SENSIRION
THE SENSOR COMPANY

SFC5xxx Mass Flow Controller

DeviceNet Communication Interface Reference

Summary

This document is intended to assist in the commissioning of the Sensirion's SFC5xxx Mass Flow Controller series to a DeviceNet network.

RECENT CHANGES ON THIS DOCUMENT

Date	Version	Author	Why
8. Jan 14	0.1	RFU	Initial Version
20. Feb. 14	1.0	RFU	minor changes, first version for customer
27. Jan. 15	1.1	RFU	swapped Input/Output Assemblies in 4.5.1 Set Produce/Consume Connection Path of Polled I/O Connection
20. Feb. 15	1.2	RFU	Added new attributes in S-Analog Sensor and S-Gas Calibration Object for gas recognition. Added new attribute in S-Single Stage Controller Object to adjust user controller gain.

1 INTRODUCTION

This document is intended to assist in the commissioning of the Sensirion's SFC5xxx Mass Flow Controller series to a DeviceNet network.

DeviceNet is a CAN-based fieldbus that is standardisiert by the ODVA (Open DeviceNet Vendor Association).

For Mass Flow Controllers, a profile is defined by ODVA, which standardizes the DeviceNet functionality. The Mass Flow Controller Profile (0x1A) is also used by the Sensirion SFC5xxx Mass Flow Controller series.

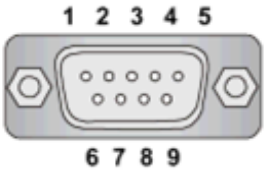
This document contains detailed descriptions for the DeviceNet functionality on the SFC5xxx Mass Flow Controller series. In some examples, the communication process between the Master and the Slave (Mass Flow Controller) is shown. Because of the scope of the DeviceNet and CAN specifications here only the main commands are described in detail.

More Information and the full specification of DeviceNet and the Mass Flow Controller profile can be found at the website of de ODVA organisation: http://www.odva.org/

2 CONNECTOR

The SFC5xxx Mass Flow Controller is connected via a D-Sub 9 connector to the DeviceNet Network, on which also other digital interfaces are available.

SFC5xxx Mass Flow Controller

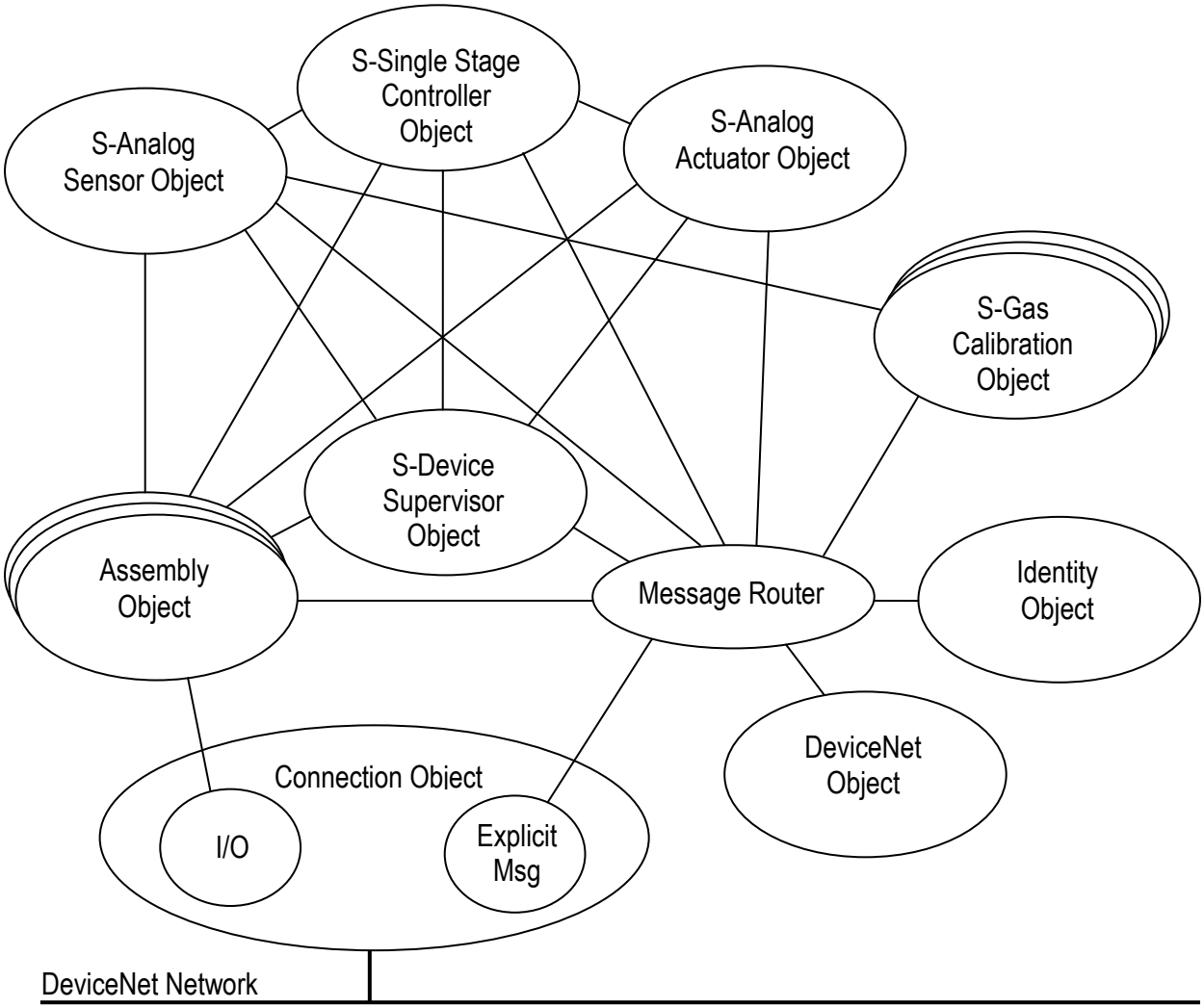


SFC5xxx Connector:
D-Sub 9 (male)

