

Supplemental Manual for Brooks® L-protocol over RS485 for GF40/GF80 Series Mass Flow Controllers and Meters



*Brooks® GF40/GF80 Series
with RS485 L-protocol Communications*

Brooks® GF40/GF80 L-protocol over RS485

Dear Customer,

We recommend that you read this manual in its entirety as this will enable efficient and proper use of the L-protocol over RS485 thermal mass flow controllers and meters. Should you require any additional information concerning the L-protocol over RS485 thermal mass flow controllers and meters, please feel free to contact your local Brooks Sales and Service Office; see back cover for contact information, or visit us on the web at www.BrooksInstrument.com. We appreciate this opportunity to service your fluid measurement and control requirements, and trust that we will be able to provide you with further assistance in future.

Yours sincerely,
Brooks Instrument

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1.1 Introduction

The L-protocol is a digital communication protocol which provides a reliable, transaction oriented service between a master device, such as a PC, and one or more Brooks® Digital Series Mass Flow Controllers and Meters. The protocol is designed to allow a centralized controller to acquire measurement data from a Mass Flow device and, in case of Mass Flow Controllers, send setpoint values.

The Brooks RS485 on GF40/80 MFCs/MFMs support digital communications as defined by this manual. The physical layer supported is RS485 only.

This document is intended to give a user the means to implement the protocol structure into his own control system in order to establish communication between the control system and the RS485 based GF40/80 Series devices. It does not cover the non-communication functionality of these devices. For this description please refer to Installation and Operation Manual for this specific device.

The remaining sections of this document are summarized below:

- **Section 4 – Quick Start** defines how to properly configure and wire RS485 on GF40/80 Series MFCs/MFMs for digital communications.
- **Section 5 – Message Protocol Structure** describes the L-protocol message.
- **Section 6 – Generation 1 Messages** describes the set of generation 1 commands
- **Section 7 – Generation 2 Messages** describes the set of generation 2 commands
- **Back Cover – Warranty and Contact Information**

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2.1 Definition of Terms

Abbreviation	Description
MFC/MFM	Mass Flow Controller/Meter Device
MSB	Most Significant Bit
LSB	Least Significant Bit

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3 Before Starting

3.1 Background & Assumptions

This manual is a supplement to the Brooks GF40/80 Series installation and operation manual. It is assumed that the owner of this RS485 GF40/80 MFC/MFM is thoroughly familiar with the theory and operation of this device. If not, it is recommended that the owner reads the installation and operation manual first before continuing with this supplement.

3.2 Numbers

Numeric values used throughout this manual will be clearly denoted as to the base numeric system it represents. All hexadecimal numbers (base 16) will be prefixed with a 0x, like 0xA4. All binary numbers (base 2) will be suffixed with a b, like 1001b. All other numbers not annotated this way will be assumed decimal (base 10).

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4 Quick Start

This section assumes the owner of the Digital Series device has a fully operational and trouble-free RS485 communications network with appropriate power supplies.

4.1 Supported Baud Rates

Data communication can be performed at a number of baud rates: 9600, 38.4K and 115.2K baud. The baud rate can be changed using the 'Set Current Baud Rate' or 'Set Default Baud Rate' message. The device is shipped with the baud rate set to 38.4K baud. Good network wiring is important in order to achieve consistent results at a baud rate of 115.2K. Bad termination will cause random, intermittent communication failures.

4.2 Character Coding

L-protocol messages are coded as a series of 8-bit characters or bytes. These are transmitted serially, using a conventional UART (Universal Asynchronous Receiver/ Transmitter). As in normal RS-232 and other asynchronous communication links, a start bit, a parity bit and a stop bit are added to each byte. These allow the receiving UART to identify the start of each character and to detect bit errors due to electrical noise or other interference. An L-protocol character is built up from:

