field unit response, the Host transceiver must be turned before the field unit begins transmitting data back to the Host. The field unit can respond in 10 ms.

3) Earth ground should not be routed through sensitive electronic equipment. Connect the network cable shield directly to an effective local, low-impedance earth ground (less than 5 ohms).

6 Programming Recommendations

Programming the Host to control a DDC-100 Network of Flowserve Limitorque Field Units will require information about the design of the network. Flowserve recommends gathering this information before starting the program. After the program has been completed, the network should be fully tested before commissioning. The following recommendations are provided as the result of a number of successful installations:

1) Obtain a wiring diagram of the digital inputs and digital outputs to the controlled devices before programming the controller.

2) Develop a tag table for the installation. This table should include the tag name, network address, desired status indication, and command format (bit or register write).

3) If possible, test the program prior to site installation. This will provide a program verification time for debugging.

4) Attach a protocol analyzer to the DDC-100 Network and monitor the timing, message structure, and message issuance to verify the Host code. This will assist in the diagnosis of proper command issuing and sequencing of the Host control algorithm.

6.1 Monitoring Field Unit Status

Network control involves two basic functions—monitoring field unit status and issuing control commands. The following checklist is provided for monitoring the status of the field units:

1) Determine the Host time-out period. Verify that the time-out period is of sufficient duration to allow a field unit response under the worst-case conditions (greater than 200 ms).

2) Limit the number of retries to a maximum of three. This will enable the Host to continue with the polling process without undue delays.

3) Do not allow more than one Master control of the network at any time. A Host with two serial ports should only have one actively in control at any time.

4) The actuator field unit digital input 0 is factory defaulted for local ESD (Emergency Shutdown). For the MX-DDC or UEC-3-DDC, placing 24 VDC or 120 VAC (MX-DDC only) on this input will cause the field unit to send the actuator to the default local ESD position of close. To use this digital input as a generic input, the local ESD setting must be set to Ignore.

5) Field unit register 10, bit 10 will only report network ESD when the field unit network ESD parameter is set to any value but Ignore.

6) Field unit register 9, bit 5 (Valve Jammed) will only be active when the actuator is moving the valve and the torque switch is tripped.

7) In MOV (Motor-Operated Valve) mode, Field unit registers 9, 10, 11 bits are a value of 0 when false. A value of 1 indicates true.

8) In MOV mode, field unit register 12 low-byte bits are a value of 0 when false. A value of 1 indicates true.

9) In MOV mode, field unit register 12 bit 11 is default inverted, by default, to a value of 1 on false and 0 on true. The remaining bits in the high-byte are set, by default, to a value of 0 on false and 1 on true.

6.2 Issuing Control Commands

The following checklist is provided for issuing control commands:

1) The normal polling process should be interrupted to issue any control commands to a field unit on the network. This interruption should take place after the Host receives the response from a previously issued query. Once the field unit control command has been issued and the acknowledge returned, the normal polling process should resume.

2) Prior to issuing commands to an actuator-mounted field unit:

- Verify successful communication. This is accomplished via the normal polling process.
- Verify actuator is in Remote mode.
- Verify the actuator is capable of movement.

a) Combined Fault bit is not a value of 1.

b) Actuator is not at desired position. (Do not send open command if actuator is in open position.)

c) Verify that the desired direction of travel does not have a torque switch fault.

3) Prior to issuing commands to an I/O Module-style field unit:

- Verify successful communication. This is accomplished via the normal polling process.
- When using 2 relays to control a single device, always disengage the first relay before engaging the second relay.

4) Commands can be issued with either the Modbus function code 05 or 06. Either command is capable of opening or closing the actuator or engaging or disengaging field unit physical relays 1 - 6. If the actuator is configured for intermediate position control, Modbus function code 06 must be used to move the actuator to the desired position.

5) An actuator configured for intermediate position control ("move-to") should be issued position commands between 2 and 98% of open. Issue open or close commands for 0 and 100% of open.

6) Commands issued to the field unit should never be repeated if the command acknowledgment is received from the field unit. Commands should be reissued only when the field unit does not acknowledge receipt of the command. Repeated commands sent to the field unit will result

in increased network traffic that increases network scan times. Also, repeating acknowledged commands can cause erratic field unit operation (e.g., stop).

7) The field unit will automatically stop (disengage contactor) when the actuator reaches the full open or close position. There is no requirement for issuing a Stop command when the actuator reaches the open or close limit switch.

8) A Stop command can be used to stop the actuator in mid-travel. When the actuator has stopped in mid-travel (between the open and close limit switches), the field unit register 9 bit 02 (Stopped) will be true (1).

9) There is no requirement to first issue a Stop command when changing directions from open to close or close to open. When the field unit receives the command to change directions, the field unit will first disengage the contactor (stop the actuator), then engage the other contactor.

10) A network Stop command will stop the actuator if the selector switch is in Remote or Local mode. The actuator local Stop pushbutton will stop the actuator if the selector switch is in Remote or Local mode.

