

RS485 L-Protocol Supplemental Manual

GP200 Series Metal Sealed, Pressure-Based Mass Flow Controllers

BROOKS[®]
INSTRUMENT

Beyond Measure

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Introduction

Purpose

The purpose of this document is to outline the generic RS485 multi-drop communication protocol for the GP200 Series Pressure-Based MFCs.

Scope

This protocol is intended to serve all digital MFCs. Only the following messages are supported:

- Query for MAC – Master controller will use this message to query the existence of a MFC controller.
- Digital mode selection – Master controller will use this message to set a MFC controller to digital mode.
- Freeze Follow – Master controller will use this message to configure a MFC controller to act upon a new set point when received.
- Set Point – Master controller will use this message to send a new set point to a MFC controller.
- Ramp Time – Master controller will use this message to send a ramp time to a MFC controller.
- Filtered Set Point – Master controller will use this message to get the current set point from a MFC controller.
- Indicated Flow - Master controller will use this message to get the current flow reading from a MFC controller.
- Valve Drive Current - Master controller will use this message to get the valve drive current.
- Calibration Instance (Process Gas) Selection - Master controller will use this message to select which calibration instance is to be used for flow metering.
- Query for Calibration Instance (Process Gas) Selected - Master controller will use this message to query the selected calibration instance, which is currently being used for flow metering.

Section 1 - Introduction

- Query for Available Calibration Instances (Process Gases) - Master controller will use this message to query available number of calibration instances.
- Auto Zero Enable/Disable - Master controller will use this message to enable auto zero function.
- Requested Zero Enable - Master controller will use this message to enable requested function.
- Query for Requested Zero Status – Master controller will use this message to query if the requested zero function has been completed.
- Query for Sensor Current Zero - Master controller will use this message to query the current sensor zero offset.
- Query for Sensor Reference Zero - Master controller will use this message to query the sensor reference zero offset.
- Set Sensor Reference Zero - Master controller will use this message to set sensor reference zero offset.
- Query for Inlet Pressure – Master controller will use this message to query the pressure transducer reading.
- Query for Temperature – Master Controller will use this message to query the temperature reading

Background

Topology

The controller acts as a Master device on an RS-485 multi-drop bus. It controls all transactions on the bus.

The digital MFC controller (up to 31) acts as a slave device on an RS-485 multi-drop bus. It continually listens for transaction requests from the Master controller, processes requests addressed to it, and sends replies as needed.

Communication Parameters

- BAUD rate: 9600, 19200, 38400, 57600
 - Data bits: 8 ✧ Start bit: 1 ✧ Stop bit: 1 ✧ Parity: none
 - Byte order: LSB first
 - MAC(Address) assignment:
 - Master controller: 0
 - Digital MFC controller 1-31: 0x21(33) – 0x3F(63)
 - Broadcast packet address: 0xFF(255)
 - Addresses 0x01 to 0x1f are reserved for bus control characters
 - ACK – 0x06
 - NAK – 0x16

Section 2 - Background

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 MFC 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 2. 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. This message structure resembles with the one used by DeviceNet protocol.

MAC ID (Targeted MFC Controller Address)
STX(0x02)
Command Code(0x80 for read, 0x81 for write)
Packet Length
Class ID
Instance ID
Attribute ID
Data(0 - 2 bytes)
Pad(0x00)
Checksum

All communication on the bus is done by service requests (from Master controller to a specified MFC slave controller), each addressed to a specific MAC ID, Class ID, Instance ID and Attribute ID. Currently this protocol supports only 2 services – Read and Write.

All communication on the bus is done by service requests (from Master controller to a specified MFC slave controller), each addressed to a specific MAC ID, Class ID, Instance ID and Attribute ID. Currently this protocol supports only 2 services – Read and Write.