- 8 Data bits
- 1 start bit
- No parity bit
- 1 stop bit
- No handshake

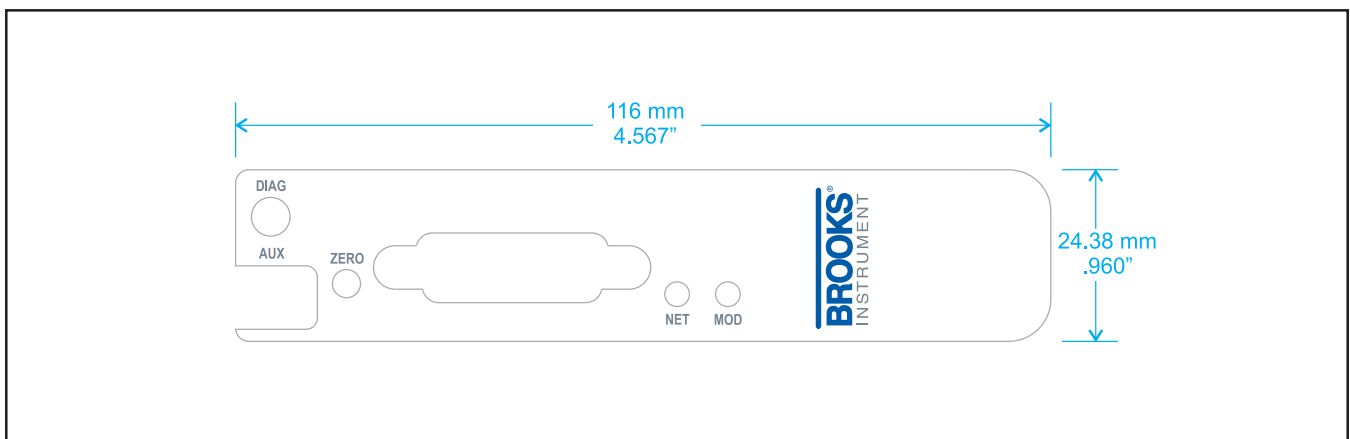


Figure 4-1 RS485 Label on Cover

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4.3 Bus and Device LEDs

The device supports a Bus and Device LED to indicate the status of network communication and the device.

The Bus LED will indicate the following:

Table 4-1 Bus LED Specification

Flash Code	Description
Off	No Network Connected
Solid Green	Communication Established at least once, resets after power cycle (no periodic check)

The Device LED will indicate the following:

Table 4-2 Device Led Specification

Flash Code	Description
Flashing Red/Green	The device is in the Self-Test/initializing mode
Solid Green	All self-tests/initialization have passed. No faults have been detected
Flashing Red	A recoverable fault has been detected. ex.: low/high flow alarm
Solid Red	An unrecoverable fault has occurred. ex.: internal power supply failure

4.4 Device Wiring

4.4.1 Electrical Connections

The RS485 on GF40/GF80 Series device has a 15-pin D-sub connector, for analog I/O, power supply and digital communication signals. See Table 4-3 for the pin-outs. For more detailed information refer to the instruction and operations manual.

4.4.2 Multi Drop

The RS485 communications interface is a multi drop connection making it possible to connect up to 32 devices to a computer on a single multi drop line as shown Figure 4-2. Most Computers are NOT equipped with RS485 ports. In order to connect an RS485 to a computer, one will need an RS485 to RS232 converter. Figure 4-2 shows the interconnection diagram of an RS485 on GF40/GF80 MFC/MFM via an RS485 bus and an RS485 to RS232 converter to the RS232 serial port of a typical computer. The RS485 bus requires two matching resistors of 120Ω, one at the end of the bus and one at the beginning, near the converter. Note the control line from the PC to the converter necessary to control the data direction of the RS485 buffers. The RTS ("Request To Send") line shown in Figure 4-2 because this line is used to control data direction in many of the commercially available converters. The actual line used depends on the converter selected.

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Table 4-3 Pin-outs for D-Sub Connector

Pin No.	Function at Remote Connector
1	Setpoint Signal Ground
2	Flow Voltage Output
3	Alarm Output
4	Flow Current Output
5	Positive Supply Voltage
6	Not Used
7	Setpoint Current Input
8	Setpoint Voltage Input
9	Power Supply Common
10	Flow Signal Ground
11	Not Used
12	Valve Override Input
13	Auxiliary input
14	RXD/A-
15	TXD/A+

Table 4-4 D-Connector Communication Pins

D-Connector Pin Number	RS485
Pin #14	B (inverted driver side)
Pin #15	A (non-inverted driver side)

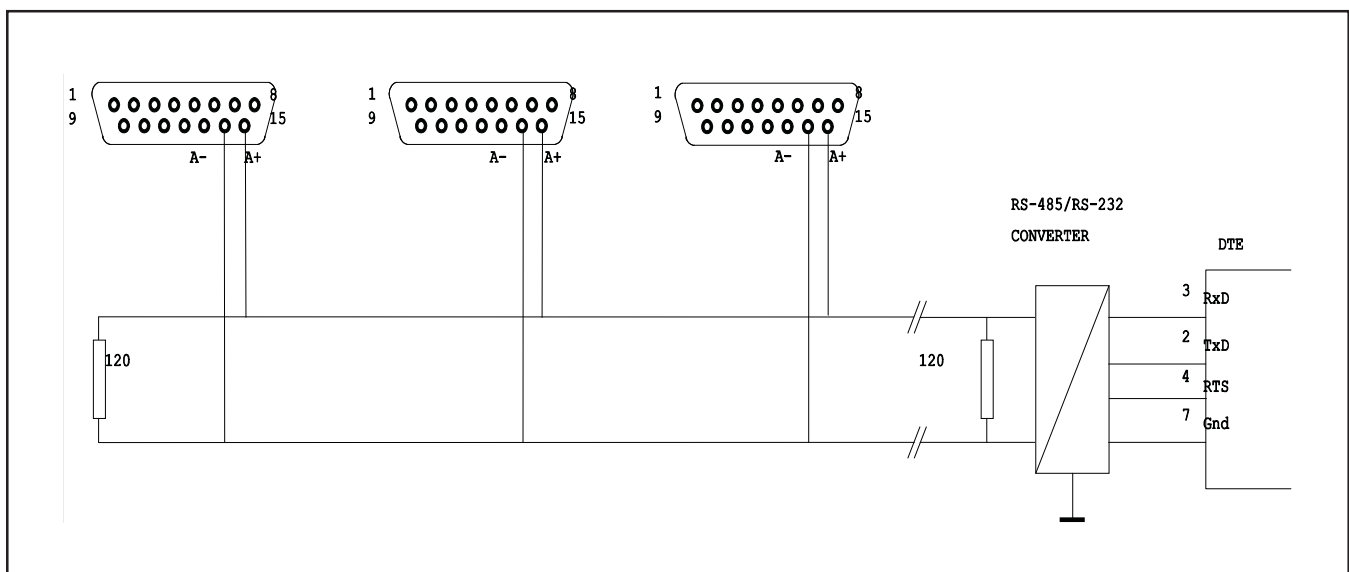


Figure 4-2 RS485 Multi Drop Interconnection MFC/MFM

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5 Message Protocol Structure