Table 6.1 – Sample Tag Table for Direct-to-Host applications

Tag Name	Description	Modbus Slave Address	Comments	Modbus Register	Modbus Command Data
80-HS-4141A	Open actuator	1	Command to open the valve	40001	256 (Dec)
80-HS-4141B	Close actuator	1	Command to close the valve	40001	768 (Dec)
80-POS-4141	Position feedback	1	Valve position in % of Open	40008	n/a
80-STAT-4141	Status register	1	16 bits of status	40009	n/a
80-HS-4142A	Open actuator	2	Command to open the valve	40001	256 (Dec)
80-HS-4142B	Close actuator	2	Command to close the valve	40001	768 (Dec)
80-POS-4142	Position feedback	2	Valve position in % of Open	40008	n/a
80-STAT-4142	Status register	2	16 bits of status	40009	n/a
80-GO-5253A	Initiate "move-to"	3	Initiate "move-to"	40001	6656 (Dec)
80-GO-5253B	"move-to" value	3	% of Open value	40002	0-100 (Dec)
80-POS-5253	Position feedback	3	Valve position in % of Open	40008	n/a
80-STAT-5253	Status register	3	16 bits of status	40009	n/a

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A Typical DDC-100 Network Installation Assignments

Various project suppliers play important roles in the design, purchase, installation, and commissioning of a plant control system. A typical assignment of roles for the installation of a DDC-100 Network with its valve controllers is presented in this section. This material is presented for guidance only and is not necessarily representative of a particular installation.

Project supplier responsibilities

S.I. (System Integrator) Responsible for developing code to operate the plant per the specification. This includes the interface between the DDC-100 Network and the Host. The System Integrator may be a third-party programmer or a site engineer responsible for computer programming.

Engineer (Project Engineer) Responsible for developing the site layout, specifications, and requirements for the project.

Contractor Responsible for site project development. The contractor is the site coordinator responsible for completing the upgrade or new facility installation per the specification. This may be a third-party (independent) contractor or a site maintenance group.

Flowserve Limitorque Valve actuator manufacturer. Supplier of the valve actuators per the specification.

OEM (Valve Original Equipment Manufacturer) Valve manufacturer responsible for providing valves per specification to contractor or job site. The valve OEM may also provide the Limitorque actuators as a part of its scope of supply.

Fourth-Party Hardware/Software Supplier of hardware and/or software packages needed to complete system integrator’s scope of supply. Equipment typically includes: PLC racks, components, personal computers, Graphical User Interfaces, etc.

System Integrator Tasks

Deliverable	From	To	Comments
Specification	Engineer	S.I	Detail functionality of system
Schedule	Contractor	S.I.	Production Schedule
Manuals	Limitorque	S.I.	Manuals for DDC-100 Operation: • LMAIM4019 Direct-to-Host Programming Guide • LMAIM1329 Accutronix Installation and Operation for MX-DDC Field Unit • LMAIM4029 DDC-100 UEC Field Unit (Modbus) Installation and Operation Manual • LMAIM4030 DDC-100 UEC Field Unit Installation and Commissioning Manual • LMAIM4022 DDC-100 UEC Field Unit Wiring and Startup Guidelines • Modicon Modbus Protocol Reference Guide PI-MODBUS-300 Rev. G (available from Modicon)
Hardware for system development	Contractor	S.I.	Hardware may include: DDC-100 Field Units, RS-232/485 converters
Fourth-Party Hardware/Software	Component supplier	S.I.	Modbus interface modules, Modbus drivers, non-Limitorque converters, or surge suppression
Actuator	Contractor	S.I.	Availability of DDC-100 Field Unit for testing developed application software
Site Preparation	Contractor	S.I.	Complete actuator or field unit installation. Provide actual (as installed) site loop diagram to System Integrator
Operational System	S.I.	Contractor	Software only (code) or Hardware and Software (hardware and code)
Documentation	S.I.	Contractor	System Operation and Maintenance Manuals, Operational characteristics of system, Network Addresses to equipment tag names

Engineer Tasks

Deliverable	From	To	Comments
Specification	End-user	Engineer	Site and system requirements
Schedule	End-user	Engineer	Production Schedule. Completion dates
Sales Support	Limitorque	Engineer	Information on Limitorque products
Manuals	Limitorque	Engineer	Manuals for DDC-100 Operation: • LMAIM4019 Direct-to-Host Programming Guide • LMAIM1329 Accutronix Installation and Operation for MX-DDC Field Unit • LMAIM4029 DDC-100 UEC Field Unit (Modbus) Installation and Operation Manual • LMAIM4030 DDC-100 UEC Field Unit Installation and Commissioning Manual • LMAIM4022 DDC-100 UEC Field Unit Wiring and Startup Guidelines • Modicon Modbus Protocol Reference Guide PI-MODBUS-300 Rev. G (available from Modicon)
Project Specification	Engineer	Contractor, S/I, OEM, Limitorque	Provide operational specifications for all equipment and service providers
Project Responsibility	Engineer	Contractor	Define which supplier is responsible for each portion of project
P&ID	Engineer	Contractor	Detailed layout and instructions for building site. Information should include actuator tag names, required data points from actuator, field unit, and field wiring
Site Electrical and electronics	Engineer	Contractor	Detail site electrical requirements, cable type, layout, and locations. Voltages available for equipment
Loop Drawings	Engineer	Contractor	Detail cable routings from Host to each field device. This defines how the network cable is to run throughout the facility