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

Section 2 - Background

Message	Class ID	Instance ID	Attribute ID
Query for MAC ID	0x03	0x01	0x01
Digital Mode Selection	0x69	0x01	0x03
Query for Present Control Mode	0x69	0x01	0x03
Freeze Follow	0x69	0x01	0x05
New Setpoint	0x69	0x01	0xA4
Ramp Time	0x6A	0x01	0xA4
Filtered Setpoint	0x6A	0x01	0xA6
Indicated Flow	0x6A	0x01	0xA9
Valve Drive Current	0x6A	0x01	0xB6
Calibration Instance	0x66	0x00	0x65
Query for Calibration Instance	0x66	0x00	0x65
Query for Available # of Calibration Instances	0x66	0x00	0xA0
Auto Zero Enable/Disable	0x68	0x01	0xA5
Requested Zero Enable	0x68	0x01	0xBA
Query for Requested Zero Status	0x68	0x01	0xBA
Query for Sensor Current Zero	0x68	0x01	0xA9
Query for Sensor Reference Zero	0x68	0x01	0xAA
Set Sensor Reference Zero	0x68	0x01	0xAA
Set Default Control Mode	0x69	0x01	0x03
Query for Default Control Mode	0x69	0x01	0x03
Query for Inlet Pressure	0x31	0x02	0x06
Query for Temperature	0x31	0x03	0x06
Set MAC ID (Hardware Dependent): See Appendix	0x03	0x01	0x01

Section 3 - Message Protocol Details

Message Protocol Details

The following sub-sections describe in detail the supported messages.

Query for MAC ID

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

Query message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0x01)
Pad(0x00)
Checksum(0x8A)

Section 3 - Message Protocol Details

Response message from a digital MFC controller to Master controller

MAC ID (0 – Master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x04)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0x01)
MFC MAC ID
Pad(0x00)
Checksum

Section 3 - Message Protocol Details

Digital Mode Selection

Master controller will use this message to set a MFC controller to digital or analog mode.

MAC ID (Targeted MFC 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

Section 3 - Message Protocol Details

Query Present Control Mode

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

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x03)
Pad(0x00)
Checksum(0xF2)

Section 3 - Message Protocol Details

Response message from a digital MFC controller 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

Section 3 - Message Protocol Details

Freeze Follow

Master controller will use this message to configure a MFC controller to act upon, or ignore, a new set point when received.

MAC ID (Targeted MFC 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-(default)) (0-Ignore change in set point)
Pad(0x00)
Checksum

Section 3 - Message Protocol Details

New Setpoint

Master controller will use this message to send a new set point to a MFC controller.

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x05)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0xA4)
Data Byte#1(LSB)*
Data Byte#2(MSB)*
Pad(0x00)
Checksum

**See New Setpoint conversion Table, pg. 51*

Section 3 - Message Protocol Details

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 set point from the current set point. The unit is millisecond. A zero ramp time effectively disables the ramping.

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC 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

Ramp time (msec)	Ramp Time value (hex)
0	0000
65535	FFFF

Query for Ramp Time Setting

Master controller will use this message to query the ramp time setting

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA4)
Pad(0x00)
Checksum (0x94)

Section 3 - Message Protocol Details

Request message from Master controller to a digital MFC controller

MAC ID (0 - controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x07)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA4)
Data Byte #1(LSB)
Data Byte #2(MSB)
Reserved Byte #1
Reserved Byte #2
Pad(0x00)
Checksum

Section 3 - Message Protocol Details

Filtered Setpoint

Master controller will use this message to get the current set point from a MFC controller. This is the current set point after ramping has been applied.

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA6)
Pad(0x00)
Checksum (0x96)

Section 3 - Message Protocol Details

Response message from a digital MFC controller 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

**See New Setpoint Conversion Table Pg. 51*

Section 3 - Message Protocol Details

Indicated Flow

Master controller will use this message to get the current flow reading from a MFC controller.