5.1 Introduction

The A-protocol is a “master-slave” protocol: each message transaction is originated by the master (central) station, whereas the slave (field) device only replies when it receives a command message addressed to it. The reply from the slave device will acknowledge that the command has been received and it may contain the data requested by the master.

5.2 Message Format

Messages on the bus are sent as packets with a fixed format, illustrated as the following diagram. Each packet begins with the target digital device controller MAC ID (address), an STX character (0x02), a service (command) code (0x80 for read and 0x81 for write), a packet length character, a variable identifier (consisting of Class ID, Instance ID, Attribute ID) and a data count between 0 to x. Each packet ends with a pad byte of 0, and a 1-byte checksum, which is the sum of all of the bytes in the packet, other than the target MAC ID, modulo 256. The checksum calculation discards the carry from the byte summation calculation.

All communication on the bus is done by service requests (from master controller to a specified Device slave controller), each addressed to a specific MAC ID, Class ID, Instance ID and Attribute ID. The RS485 protocol supports only 2 services – Read and Write (Query and Set).

Table 5-1 Fixed Format of the Message Packets

STX (0x02)
Command Code (0x80 for read, 0x81 for write)
Packet Length
Class ID
Instance ID
Attribute ID
Data (0 - x bytes)
Pad (0x00)
Checksum

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6 Generation 1 Messages

6.1 Overview

The following table summarizes the specification of Class ID, Instance ID and Attribute ID for each supported message:

Table 6-1 Summary of Messages and Specifications for Each Supported Message

Message	Class ID	Instance ID	Attribute ID
Query for MAC ID	0x03	0x01	0x01
Set MAC ID (Hardware Dependant)	0x03	0x01	0x01
Query for Current Baud Rate ¹	0x03	0x01	0x65
Set Current Baud Rate ¹	0x03	0x01	0x65
Query for Default Baud Rate ¹	0x03	0x01	0x66
Set Default Baud Rate ¹	0x03	0x01	0x66
Set Calibration Instance	0x66	0x00	0x65
Query for Calibration Instance	0x66	0x00	0x65
Query for Available # of Calibration Instances	0x66	0x00	0xA0
Set Auto Zero Enable/Disable	0x68	0x01	0xA5
Query for Sensor Current Zero	0x68	0x01	0xA9
Query for Sensor Reference Zero	0x68	0x01	0xAA
Set Sensor Reference Zero	0x68	0x01	0xAA
Set Requested Zero Enable	0x68	0x01	0xBA
Query for Requested Zero Status	0x68	0x01	0xBA
Set Digital Mode Selection*	0x69	0x01	0x03
Query for Analog/Digital Control Mode Setting	0x69	0x01	0x03
Query for Default Control Mode	0x69	0x01	0x04
Set Default Control Mode	0x69	0x01	0x04
Set Freeze Follow	0x69	0x01	0x05
Set New Set Point	0x69	0x01	0xA4
Set Ramp Time	0x6A	0x01	0xA4
Query Filtered Set Point	0x6A	0x01	0xA6
Query Indicated Flow/Pressure	0x6A	0x01	0xA9
Query Valve Drive Current	0x6A	0x01	0xB6

*Command supported but has no effect on device behavior – Recognized but not implemented

¹ These commands are optional for Gen 1 implementations.

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6.2 RS485 Device NewSetpoint Conversion

The NewSetpoint request take values in the range of 0x4000 to 0xC000 which represent setpoints between 0% and 100% full scale. The linear relationship between Full Scale setpoints and the NewSetpoint is demonstrated in the following table:

Full Scale % Setpoint	New Setpoint Value (Hex)
0.0	4000
25.0	6000
50.0	8000
75.0	A000
99.0	BEB8
100.0	C000

The "NewSetpoint" value may be calculated from the full scale percent value by:

$$\text{"NewSetpoint"} = (327.68 * \text{full scale \%}) + 16,384$$

or

$$\text{"NewSetpoint"} = ((0xC000 - 0x4000) / 100 * \text{full scale \%}) + 0x4000$$

Note that at the communication level all values are sent in binary format. The decimal and hexadecimal formats shown above are for convenience.

6.3 Messages

The following sections describe in detail the supported messages.

6.3.1 Query for MAC ID

Master controller will use this message to query the existence of a RS485 device controller.