SFC5xxx Connector Pinout			
Pin	**Pin Name**	**Description**	
1	RS485 GND	RS485 GND	(not required for DeviceNet)
2	**Power GND**	Power Ground	
3	**Power V+**	Power +24V (<400 mA)	
4	**CAN_L**	Signal CAN_L, CAN-	
5	**CAN_H**	Signal CAN_H, CAN+	
6	RS485 A	Signal RS485 A, RS485+	(not required for DeviceNet)
7	RS485 B	Signal RS485 B, RS485-	(not required for DeviceNet)
8	C/Q	IO-Link C/Q	(not required for DeviceNet)
9	NC*	Not Connected	(not required for DeviceNet)
-	Case		

3 DeviceNet Object Description

3.1 Object Model for SFC5xxx Mass Flow Controller



The graphics above shows all objects and their relationships to each other, which are implemented in SFC5xxx Mass Flow Controller. These objects will be described in the following sections.

3.2 IDENTITY OBJECT, CLASS CODE 0X01

This object provides identification and general information about the device. There is only a single Instance #1 of the Identity Object.

Identity Object Instance Attributes Class Code: 0x01				
Attribute ID	**R/W**	**Attribute Name**	**Data Type**	**Comment**
0x01	R	Vender ID	UINT	0x053D
0x02	R	Device Type	UINT	0x001A
0x03	R	Product Code	UINT	5400
0x04	R	Revision	STRUCT of:	
		Major Revision	UINT	1
		Minor Revision	UINT	1
0x05	R	Status	WORD	
0x06	R	Serial Number	UDINT	########
0x07	R	Product Name	SHORT_STRING	“SFCxxxx”
0x08	R	State	USINT	
0x0A	R/W	Heartbeat Interval	USINT	The nominal interval between heartbeat messages in seconds.

<table>
<tr><th colspan="4">Identity Object Services
Class Code: 0x01</th></tr>
<tr><th>Service Code</th><th>Service Name</th><th colspan="2">Description of Service</th></tr>
<tr><td>0x05</td><td>Reset</td><td colspan="2">Invokes the Reset service for the device.

Parameter:
<table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Semantics of Values</th></tr>
<tr><td>Type</td><td>USINT</td><td>Type of Reset</td><td>0 = Reset
1 = Load default Values + Reset
2 = Load default Values, expect baud rate and MAC ID + Reset</td></tr>
</table></td></tr>
<tr><td>0x0E</td><td>Get_Attribute_Single</td><td colspan="2">Returns the contents of the specified attribute</td></tr>
<tr><td>0x10</td><td>Set_Attribute_Single</td><td colspan="2">Modifies an attribute value</td></tr>
</table>

3.3 MESSAGE ROUTER 0X02

The Message Router Object provides a messaging connection point through which a Client may address a service to any object class or instance. This Object does not have its own attributes, and also does not provide services.

3.4 DEVICENET OBJECT, CLASS CODE 0X03

The DeviceNet Object is used to provide the configuration and status of a physical attachment to DeviceNet. There is only a single Instance #1 of the DeviceNet Object.

DeviceNet Object Instance Attributes **Class Code: 0x03**				
Attribute ID	**R/W**	**Attribute Name**	**Data Type**	**Comment**
0x01	R/W	MAC ID	USINT	0 … 63
0x02	R/W	Baud Rate	USINT	0 = 125 kbps, 1 = 250 kbps, 2 = 500 kbps
0x03	R/W	Bus-Off Interrupt (BOI)	BOOL	0 = False, 1 = True
0x04	R/W	Bus-Off Counter	USINT	0 … 255
0x05	R	Allocation Information	STRUCT of:	
		Allocation Choice Byte	BYTE	1 = Explicit Message, 2= Polled I/O
		Master's MAC ID	USINT	

DeviceNet Object Services **Class Code: 0x03**		
Service Code	**Service Name**	**Description of Service**
0x0E	Get_Attribute_Single	Returns the contents of the specified attribute
0x10	Set_Attribute_Single	Modifies an attribute value
0x4B	Allocate M/S connection set	Requests the use of the predefined Master/Slave connection set
0x4C	Release M/S connection set	Release Master/Slave connection set

3.5 ASSEMBLY OBJECT, CLASS CODE 0X04

The Assembly Object binds attributes of multiple objects, which allows data to or from each object to be sent or received over a single connection. The terms ”input” and ”output” are defined from the network’s point of view. An input will produce data on the network and an output will consume data from the network.

The Assembly Object has multiple Instances which containing different data. The MFC has implemented four different Input Assemblies and four Output Assemblies.