Contractor Tasks

Deliverable	From	To	Comments
Specifications	Engineer	Contractor	Complete P&IDs for site
Schedule	Engineer	Contractor	Time line complete w/milestones
Project Responsi-bilities	Engineer	Contractor	Define which supplier is responsible for each portion of project
P&ID	Engineer	Contractor	Detailed layout and instructions for building site. Information should include actuator tag names, required data points from actuator, field unit, and field wiring
Site Electrical and electronics	Engineer	Contractor	Detail site electrical requirements, cable type, layout, and locations. Voltages available for equipment
Loop Drawings	Engineer	Contractor	Detail cable routings from Host to each field device. This defines how the network cable is to run throughout the facility
Schedule	Contractor	Limitorque	Provide material delivery dates for hardware. Schedule Flowserve Limitorque Controls Service Technician for actuator commis-sioning (when requested according to purchase order)
Hardware	Limitorque, OEM	Contractor	Provide Motor-Operated Valves, RS-232/485 converters (if supplied), valves, mounting adapters, etc.
Manuals	Limitorque	Contractor	Product Bulletins for Actuators: • LMAIM4019 Direct-to-Host Programming Guide • LMAIM1329 Accutronix Installation and Operation for MX-DDC Field Unit • LMAIM4029 DDC-100 UEC Field Unit (Modbus) Installation and Operation Manual • LMAIM4030 DDC-100 UEC Field Unit Instal-lation and Commissioning Manual • LMAIM4022 DDC-100 UEC Field Unit Wiring and Startup Guidelines • Modicon Modbus Protocol Reference Guide PI-MODBUS-300 Rev. G (available from Modicon)
Operational System	S.I.	Contractor	Develop and test programming for DCS system
Documents	S.I.	Contractor	Documentation of program operational char-acteristics, equipment used, and Operation and Maintenance Manuals for equipment
Schedule	Contractor	S.I.	Provide delivery dates for commissioning control system. Include dates for testing, documentation, and turnover to site personnel
Hardware for system development	Contractor	S.I.	Hardware may include: DDC-100 Field Units, RS-232/485 converters
Actuator	Contractor	S.I.	Availability of DDC-100 Field Unit for testing developed application software
Site Preparation	Contractor	S.I.	Complete actuator or field unit installation. Provide actual (as installed)
Site Preparation	Contractor	Limitorque	Install specified equipment, cables for power and network communication. Verify all network and power cables are properly routed, terminated, and documented prior to commissioning of DDC-100 Network. The contractor should provide detail on network routing from Host system to each field unit. Verify all field units are properly grounded
Field Unit Startup	Limitorque	Contractor	According to purchase order requirements, when scheduled

Limitorque Tasks

Deliverable	From	To	Comments
Specifications	Engineer	Limitorque	Provide specification on Motor-Operated Valves, other DDC-100 Field Units (I/O Modules). Provide P&IDs
Schedule	Contractor	Limitorque	Provide material delivery dates for hardware. Schedule Flowserve Limitorque Controls Service Technician for actuator commis-sioning
Site Preparation	Contractor	Limitorque	Install specified equipment, cables for power, and network communication. Verify all network and power cables are properly routed, terminated, and documented prior to commissioning of DDC-100 Network. The contractor should provide detail on network routing from Host system to each field unit. Verify all field units are properly grounded
Operational	S.I.	Limitorque	Provide unique field unit requirements to Controls Service Technician Requirements prior to start of field unit commissioning process. Include: ESD requirements, open/close service or position control (“move-to”), digital inputs/outputs, analog inputs
Tag List	S.I.	Limitorque	Provide a tag list detailing valve tag name to network address. This will allow the Limitorque Controls Service Technician (when requested according to purchase order) to properly address the actuators to the developed Host software
Sales Support	Limitorque	Engineer	Information on Limitorque products
Manuals	Limitorque	S.I. Engineer Contractor	Product Bulletins for Actuators: • LMAIM4019 Direct-to-Host Programming Guide • LMAIM1329 Accutronix Installation and Operation for MX-DDC Field Unit. • LMAIM4029 DDC-100 UEC Field Unit (Modbus) Installation and Operation Manual • LMAIM4030 DDC-100 UEC Field Unit Instal-lation and Commissioning Manual • LMAIM4022 DDC-100 UEC Field Unit Wiring and Startup Guidelines • Modicon Modbus Protocol Reference Guide PI-MODBUS-300 Rev. G (available from Modicon)
Hardware	Limitorque,	Contractor	Provide Motor-Operated Valves, RS-232/485 converters (if supplied), OEM valves, mounting adapters, etc.
Field Unit Startup	Limitorque	Contractor	According to purchase order requirements, when scheduled

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