Query message from master controller	Response message to master controller
MAC ID (Targeted Device controller address)	MAC ID (0- master controller)
STX(0x02)	STX(0x02)
Command Code(0x80 for read)	Command Code(0x80 for read)
Packet Length(0x03)	Packet Length(0x04)
Class ID(0x03)	Class ID(0x03)
Instance ID(0x01)	Instance ID(0x01)
Attribute ID(0x01)	Attribute ID(0x01)
Pad(0x00)	MFC MAC ID
Checksum	Pad(0x00)
	Checksum

The value of "MFC MAC ID" returned will be a hex value representing the MFC's MAC ID. If the MAC ID if the MFC is 33 the value returned in this byte should be 0x21.

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6.3.2 Set MAC ID Configuration

RS485 devices can have software configurable MAC ID's by sending the "Set MAC ID" command to the current RS485 device controller address.

Master controller will use this message to set the MAC ID of an RS485 device.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x04)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0x01)
Data(0x21~0x(21+x))
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

6.3.3 Query for Current Baud Rate

Master controller will issue this command to determine the current device BAUD rate.

Query message from master controller	Response message to master controller
MAC ID (Targeted Device controller address)	MAC ID (0-master controller)
STX(0x02)	STX(0x02)
Command Code(0x80 for read)	Command Code(0x80 for read)
Packet Length(0x03)	Packet Length(0x07)
Class ID(0x03)	Class ID(0x03)
Instance ID(0x01)	Instance ID(0x01)
Attribute ID(0x065)	Attribute ID(0x65)
Pad(0x00)	Baud Rate Byte 0 (LSB)
Checksum	Baud Rate Byte 1
	Baud Rate Byte 2
	Baud Rate Byte 3 (MSB)
	Pad(0x00)
	Checksum

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6.3.4 Set Current Baud Rate

Master controller will issue this command to set the current device BAUD rate.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x07)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0x065)
Baud Rate Byte 0 (LSB)
Baud Rate Byte 1
Baud Rate Byte 2
Baud Rate Byte 3 (MSB)
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

(9600 = 0X2580. Byte 0 = 0x80; Byte 1 = 0X25; Byte 2 = 0X0; Byte 3 = 0X0.)
(38400 = 0x9600. Byte 0 = 0X0; Byte 1 = 0x96; Byte 2 = 0X0; Byte 3 = 0x0.)
(115200 = 0X1C200. Byte 0 = 0X0; Byte 1 = 0XC2; Byte 2 = 0X01; Byte 3 = 0X0.)

6.3.5 Query for Default Baud Rate

Master controller will issue this command to determine the default device BAUD rate.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0x066)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x07)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0x66)
Baud Rate Byte 0 (LSB)
Baud Rate Byte 1
Baud Rate Byte 2
Baud Rate Byte 3 (MSB)
Pad(0x00)
Checksum

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6.3.6 Set Default Baud Rate

Master controller will issue this command to set the default device BAUD rate.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x07)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0x066)
Baud Rate Byte 0 (LSB)
Baud Rate Byte 1
Baud Rate Byte 2
Baud Rate Byte 3 (MSB)
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

(9600 = 0X2580. Byte 0 = 0x80; Byte 1 = 0X25; Byte 2 = 0X0; Byte 3 = 0X0.)
(38400 = 0x9600. Byte 0 = 0X0; Byte 1 = 0x96; Byte 2 = 0X0; Byte 3 = 0x0.)
(115200 = 0X1C200. Byte 0 = 0X0; Byte 1 = 0XC2; Byte 2 = 0X01; Byte 3 = 0X0.)

6.3.7 Set Calibration Instance (Process Gas) Selection

Master controller will use this message to select which calibration instance is to be used for flow metering.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x04)
Class ID(0x66)
Instance ID(0x00)
Attribute ID(0x65)
Calibration Instance ID(#)
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

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6.3.8 Query for Calibration Instance (Process Gas) Selection

Master controller will use this message to query the selected calibration instance, which is currently being used for flow metering.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x66)
Instance ID(0x00)
Attribute ID(0x65)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x04)
Class ID(0x66)
Instance ID(0x00)
Attribute ID(0x65)
Calibration Instance ID(#)
Pad(0x00)
Checksum

6.3.9 Query for Available Calibration Instances (Process Gases)

Master controller will use this message to query available number of calibration instances.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x66)
Instance ID(0x00)
Attribute ID(0xA0)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x04)
Class ID(0x66)
Instance ID(0x00)
Attribute ID(0xA0)
Available # Of Calibration Instances
Pad(0x00)
Checksum

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6.3.10 Set Auto Zero Enable/Disable

Master controller will use this message to enable auto zero function.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x04)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xA5)
>0 for enable, = 0 for disable
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

6.3.11 Query for Sensor Current Zero

Master controller will use this message to query the current sensor zero offset.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xA9)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x05)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xA9)
Data Byte #1 (LSB)
Data Byte #2(MSB)
Pad(0x00)
Checksum

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6.3.12 Query for Sensor Reference Zero

Master controller will use this message to query the sensor reference zero offset.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xAA)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x05)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xAA)
Data Byte #1 (LSB)
Data Byte #2(MSB)
Pad(0x00)
Checksum

6.3.13 Set Sensor Reference Zero

Master controller will use this message to set sensor reference zero offset.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x05)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xAA)
Data Byte #1 (LSB)
Data Byte #1 (LSB)
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