All supported Instances are shown in the following table. Data types with multiple bytes starts with the LSB at the lowest byte number and ends with MSB.

LSB			MSB
REAL			

LSB	MSB
INT	

Instances	
Nr.	**Description**
2	Input Assembly, Size = 3 Byte: 0 | 1 2 Type: BYTE | INT Data: Exception Status | Flow
6	Input Assembly, Size = 8 Byte: 0 | 1 2 | 3 4 | 5 | 6 7 Type: BYTE | INT | INT | USINT | INT Data: Exception Status | Flow | Setpoint | Override | Valve
7	Output Assembly, Size = 2 Byte: 0 1 Type: INT Data: Setpoint
8	Output Assembly, Size = 3 Byte: 0 | 1 2 Type: USINT | INT Data: Override | Setpoint
14	Input Assembly, Size = 5 Byte: 0 | 1 2 3 4 Type: BYTE | REAL Data: Exception Status | Flow
18	Input Assembly, Size = 14 Byte: 0 | 1 2 3 4 | 5 6 7 8 | 9 | 10 11 12 13 Type: BYTE | REAL | REAL | USINT | REAL Data: Exception Status | Flow | Setpoint | Override | Valve
19	Output Assembly, Size = 4 Byte: 0 1 2 3 Type: REAL Data: Setpoint
20	Output Assembly, Size = 5 Byte: 0 | 1 2 3 4 Type: USINT | REAL Data: Override | Setpoint

Instance Attributes				
Attribute ID	**R/W**	**Attribute Name**	**Data Type**	**Comment**
0x01	R	Number of members in List	UINT	
0x02	R	Member List	ARRAY of STRUCT:	
		Member Data Description	UINT	
		Member Path Size	UINT	
		Member Path	Packed EPATH	
0x03	R/W	Data	ARRAY of BYTE	
0x04	R	Size	UINT	Number of bytes in Attribute 3

Services		
Service Code	**Service Name**	**Description of Service**
0x0E	Get_Attribute_Single	Returns the contents of the specified attribute
0x10	Set_Attribute_Single	Modifies an attribute value

3.6 CONNECTION OBJECT, CLASS CODE 0X05

Use the Connection Object to manage the characteristics of a communication connection.

From the Connection Object, there are two Instances; Instance #1 represents the Explicit Message Connection and Instance #2 represents the Polled I/O Connection.

Instances	
Nr.	**Description**
1	Explicit Message Connection
2	Polled I/O Connection

Instance Attributes				
Attribute ID	**R/W**	**Attribute Name**	**Data Type**	**Comment**
0x01	R	State	USINT	
0x02	R	Instance type	USINT	
0x03	R	Transport class trigger	BYTE	
0x04	R	Produced connection ID	UINT	
0x05	R	Consumed connection ID	UINT	
0x06	R	Initial comm. characteristics	BYTE	
0x07	R	Produced connection size	UINT	
0x08	R	Consumed connection size	UINT	
0x09	R/W	Expected packet rate	UINT	
0x0C	R/W	Watchdog time-out action	USINT	
0x0D	R	Produced connection path length	UINT	
0x0E	R/W	Produced connection path	EPATH	
0x0F	R	Consumed connection path length	UINT	
0x10	R/W	Consumed connection path	EPATH	
0x12	R/W	Production inhibit time	UINT	
0x13	R	Connection timeout multiplier	USINT	

Services		
Service Code	**Service Name**	**Description of Service**
0x05	Reset	Used to reset all resettable Connection Objects
0x09	Delete	Used to delete all Connection Objects and to release all associated resources
0x0E	Get_Attribute_Single	Returns the contents of the specified attribute
0x10	Set_Attribute_Single	Modifies an attribute value

3.7 S-DEVICE SUPERVISOR OBJECT, CLASS CODE 0X30

This object models the interface, functions and behavior associated with the management of application objects for devices within the "Hierarchy of Semiconductor Equipment Devices". There is only a single Instance #1 of the S-Device Supervisor Object.

Instance Attributes

Attribute ID	R/W	Attribute Name	Data Type	Comment
0x03	R	Device Type	SHORT STRING	"MFC", "MFM"
0x04	R	SEMI Standard Revision	SHORT STRING	"E54-0997"
0x05	R	Manufacturer Name	SHORT STRING	"Sensirion AG"
0x06	R	Manufacturer Model Number	SHORT STRING	"x-xxxxxx-xx"
0x07	R	S/W Revision	SHORT STRING	"Major.Minor"
0x08	R	H/W Revision	SHORT STRING	"Major.Minor"
0x09	R	Manufacturer Serial Number	SHORT STRING	"########"
0x0B	R	Device Status	USINT	State: Description 0: Undefined 1: Self Testing 2: Idle 3: Self-Test Exception 4: Executing 5: Abort 6: Critical Fault
0x0C	R	Exception Status	BYTE	Bit: Description 0: ALARM, device-common 1: ALARM, device-specific 2: ALARM, manufacturer-specific 3: always = 0 4: WARNING, device-common 5: WARNING, device-specific 6: WARNING, manufacturer-specific 7: always = 1, expanded method
0x0D	R	Exception Detail Alarm	USINT	Common Exception Detail Size = 2
			BYTE	Common Exception Detail 0
			BYTE	Common Exception Detail 1
			USINT	Device Exception Detail Size = 2
			BYTE	Device Exception Detail 0
			BYTE	Device Exception Detail 1
			USINT	Manufacturer Exception D. Size = 1
			BYTE	Manufacturer Exception Detail 0
0x0E	R	Exception Detail Warning	USINT	Common Exception Detail Size = 2
			BYTE	Common Exception Detail 0
			BYTE	Common Exception Detail 1
			USINT	Device Exception Detail Size = 2
			BYTE	Device Exception Detail 0
			BYTE	Device Exception Detail 1
			USINT	Manufacturer Exception D. Size = 1
			BYTE	Manufacturer Exception Detail 0
0x0F	R/W	Alarm Enable	BOOL	0 = Disabled, 1 = Enabled
0x10	R/W	Warning Enable	BOOL	0 = Disabled, 1 = Enabled