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xA9)
Pad(0x00)
Checksum (0x99)

Section 3 - Message Protocol Details

Response message from a digital MFC controller 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

**See New Setpoint Conversion Table Pg. 51*

Section 3 - Message Protocol Details

Valve Drive Current

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

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for re ad)
Packet Length(0x03)
Class ID(0x6A)
Instance ID(0x01)
Attribute ID(0xB6)
Pad(0x00)
Checksum (0xA6)

Section 3 - Message Protocol Details

Response message from a digital MFC controller 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

*

% Valve Drive	Valve Drive value (Hex)
0.0	0000
100.0	FFFF

Section 3 - Message Protocol Details

Calibration Instance (Process Gas) Selection

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

MAC ID (Targeted MFC 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

Section 3 - Message Protocol Details

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.

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x66)
Instance ID(0x00)
Attribute ID(0x65)
Pad(0x00)
Checksum (0x50)

Section 3 - Message Protocol Details

Response message from a digital MFC controller to Master controller

MAC ID (0 – Master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x05)
Class ID(0x66)
Instance ID(0x00)
Attribute ID(0x65)
Calibration Instance ID(#)
Reserved Byte
Pad(0x00)
Checksum

Section 3 - Message Protocol Details

Query for Available Calibration Instances (Process Gases)

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

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x66)
Instance ID(0x00)
Attribute ID(0xA0)
Pad(0x00)
Checksum (0x8B)

Section 3 - Message Protocol Details

Response message from a digital MFC controller 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

Section 3 - Message Protocol Details

Auto Zero Enable/Disable

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

MAC ID (Targeted MFC 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

Section 3 - Message Protocol Details

Requested Zero Enable

Master controller will use this message to enable requested function.

MAC ID (Targeted MFC 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

Section 3 - Message Protocol Details

Query for Requested Zero Status

Master controller will use this message to query if the requested zero function has been completed.

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xBA)
Pad(0x00)
Checksum (0xA8)

Section 3 - Message Protocol Details

Response message from a digital MFC controller 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

Section 3 - Message Protocol Details

Query for Sensor Current Zero

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

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xA9)
Pad(0x00)
Checksum (0x97)

Section 3 - Message Protocol Details

Response message from a digital MFC controller to Master controller

MAC ID (0 – Master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x07)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xA9)
Data Byte #1(LSB)
Data Byte #2(MSB)
Reserved Byte #1
Reserved Byte #2
Pad(0x00)
Checksum

Section 3 - Message Protocol Details

Query for Sensor Reference Zero

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

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x68)
Instance ID(0x01)
Attribute ID(0xAA)
Pad(0x00)
Checksum (0x98)

Section 3 - Message Protocol Details

Response message from a digital MPC controller 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

Section 3 - Message Protocol Details

Set Sensor Reference Zero

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

MAC ID (Targeted MFC 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#2(MSB)
Pad(0x00)
Checksum

Section 3 - Message Protocol Details

Set Default Control Mode

Master controller will use this message to set MFC control mode when first powered up.

MAC ID (Targeted MFC 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

Section 3 - Message Protocol Details

Query Default Control Mode

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

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x69)
Instance ID(0x01)
Attribute ID(0x04)
Pad(0x00)
Checksum (0xF3)

Section 3 - Message Protocol Details

Response message from Digital MFC controller to Master controller

MAC ID (Targeted MFC controller address)
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

Section 3 - Message Protocol Details

Query for Inlet Pressure

Master Controller will use this message to query the current pressure transducer reading.

Request message from Master controller to digital MFC controller

MAC ID (Targeted MFC Controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x31)
Instance ID(0x02)
Attribute ID(0x06)
Pad(0x00)
Checksum (0xBE)

Section 3 - Message Protocol Details

Response message from a digital MFC controller to Master Controller

MAC ID (0 – Master controller))
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x05)
Class ID(0x31)
Instance ID(0x02)
Attribute ID(0x06)
Data Byte #1(LSB)
Data Byte #2(MSB)
Pad(0x00)
Checksum

Actual Pressure Reading (psia)	Output Value (hex)	Output Value (decimal)
0	0000	0
100	6000	24576

The actual pressure reading is calculated from the output value:

$$\text{Actual Pressure Reading} = (\text{Output_Value} / \text{Full_scale_output_value}) * 100$$

Where Full_scale_output_value = 24576 (0x6000)

Section 3 - Message Protocol Details

3.22. Query for Temperature

Master controller will use this message to query the current temperature reading.