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6.3.14 Set Requested Zero Enable

Master controller will use this message to enable requested function.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x04)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xBA)
1 for enable
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

6.3.15 Query for Requested Zero Status

Master controller will use this message to query if the requested zero function has been completed which should take no longer than 120 seconds.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xBA)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x04)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xBA)
0: completed. 1: in progress
Pad(0x00)
Checksum

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6.3.16 Set Digital Mode Selection

Master controller will use this message to set an RS485 device controller to digital or analog mode.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x04)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x03)
Mode(1 - digital, 2 - analog)
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

6.3.17 Query Present Digital/Analog Mode Setting

Master controller will use this message to query the present control mode.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x03)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x04)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x03)
Mode(1 - digital, 2 - analog)
Pad(0x00)
Checksum

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6.3.18 Query for Default Control Mode

Master controller will use this message to query the default control mode.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x04)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x04)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x04)
Mode(1 - digital, 2 - analog)
Pad(0x00)
Checksum

6.3.19 Set Fault Control Mode

Master controller will use this message to set an RS485 device control mode when first powered up.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x04)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x04)
Mode(1 - digital, 2 - analog)
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

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6.3.20 Set Freeze Follow

Master controller will use this message to configure an RS485 controller to act upon a new setpoint when recieved.

Query message from master controller

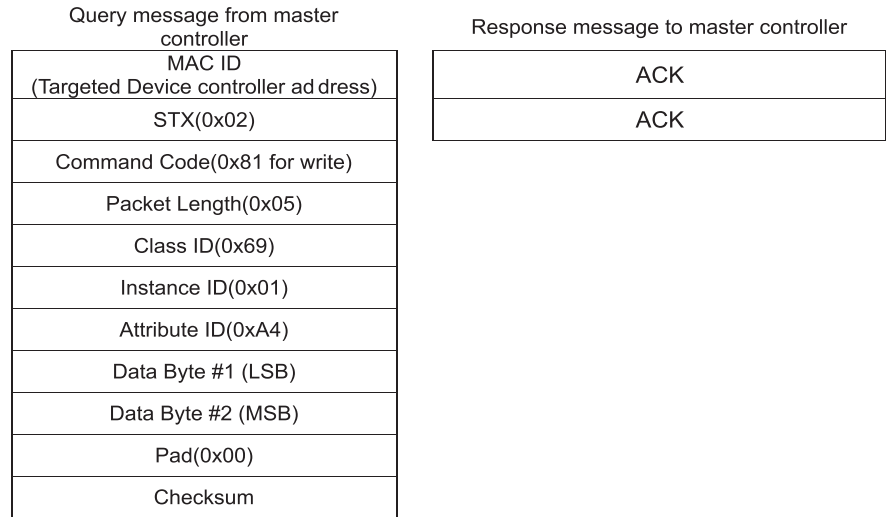
MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x04)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x05)
FreezeFollow (1-Act on new set point immediately)
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

6.3.21 Set New Setpoint

Master controller will use this message to send a new setpoint to an RS485 device controller.



Flow/Pressure Full Scale %	Value (Hex)
0.0	4000
25.0	6000
50.0	8000
75.0	A000
99.0	BEB8
100.0	C000
125.0	E000

The flow calculation method is as defined in "6.2 RS485 Device New Setpoint Conversion".

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6.3.22 Set Ramp Time

Master controller will use this message to send a ramp time to a MFC controller. The ramp time is how long the MFC controller should take to reach the final setpoint for the current setpoint. The unit is millisecond. A zero ramp time effectively disables the ramping.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x05)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA4)
Data Byte #1 (LSB)
Data Byte #2 (MSB)
Pad(0x00)
Checksum

Response message to master controller

ACK
ACK

6.3.23 Query Filtered Setpoint

Master controller will use this message to get the current setpoint from an RS485 controller. This is the current setpoint after ramping has been applied.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA6)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x05)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA6)
Data Byte #1 (LSB)
Data Byte #2(MSB)
Pad(0x00)
Checksum

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6.3.24 Query Indicated Flow/Pressure

Master controller will use this message to get the current flow reading from an RS485 device controller.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA9)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x05)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA9)
Data Byte #1 (LSB)
Data Byte #2(MSB)
Pad(0x00)
Checksum

Flow/Pressure Full Scale %	Value (Hex)
0.0	4000
25.0	6000
50.0	8000
75.0	A000
99.0	BEB8
100.0	C000
125.0	E000

The flow calculation method is as defined in "6.2 RS485 Device New Setpoint Conversion".

6.3.25 Query Valve Drive Current

Master controller will use this message to get the valve drive current.