Exception Detail Alarm								
Data Component	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Common Exception Detail Size	0	0	0	0	0	0	1	0
Common Exception Detail 0	0	0	0	0	0	0	0	Internal Diagnostic
Common Exception Detail 1	0	0	0	0	PS Input Voltage	0	0	0
Device Exception Detail Size	0	0	0	0	0	0	0	1
Device Exception Detail 0	0	0	0	0	0	0	0	Sensor Com.
Manufacturer Exception Detail 1	0	0	0	0	0	0	0	1
Manufacturer Exception Detail 0	0	0	0	0	0	0	Actuator Output	Actuator Supply

Exception Detail Warning								
Data Component	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Common Exception Detail Size	0	0	0	0	0	0	1	0
Common Exception Detail 0	0	0	0	0	0	0	0	0
Common Exception Detail 1	0	0	0	0	0	0	0	0
Device Exception Detail Size	0	0	0	0	0	0	0	1
Device Exception Detail 0	0	0	0	0	0	0	0	0
Manufacturer Exception Detail 1	0	0	0	0	0	0	0	1
Manufacturer Exception Detail 0	0	0	0	0	Setpoint out of Range	Gas Pressure	0	0

In the current version the S-Device Supervisor Object does not yet support all Services that are provided in the DeviceNet specification. The not fully functioning Services are put in square brackets.

Services		
Service Code	**Service Name**	**Description of Service**
0x05	Reset	Resets the device to the Self-Testing state
0x06	[Start] *	Starts the device execution by moving the device to the Executing state
0x07	[Stop] *	Moves the device to the Idle state
0x0E	Get_Attribute_Single	Returns the contents of the specified attribute
0x10	Set_Attribute_Single	Modifies an attribute value
0x4B	[Abort] *	Moves the device to the Abort state
0x4C	[Recover] *	Moves the device out of the Abort state
0x4E	Perform Diagnostics	Causes the device to perform a set of diagnostic routines

* no effect, the device always runs

3.8 S-Analog Sensor Object, Class Code 0x31

The S-Analog Sensor Object models the acquisition of a reading from a physical sensor in a device. There is only a single Instance #1 of the S-Analog Sensor Object.

Instance Attributes				
Attribute ID	**R/W**	**Attribute Name**	**Data Type**	**Comment**
0x03	R/W	Data Type	USINT	0xC3 = INT, 0xCA = REAL
0x04	R/W	Data Units	ENGUNITS	see 6.1.2 Engineering Units
0x05	R	Reading Valid	BOOL	0 = invalid, 1 = valid
0x06	R	Sensor Value	INT or REAL	Depends on the *Data Type* attribute
0x07	R	Status	BYTE	
0x0A	R	Full Scale	INT or REAL	Depends on the *Data Type* attribute
0x23	R/W	Gas Calibration Object Inst.	UINT	0 = no calibration, controller disabled 1…30 = active calibration Nr.
0x53	R	Raw Thermal Conductivity *	UINT	Raw value of thermal conductivity measurement for gas recognition. To read the value, the valve must be closed!
0x54	R	Thermal Conductivity Ref. *	UINT	Thermal conductivity reference value from active gas calibration.

Services		
Service Code	**Service Name**	**Description of Service**
0x0E	Get_Attribute_Single	Returns the contents of the specified attribute
0x10	Set_Attribute_Single	Modifies an attribute value

3.9 S-Analog Actuator Object, Class Code 0x32

The S-Analog Actuator Object models the interface to a physical actuator in a device. There is only a single Instance #1 of the S-Analog Actuator Object.

Instance Attributes				
Attribute ID	**R/W**	**Attribute Name**	**Data Type**	**Comment**
0x03	R/W	Data Type	USINT	0xC3 = INT, 0xCA = REAL
0x05	R/W	Override	USINT	Value: Description 0: Normal control 1: Valve closed 2: Valve fully opened 3: Hold valve at the current position
0x06	R/W	Actuator Value	INT or REAL	always = 0
0x07	R	Status	BYTE	always = 0

* This attributes are not standardized by the ODVA and applies only to Sensirion MFC.

Services		
Service Code	**Service Name**	**Description of Service**
0x0E	Get_Attribute_Single	Returns the contents of the specified attribute
0x10	Set_Attribute_Single	Modifies an attribute value

3.10 S-SINGLE STAGE CONTROLLER, CLASS CODE 0X33

The S-Single Stage Controller Object models a closed-loop control system within a device. There is only a single Instance #1 of the S-Single Stage Controller Object.