Request message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x03)
Class ID(0x31)
Instance ID(0x03)
Attribute ID(0x06)
Pad(0x00)
Checksum(0xBF)

Section 3 - Message Protocol Details

Response message from a digital MFC controller to Master Controller

MAC ID (0 – Master controller)
STX(0x02)
Command Code(0x80 for read)
Packet Length(0x05)
Class ID(0x31)
Instance ID(0x03)
Attribute ID(0x06)
Data Byte #1(LSB)
Data Byte #2(MSB)
Pad(0x00)
Checksum

Actual Temperature Reading (psia)	Output Value (hex)	Output Value (decimal)
0	0000	0
500	6000	24576

The actual temperature reading is calculated from the output value:

$$\text{Actual Temperature Reading (}^{\circ}\text{K)} = (\text{Output_Value}/\text{Full_scale_output_value}) * 500$$

Where Full_scale_output_value = 24576 (0x6000)

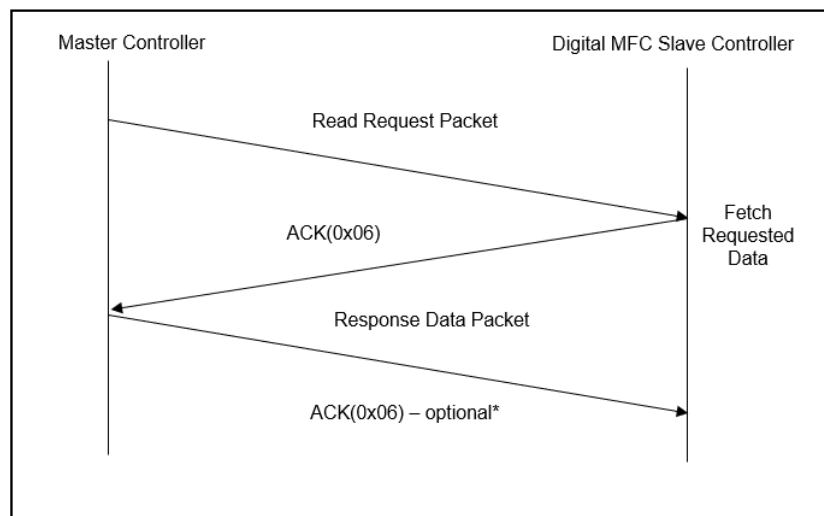
$$\text{Actual Temperature Reading (}^{\circ}\text{C)} = ((\text{Output_value}/\text{Full_scale_output_value}) * 500) - 273.15$$