Query message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xB6)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0-master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x05)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xB6)
Data Byte #1 (LSB)
Data Byte #2(MSB)
Pad(0x00)
Checksum

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7 Generation 2 Messages

7.1 Overview

GENERATION 2: Must support all of Generation 1 commands as defined – plus the following:

Message	Class ID ¹	Instance ID	Attribute ID
Query Who Are You Manufacturer ID	0x03	0x01	0xC5
Query Who Are You Firmware	0x03	0x01	0xC6
Query Who Are You Device Details	0x03	0x01	0xC7
Query Who Are You Serial Number	0x03	0x01	0xC8
Set Freeze Follow Broadcast	0x69	0x01	0x05
Set New Set Point Long	0x69	0x01	0xA6
Query Indicated Flow Long	0x6A	0x01	0xAA
Query Command Retrieval	0x6A	0x01	0xAB

¹ Commands will not be created with the following Class ID values: A0, A1, and A2. These will be considered Restricted Class ID values, for use by MFC suppliers should such suppliers require them for internal purposes

² These commands are supplier specific. All MFCs to whom these commands do not apply should return a reply of NSP.

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7.2 Messages

7.2.1 Query Who Are You Manufacturer ID

Master controller will use this message to retrieve the RS485 device Manufacturer ID.

Message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0xC5)
Pad(0x00)
Checksum

Response message to master controller

MAC ID (0 –master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length (0xyy) Where yy is actual byte count. Max part number byte count is 14.
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0xC5)
Data Byte #1(ASCII) Manufacturer ID Left most character
Data Byte #2(ASCII) Manufacturer ID
Data Byte #3(ASCII) Manufacturer ID
Data Byte #4(ASCII) Manufacturer ID Usually a hyphen “-“
Data Byte #5(ASCII) Manufacturer ID
Data Byte #6(ASCII) Manufacturer ID
Data Byte #7(ASCII) Manufacturer ID
Data Byte #8(ASCII) Manufacturer ID
Data Byte #9(ASCII) Manufacturer ID
Data Byte #10(ASCII) Manufacturer ID
Data Byte #11 (ASCII) Manufacturer ID Usually a hyphen “-“
Data Byte #12(ASCII) Manufacturer ID
Data Byte #13(ASCII) Manufacturer ID
Data Byte #14(ASCII) Manufacturer ID Right most character
Pad(0x00)
Checksum

7.2.2 Query Who Are You Firmware

Master controller will use this message to retrieve the MFC firmware version information.

Message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0xC6)
Pad(0x00)
Checksum

Response message from an RS485 device controller to master controller. Sample shows all 16 characters returned. Fewer is acceptable, as long as byte count reflects the number of characters returned.

MAC ID (0 –master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length (0xyy) Where yy is actual byte count. Max part number byte count is 16. Less is OK.
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0xC6)
Data Byte #1(ASCII) Firmware Version Number (LEFT MOST CHARACTER)
Data Byte #2(ASCII) Firmware Version Number
Data Byte #3(ASCII) Firmware Version Number
Data Byte #4(ASCII) Firmware Version Number
Data Byte #5(ASCII) Firmware Version Number
Data Byte #6(ASCII) Firmware Version Number
Data Byte #7(ASCII) Firmware Version Number
Data Byte #8(ASCII) Firmware Version Number
Data Byte #9(ASCII) Firmware Version Number
Data Byte #10(ASCII) Firmware Version Number
Data Byte #11 (ASCII) Firmware Version Number
Data Byte #12(ASCII) Firmware Version Number
Data Byte #13(ASCII) Firmware Version Number
Data Byte #14(ASCII) Firmware Version Number
Data Byte #15(ASCII) Firmware Version Number
Data Byte #16(ASCII) Firmware Version Number (RIGHT MOST CHARACTER)
Pad(0x00)
Checksum

In the response to the above command, RS485 device controller will return the firmware version of the RS485 device. Packet length will define the number of characters actually returned.

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7.2.3 Query Who Are You Device Details

Master controller will use this message to retrieve the RS485 device controller specific capability information.

Message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0xC7)
Pad(0x00)
Checksum

Response message master controller

MAC ID (0 – master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length (0x13)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0xC7)
Data Byte #1(LSB) Full scale flow size
Data Byte #2 Full scale flow size
Data Byte #3 Full scale flow size
Data Byte #4 (MSB) Full scale flow size
Data Byte #1 (LSB) SEMI gas ID No. for this MFC
Data Byte #2 ()SEMI gas ID No. for this MFC
Data Byte #3 () SEMI gas ID No. for this MFC
Data Byte #4(MSB) SEMI gas ID No. for this MFC
Data Byte #1 (LSB) SEMI calibration gas ID number
Data Byte #2 ()SEMI calibration gas ID number
Data Byte #3 ()SEMI calibration gas ID number
Data Byte #4(MSB) SEMI calibration gas ID number
Data Byte #1 (LSB) SEMI calibration secondary gas ID number
Data Byte #2 ()SEMI calibration secondary gas ID number
Data Byte #3 ()SEMI calibration secondary gas ID number
Data Byte #4(MSB) SEMI calibration secondary gas ID number
Pad(0x00)
Checksum

In response to the above command, Digital MFC Controller will return information regarding the MFC capabilities. Request is for several pieces of information in a specific order:

1. MFC Full Scale size in tenths of a SCCM 4 byte unsigned integer format,
 - To report MFC size in 10th of sccm as an integer. Take MFC size, multiple by 10, and convert to integer format.
 - In tenths of a sccm – a 100 sccm device would be returned as 100*10 to convert this to 10th of sccm in integer format.
 - If the MFC size were 100.5 sccm, the number they would return would be 1005.
 - If the MFC size were 100.55 sccm, the number reported would be 1005 (or 1006 if you round up in your math routine).
2. SEMI Gas ID number for currently selected gas instance in 4 byte unsigned integer,
3. SEMI Gas ID number for Calibration gas used in 4 byte unsigned integer, and
4. GENERIC calibration information and may be used for SEMI Gas ID number for Secondary calibration gas used or algorithm identity or other manufacturer information useful in identifying calibration information.