Instance Attributes				
Attribute ID	**R/W**	**Attribute Name**	**Data Type**	**Comment**
0x03	R/W	Data Type	USINT	0xC3 = INT, 0xCA = REAL
0x04	R	Data Units	ENGUNITS	See 6.1.2 Engineering Units The Attribute is defined in the S-Analog Sensor and mirrored here.
0x06	R/W	Setpoint	INT or REAL	Depends on the *Data Type* attribute
0x0A	R	Status	BYTE	
0x54	R/W	User Controller Gain *	UINT	User defined controller gain in [%] to adjust the speed of the controller. Default: 100%

Services		
Service Code	**Service Name**	**Description of Service**
0x0E	Get_Attribute_Single	Returns the contents of the specified attribute
0x10	Set_Attribute_Single	Modifies an attribute value

* This attributes are not standardized by the ODVA and applies only to Sensirion MFC.

3.11 S-GAS CALIBRATION, CLASS CODE 0X34

An S-Gas Calibration Object affects the behavior of an associated S-Analog Sensor Object Instance.

For each gas calibration available on the Mass Flow Controller there is an Instance of the S-Gas Calibration Object. All available calibrations can be determined from the Object Service Get_All_Instances.

Instance Attributes				
Attribute ID	**R/W**	**Attribute Name**	**Data Type**	**Comment**
0x03	R	Gas Standard Number	UINT	SEMI E52-1000: "Practice for Referencing Gases Used in Digital Mass Flow Controllers"
0x04	R	Valid Sensor Instance	UINT	always 1
0x06	R	Full Scale	STRUCT of:	
		Amount	REAL	maximal Flow
		Unit	ENGUNITS	Depends on the *Data Type* attribute
0x54	R	Thermal Conductivity Ref.*	UINT	Thermal conductivity reference value for gas recognition.

Use Instance number #0 to access the Object Services.

Object Services (Instance #0)		
Service Code	**Service Name**	**Description of Service**
0x0E	Get_All_Instances	Requests a list of all available object instances with their respective gas numbers

Services		
Service Code	**Service Name**	**Description of Service**
0x0E	Get_Attribute_Single	Returns the contents of the specified attribute

Instance List Format		
Parameter	**Data Type**	**Description**
Size of List	UINT	Specifies the number of elements in the Array
List of Gas Calibrations	ARRAY of STRUCT:	Supported Gas Type
	UINT	S-Gas Calibration Object Instance ID
	UINT	Gas Standard Number
	UINT	Valid Sensor Instance

* This attributes are not standardized by the ODVA and applies only to Sensirion MFC.