Section 4 - Software Design Requirement

Software Design Requirement

Normal Transaction Scenarios

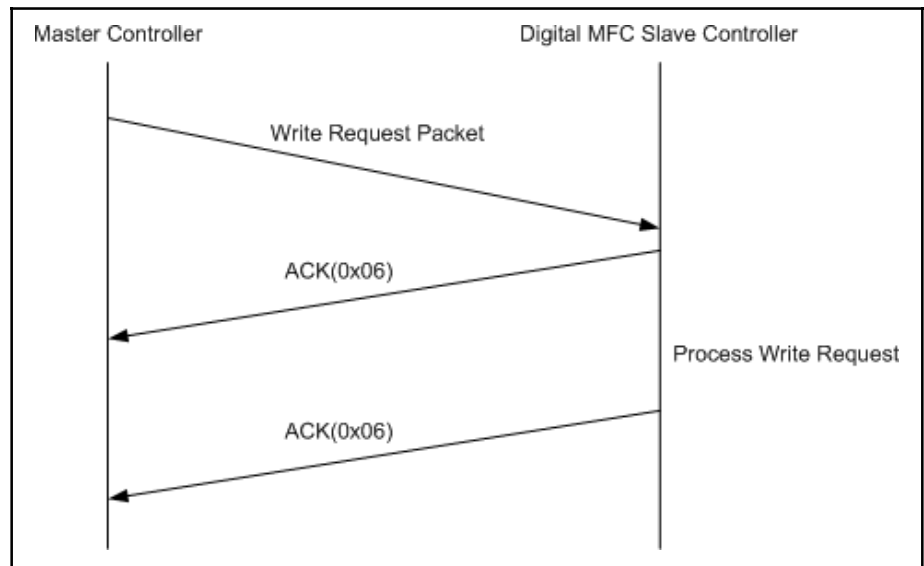
Read Transaction Scenario



* If the slave controller does not receive any response within a reasonable time (18-20 character times) after sending a message, it behaves as though it received an ACK. If the slave controller receives an invalid response, it behaves as though it received an ACK, and assumes that the invalid character is the target address for a new message.

Section 4 - Software Design Requirement

Write Transaction Scenario



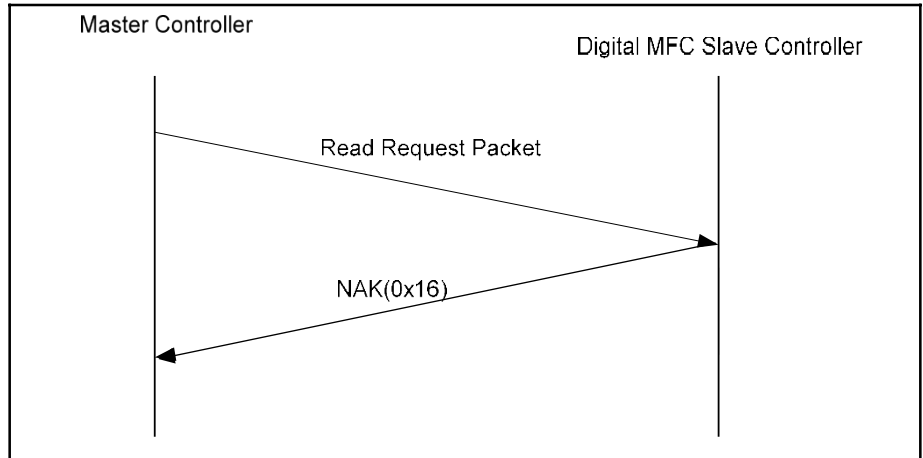
Abnormal Transaction Scenarios

Read Transaction Scenario

There are two different types of abnormal read transaction scenarios: packet error or read error within the MFC controller.

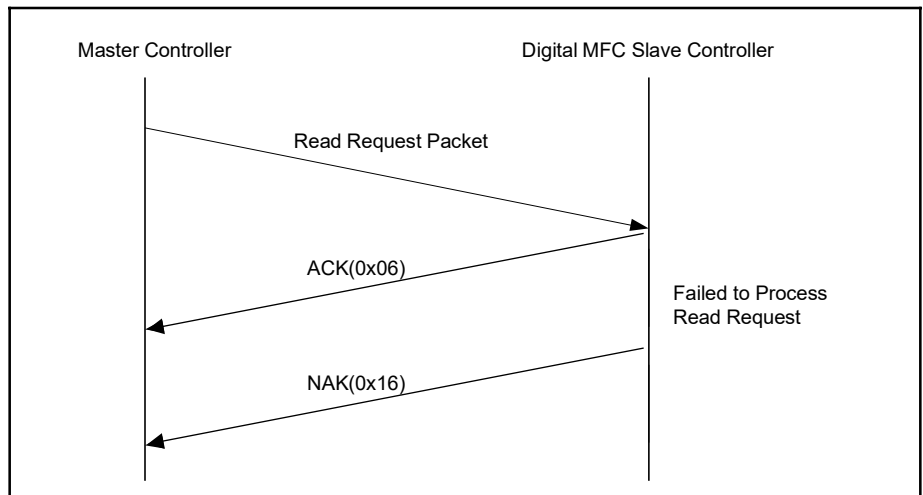
Packet Error

If the Class, Instance, or Attribute ID is invalid in the Read Request Packet, the digital MFC controller responds with a NAK(0x16) character.