Field is 4 byte unsigned integer – return zeros if not applicable.

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7.2.4 Query Who Are You Serial Number

Master controller will use this message to retrieve the device serial number information.

Message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0xC8)
Pad(0x00)
Checksum

Response message master controller

MAC ID (0 – master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length (0xyy) Where yy is actual byte count. Max part number byte count is 16. Less is OK.
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0xC8)
Data Byte #1(ASCII) Serial Number (LEFT MOST CHARACTER)
Data Byte #2(ASCII) Serial Number
Data Byte #3(ASCII) Serial Number
Data Byte #4(ASCII) Serial Number
Data Byte #5(ASCII) Serial Number
Data Byte #6(ASCII) Serial Number
Data Byte #7(ASCII) Serial Number
Data Byte #8(ASCII) Serial Number
Data Byte #9(ASCII) Serial Number
Data Byte #10(ASCII) Serial Number
Data Byte #11 (ASCII) Serial Number
Data Byte #12(ASCII) Serial Number
Data Byte #13(ASCII) Serial Number
Data Byte #14(ASCII) Serial Number
Data Byte #15(ASCII) Serial Number
Data Byte #16(ASCII) Serial Number (RIGHT MOST CHARACTER)
Pad(0x00)
Checksum

In response to the above command, the Digital Controller will return the Serial Number of the Device. Packet length will define the number of characters actually returned.

Response message from a digital Device controller to master controller. Sample shows all 16 characters returned. Fewer are acceptable, as long as byte count reflects the number of characters returned.

7.2.5 Set Freeze Follow Broadcast

Single Freeze Follow Broadcast Message form Master Controller.

Message from master controller	Response message master controller
MAC ID Broadcast: (0xFE) All devices Act on this Message Devices do NOT respond	NO RESPONSE SHOULD BE SENT
STX(0x02)	
Command Code(0x80 for read)	
Packet Length(0x03)	
Class ID(0x69)	
Instance ID(0x01)	
Attribute ID(0x05)	
Freeze Follow Byte Value 0 = Freeze current setpoint 1 = Use new setpoint immediately. Set to 1 to Signal: Switch to previously Provided 'Next' Setpoint and Ramp Immediately	
Pad(0x00)	
Checksum	

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7.2.6 Set New Setpoint Long

New Setpoint Long includes Ramp and Freeze Follow.

Message from master controller	Response message master controller
MAC ID (Targeted Device controller address)	ACK
Devices do NOT respond	ACK
STX(0x02)	
Command Code(0x81)	
Packet Length(0x08)	
Class ID(0x69)	
Instance ID(0x01)	
Attribute ID(0xA6)	
Freeze Follow Byte Value 0 = Freeze current setpoint (don't change yet) 1 = Use new setpoint immediately. Typically set to 0, for Freeze Current Setpoint	
Data Byte (LSB) 'Next' Setpoint	
Data Byte #2(MSB) 'Next' Setpoint	
Data Byte #1(LSB) Linear Ramp Time (milliseconds) for 'Next' Setpoint	
Data Byte #2(MSB) Linear Ramp Time (milliseconds) for 'Next' Setpoint	
Pad(0x00)	
Checksum	

Master controller will use this long message to prepare for the next set point. This message will use a single data exchange to pass the Freeze Follow Flag, Ramp time to 'Next' set point and the 'Next' set point to the device. It will expect to receive the same response as it would have received from the standard New Set Point command – an ACK.

If Freeze Follow is set to 1 – use the 'Next' set point and its RAMP indicator immediately. If Freeze follow is set to 0 wait for a broadcast 'immediate' command (See previous Item). NOTE: May be overridden/cancelled by another 'set point' command. Status read commands received will be honored and will not change the settings for this new set point command.

If Ramp is set to zero, no ramp is required. If value is non-zero – always ramp. If a value is provided, this value is in milliseconds and is to be the time used for a linear ramp to next set point. RS485 device is to always set the last value for the set point to the actual set point requested at the end of the ramp. Once it reaches the set point it should stop. It is desired to avoid overshoot. If the time provided exceeds the RS485 device capability – set it to the RS485 device capability.

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This message is intended to be used as an alternate to the now utilized New Set Point, Ramp time, and Original Freeze Follow individual commands and simply combines all of the commands into a single message. It is intended to be issued at the same frequency as the older set commands – potentially every 250 – 500 ms.

All set point values will be percent of full scale and are passed as fractional values in the same format as historically used, with 0x4000 corresponding to 0% of the parameter, and 0xC000 corresponding to 100% of the parameter.

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7.2.7 Query Indicated Flow Long

This request will be used to obtain the current flow reading as well as other RS485 device operating status information.