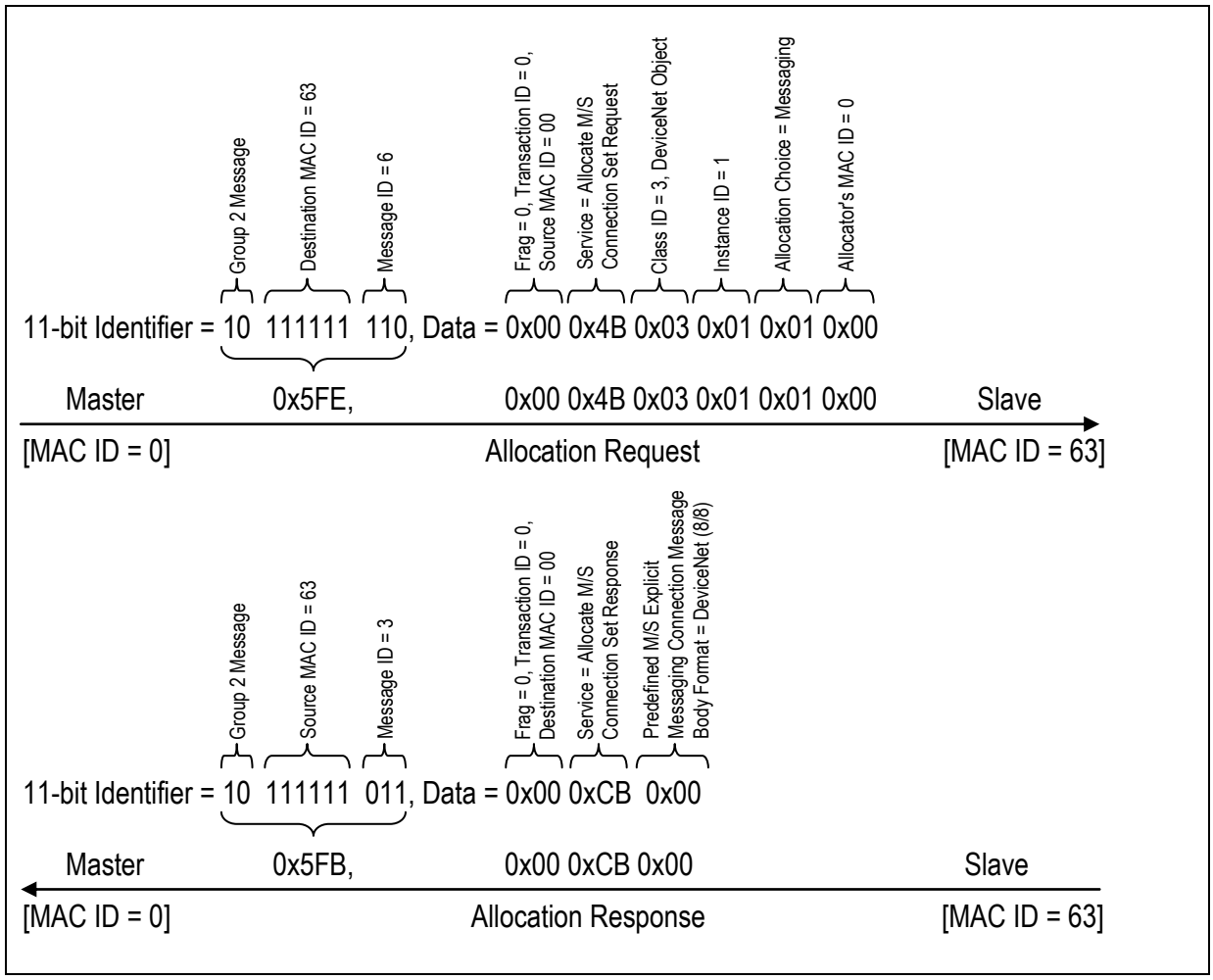
4 DEVICENET COMMUNIACTION

4.1 ALLOCATE MASTER/SLAVE CONNECTION

DeviceNet is a connection-oriented protocol, so first, a connection must be established. For the Sensirion MFC, two different connection sets are predefined:

1. Explicit Message Connection 0x01:
   With the Explicit Message Connection you have access to all in this document described Attributes and Services of the various Object Instances. For example: Change the baud rate, change the MFC's MAC ID or perform a Reset.
2. Polled I/O Connection 0x02:
   The Polled I/O Connection is optimized to read and write repeatedly the same data sets in an efficient way. Which data are exchanged, can be configure by the user. The default definition sets the Setpoint and reads the Exception Status as well as flow value.

The example below illustrates the successful allocation of the Explicit Message Connection:

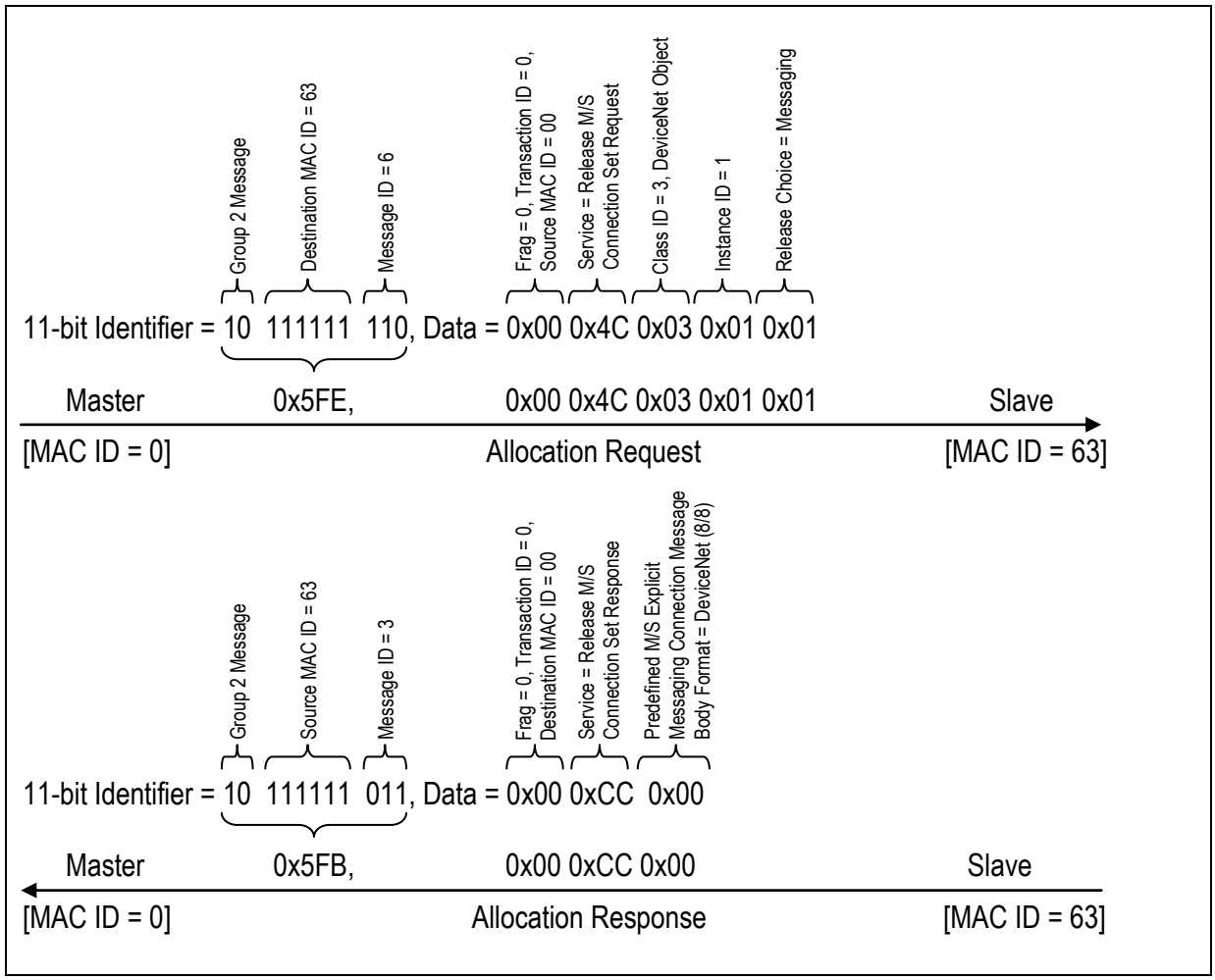


To allocate a Polled I/O Connection, the Allocation Choice byte must be set to 0x02:
0x5FE, 0x00 0x4B 0x03 0x01 **0x02** 0x00

It is also possible to allocate both connections in a single command. For this purpose, the Allocation Choice byte must be set to 0x03:
0x5FE, 0x00 0x4B 0x03 0x01 **0x03** 0x00

4.2 RELEASE MASTER/SLAVE CONNECTION

A no longer required Explicit Message Connections can be released in the following way.