Read Error

If any errors occur within the MFC controller after the first ACK is sent (no packet errors), a NAK (0x16) will be sent to indicate an execution error.



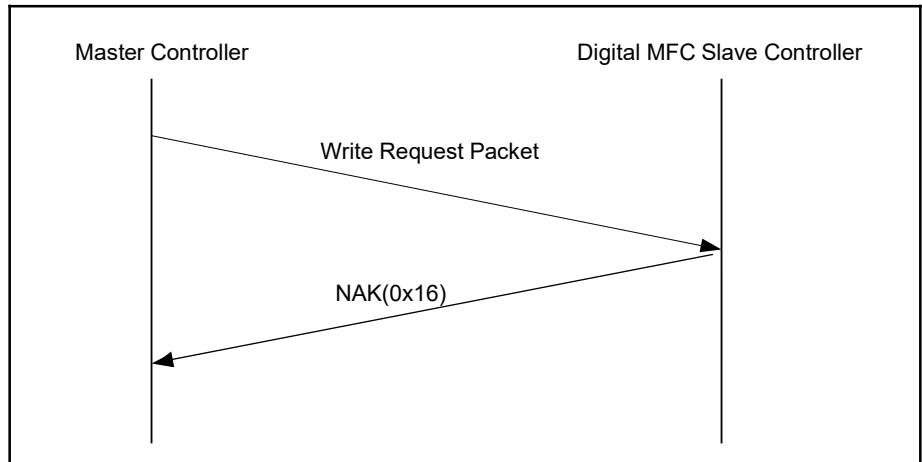
Section 4 - Software Design Requirement

Write Transaction Scenario

There are two different types of abnormal write transaction scenarios: packet error or write error within the MFC controller.

Packet Error

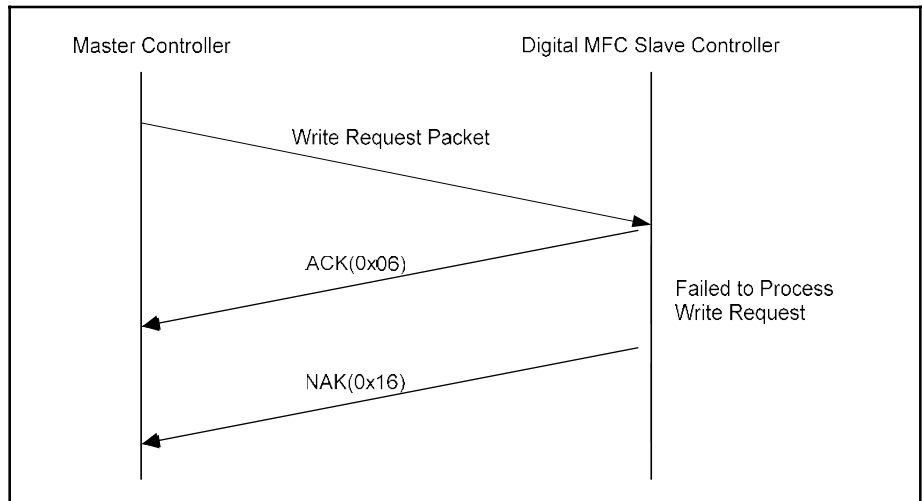
If the Class, Instance, or Attribute ID is invalid in the Write Request Packet, the digital MFC controller responds with a NAK(0x16) character.



Write Error

If any errors occur within the MFC controller after the first ACK is sent (no packet errors), a NAK (0x16) will be sent to indicate an execution error.