Message from master controller

MAC ID (Targeted Device controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xAA)
Pad(0x00)
Checksum

Response message master controller

MAC ID (0 –master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length (0x0B)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xAA)
Data Byte #1 (LSB) Indicated Flow Now % full scale 4000 to C000
Data Byte #2 (MSB) Indicated Flow Now % full scale 4000 to C000
Data Byte #1 (LSB) Upstream Transducer Now
Data Byte #2(MSB) Upstream Transducer Now
Data Byte #1 (LSB) Valve Voltage/Current Now
Data Byte #2 (MSB) Valve Voltage/Current Now
Data Byte #1 (LSB) Device Internal Temperature Reading Now
Data Byte #2(MSB) Device Internal Temperature Read ing Now
Pad(0x00)
Checksum

1. Current indicated flow in % of full scale (2 bytes)

0x3333 to 0x4000 = -10% to 0%
0x4000 to 0xC000 = 0% to 100%
0xC000 to 0xE000 = 100% to 125%

2. Reading from the upstream pressure transducer hundredths psi units (2 byte signed integer)

0x0000 to 0x7FFF = 0.00psi to 327.67psi
0x8000 to 0xFFFF = -327.68psi to -0.01psi

3. Valve voltage or Valve current as appropriate for the RS485 device hundredths of a % full scale (2 byte signed integer)

0x0000 to 0x7FFF = 0.00% to 100.00%
0x8000 to 0xFFFF = -100.00% to -0.01%

4. RS485 device internal temperature sensor reading hundredths of degree C (2 byte signed integer)

0x0000 to 0x7FFF = 0.00degC to 327.67degC
0x8000 to 0xFFFF = -327.68degC to -0.01degC

7.2.8 Query Command Retrieval

Master controller will use the following command to retrieve what commands the Digital RS485 device Controller believes it has been given.

Message from master controller	Response message master controller
MAC ID (Targeted Device controller address)	MAC ID (0 –master controller)
STX(0x02)	STX(0x02)
Command Code(0x80 for read)	Command Code(0x80 for read)
Packet Length(0x03)	Packet Length (0x0A)
Class ID(0x6A)	Class ID(0x6A)
Instance ID(0x01)	Instance ID(0x01)
Attribute ID(0xAB)	Attribute ID(0xAB)
Pad(0x00)	Data Byte #1 - Current Freeze Follow Flag setting
Checksum	Data Byte #1 (LSB) Current Target Flow Set Point
	Data Byte #2 (MSB) Current Target Flow Set point
	Data Byte #1 (LSB) Next Set point for Operation
	Data Byte #2 (MSB) Next Set point for Operation
	Data Byte #2 (MSB) Valve Voltage/Current Now
	Data Byte #1 (LSB) Ramp time (Milliseconds) for Next Set point
	Data Byte #2(MSB) Ramp time (Milliseconds) for Next Set point
	Pad(0x00)
	Checksum

Digital RS485 device Controller will return the following message in the order specified:

- 1) Current Freeze Follow Flag (1 byte)
- 2) Current Target Set point in % of Full Scale (not actual flow, not indicated flow, not valve position) (2 bytes 4000 to C000 as is standard)
- 3) Next Set point (2 bytes 4000 to C000 as is standard)
- 4) Ramp time for 'Next Set point' (2 bytes in milliseconds)

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Installation and Operation Manual
X-DPT-RS485-L-GF40-GF80-MFC-eng
Part Number: 541B179AAG
September, 2012

Brooks® GF40/GF80 L-protocol over RS485

Brooks® GF40/GF80 L-protocol over RS485

LIMITED WARRANTY

Seller warrants that the Goods manufactured by Seller will be free from defects in materials or workmanship under normal use and service and that the Software will execute the programming instructions provided by Seller until the expiration of the earlier of twelve (12) months from the date of initial installation or eighteen (18) months from the date of shipment by Seller.

Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer.

All replacements or repairs necessitated by inadequate preventive maintenance, or by normal wear and usage, or by fault of Buyer, or by unsuitable power sources or by attack or deterioration under unsuitable environmental conditions, or by abuse, accident, alteration, misuse, improper installation, modification, repair, storage or handling, or any other cause not the fault of Seller are not covered by this limited warranty, and shall be at Buyer's expense.

Goods repaired and parts replaced during the warranty period shall be in warranty for the remainder of the original warranty period or ninety (90) days, whichever is longer. This limited warranty is the only warranty made by Seller and can be amended only in a writing signed by an authorized representative of Seller.

BROOKS SERVICE AND SUPPORT

Brooks is committed to assuring all of our customers receive the ideal flow solution for their application, along with outstanding service and support to back it up. We operate first class repair facilities located around the world to provide rapid response and support. Each location utilizes primary standard calibration equipment to ensure accuracy and reliability for repairs and recalibration and is certified by our local Weights and Measures Authorities and traceable to the relevant International Standards.

Visit www.BrooksInstrument.com to locate the service location nearest to you.

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Brooks Instrument can provide start-up service prior to operation when required.

For some process applications, where ISO-9001 Quality Certification is important, it is mandatory to verify and/or (re)calibrate the products periodically. In many cases this service can be provided under in-situ conditions, and the results will be traceable to the relevant international quality standards.

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