To release a Polled I/O Connection, the Release Choice byte must be set to 0x02:
0x5FE, 0x00 0x4B 0x03 0x01 **0x02**

It is also possible to release both connections in single command. For this purpose, the Release Choice byte must be set to 0x03 or the Release Choice byte is omitted:
0x5FE, 0x00 0x4B 0x03 0x01 **0x03**

0x5FE, 0x00 0x4B 0x03 0x01

4.3 CONNECTION TIMEOUT

The Attribute Exacted Packet Rate 0x09 in the corresponding Instance of the Connection Object defines the packed rate in milliseconds that is expected by the Mass Flow Controller. If this rate is exceeded four times the connection is released without any feedback.

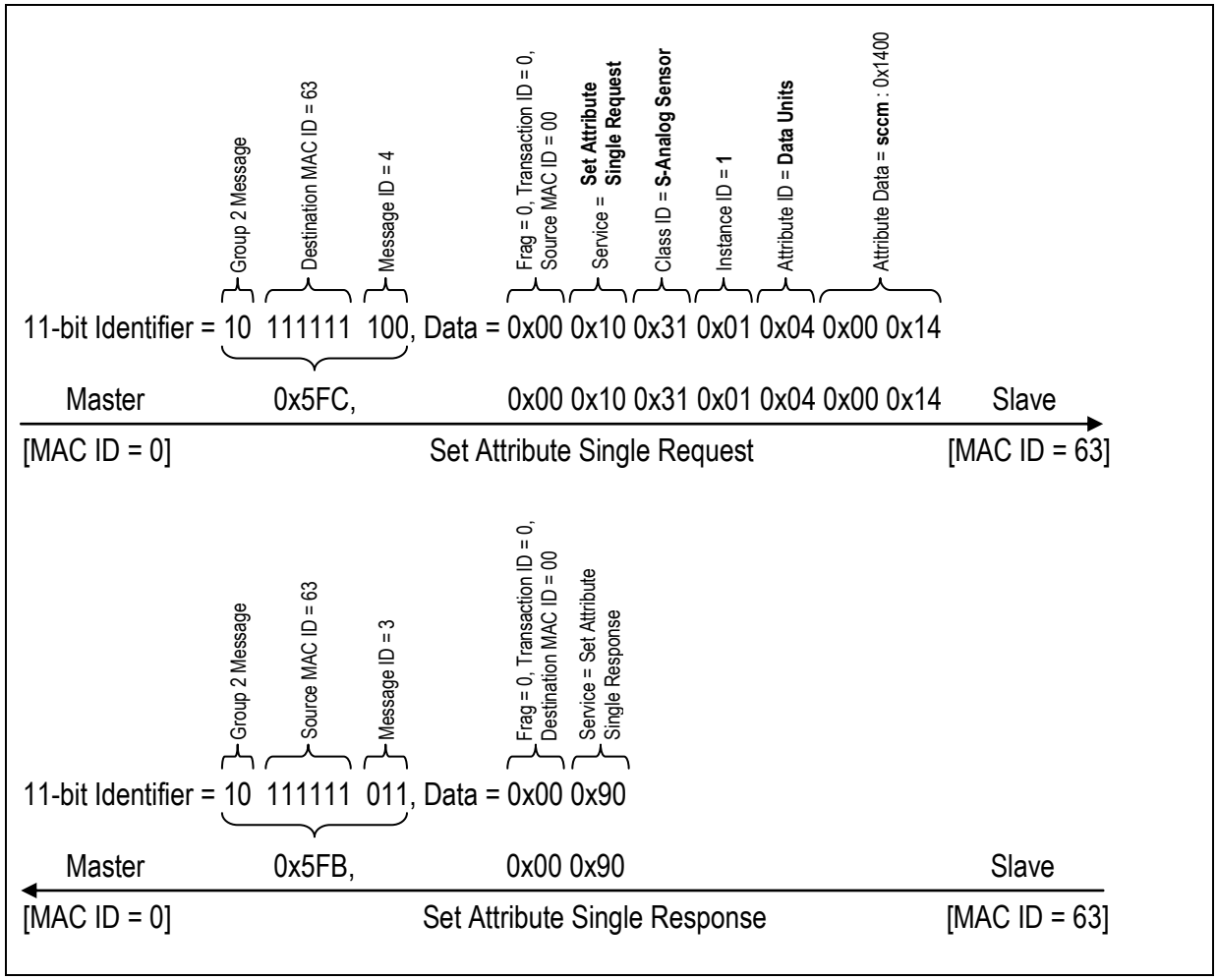
4.4 EXPLICIT MESSAGE CONNECTION

With the Explicit Message Connection you have access to all in this document described attributes and Services of the various Object Instances. For example: Change the baud rate, change the MFC's MAC ID or perform a Reset.