Section 4 - Software Design Requirement



Protocol Timing

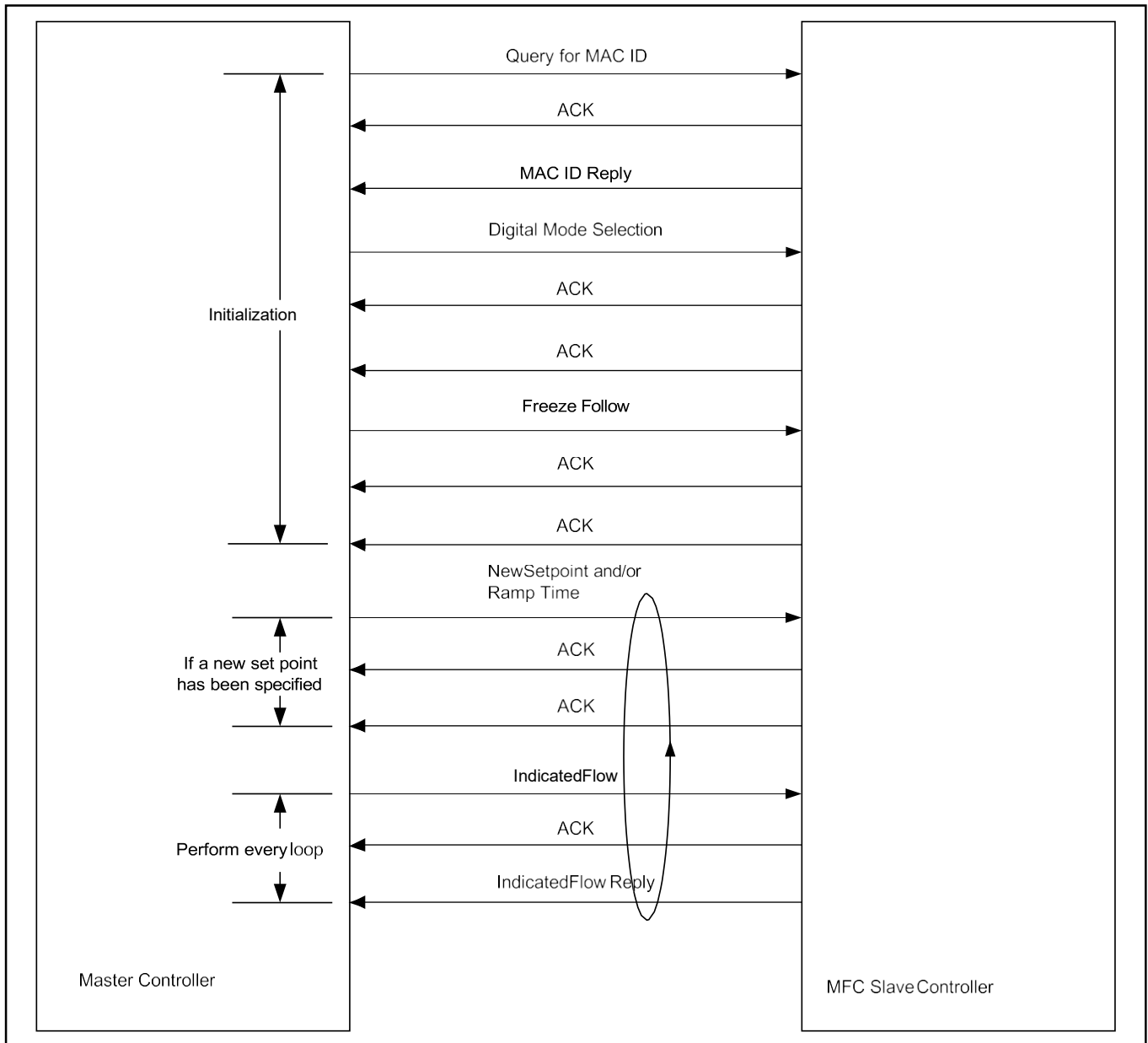
Devices on the RS485 bus distinguish address characters from other packet characters by maintaining an idle timer. This timer is started at the end of each received character and expires if the next character does not arrive within two bytes times (20 bit times). If the timer expires, the device assumes that the message has ended, and the next character received will be either a target address, or a response indicating the acceptance of the previous packet (ACK or NAK). **Thus, it is vital that devices on the bus not insert idle gaps of 1 character time or more within a packet.** A target device can also assume that an error has occurred if a new character is expected and does not arrive within 2 character times of the preceding character's arrival.

Each transaction on the bus begins when the Master controller transmits a request packet on the bus, following an idle gap of at least 1 character time. The specified slave MFC controller replies quickly with an ACK character (0x06) to indicate that it has received the packet correctly. After the request message is processed, the specified controller responds with a reply message or an ACK.

Since the current supported messages are simple and small, the Master controller expects that the entire response to the request message to be completed by the MFC controller within 5 ms. If the Master controller does not receive all response characters (ACK+ACK (2 bytes) for write request, ACK + response packet (11 or 12 bytes)) within 5ms, it assumes that an error has occurred and up to 3 retries are performed automatically.

Section 4 - Software Design Requirement

Message Sequence between Master Controller and a MFC Slave Controller



MFC New Setpoint Conversion

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

Full Scale % set point	NewSetpoint 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.

- Other commands that use this scaling are: Filtered Setpoint, Indicated flow, Sensors Zero, and Sensor Reference Zero

Sensor Zero Filter

The digital MFC controller should provide sensor zero filter to support correction for reasonably stable offsets in the gas flow sensor. The actual flow reading (IndicatedFlow) should be derived by subtracting **SensorCurrentZero** from each sensor measurement. **SensorCurrentZero** can be updated under two conditions, described in the following sub-sections.

Section 4 - Software Design Requirement

Requested Zero

When the requested zero command is issued by Master controller, the digital MFC controller should close the flow meter valve and wait until the sensor output is stabilized (typically 90 seconds). Then the requested zero function can be started and the **SensorCurrentZero** is to be updated through the entire process. At the end of the process, **SensorReferenceZero** is to be set to **SensorCurrentZero**. If Auto Zero function is never enabled, the **SensorCurrentZero** is always equal to **SensorReferenceZero**. For flexibility the **SensorReferenceZero** can also be set by the Master controller.

Due to the long duration to execute the "Enable requested Zero" command, the MFC will not return an ACK when process is completed. Instead, an ACK is sent to acknowledge start of execution. During the process time, the MFC is in an "In Progress" state. While in the "In Progress" state, the MFC will only accept commands from the "Query Requested Zero Status" command, all other request to the MFC can be ignored

Auto Zero

Auto zero process can be started under the following condition:

- Auto Zero Enable has been issued by Master controller
- The digital MFC is in OFF mode

Once the above condition has been true for a specified delay (typically 90 seconds), auto zero process can be started at the specified rate (typically 10 times per second) and the **SensorCurrentZero** is to be updated through the entire process.

During the auto zero calculations, the digital MFC controller can use **SensorReferenceZero** to check against the calculated results. If the difference between **SensorReferenceZero** and the calculated result is beyond a specified limit, exception can be raised within the digital MFC controller.

Section 4 - Software Design Requirement

Calibration Instances

Each calibration instance contains values needed by flow meter to calculate the actual gas flow rate for a particular process gas and flow range from sensor readings. This protocol allows Master controller to query for number of available calibration instances supported by the digital MFC controller and select a calibration instance for digital MFC operation and calculation. The detailed calibration instance internal setup is not supported through this interface and must be programmed through local MFC controller.

Analog / Digital Mode

The default mode for the MFC is set to Analog Mode. MFC's can be switch to Digital Mode with the "Digital Mode Selection" command as soon as communication is established

Appendix - Tool - Device Communication

Appendix: Tool - Device Communication

MFC's can have software configurable MAC ID's by sending the "Set MAC ID" command to the current MFC controller address or the default address (0xFF).

Master controller will use this message to set the MAC ID of a MFC.

Set message from Master controller to a digital MFC controller

MAC ID (Targeted MFC controller address)
STX(0x02)
Command Code(0x81 for write)
Packet Length(0x04)
Class ID(0x03)
Instance ID(0x01)
Attribute ID(0x01)
Data(0x33~0x47)
Pad(0x00)
Checksum

Brooks RS485 L-Protocol MFCs

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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.

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