4.4.1 GET/SET AN ATTRIBUTE VALUE

Allocate first an Explicit Message Connection to get or set an attribute value from an Object Instance.

The example below illustrates how the attributes *Data Units* of the *S-Analog Sensor Object* Instance is set to standard cubic centimeter per minute (sccm):



The sequence to read the same attribute is quite similar. Instead of the service Set Attribute Single the service **Get Attribute Single = 0x0E** is used and the Attribute Data is omitted:

Get Attribute Single Request: 0x5FC, 0x00 **0x0E** 0x31 0x01 0x04

In the **Get Attribute Single Response = 0x8E** the **Attribute Data** is now added at the end.

Get Attribute Single Response: 0x5FB, 0x00 **0x8E 0x00 0x14**

4.4.2 FRAGMENTED EXPLICIT MESSAGE

Per frame up to 8 bytes of data can be transmitted after the identifier. If this is insufficient, the message must be divided into several fragments.

In this case, the fragmentation flag in the first data byte has to be set. The second byte now contains additional information on the fragmented message.

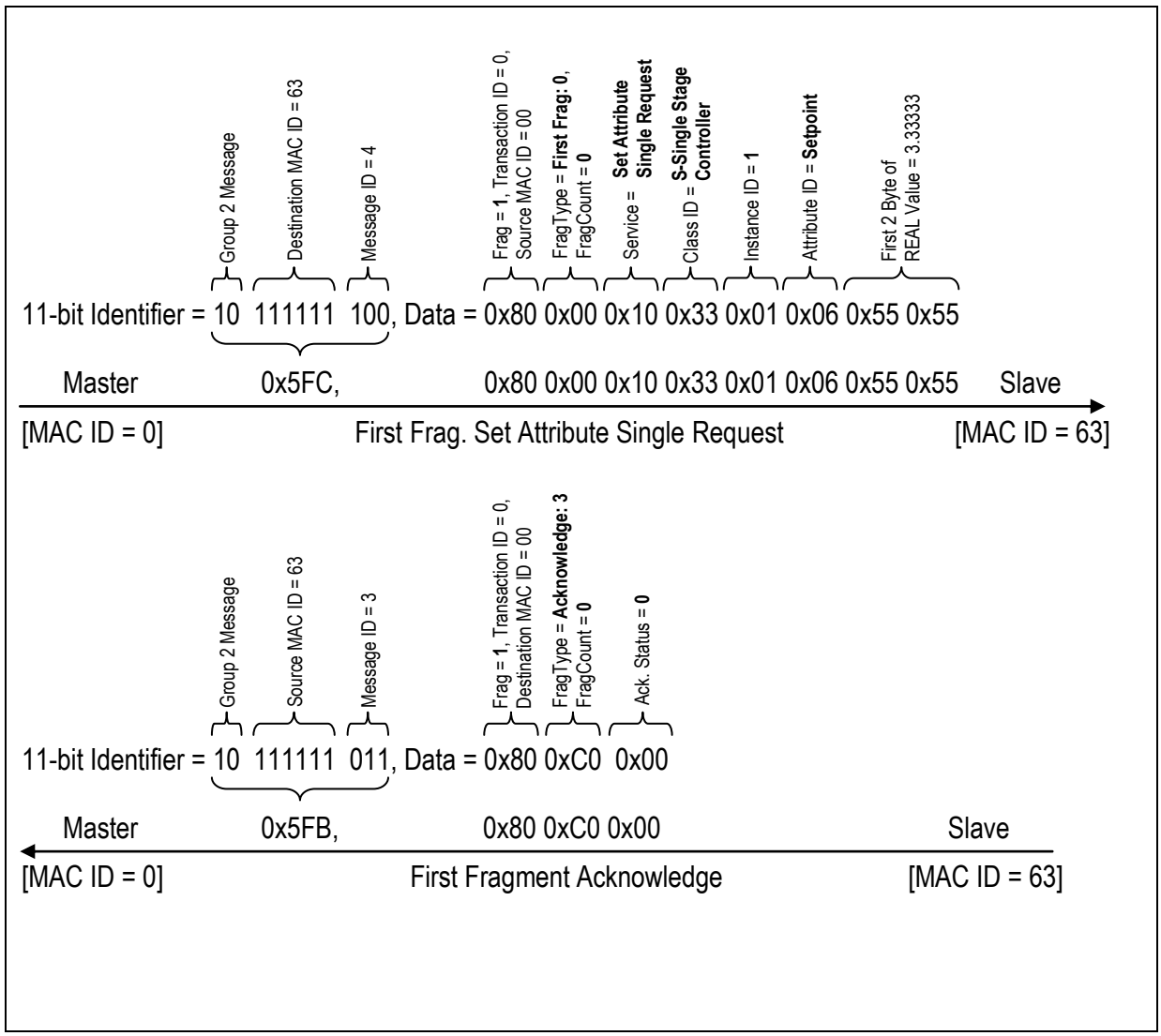
Fragmented Frame								
Byte	7	6	5	4	3	2	1	0
0	Frag = 1		Source MAC ID					
1	Fragment Type		Fragment Count					
2	Data							
…								

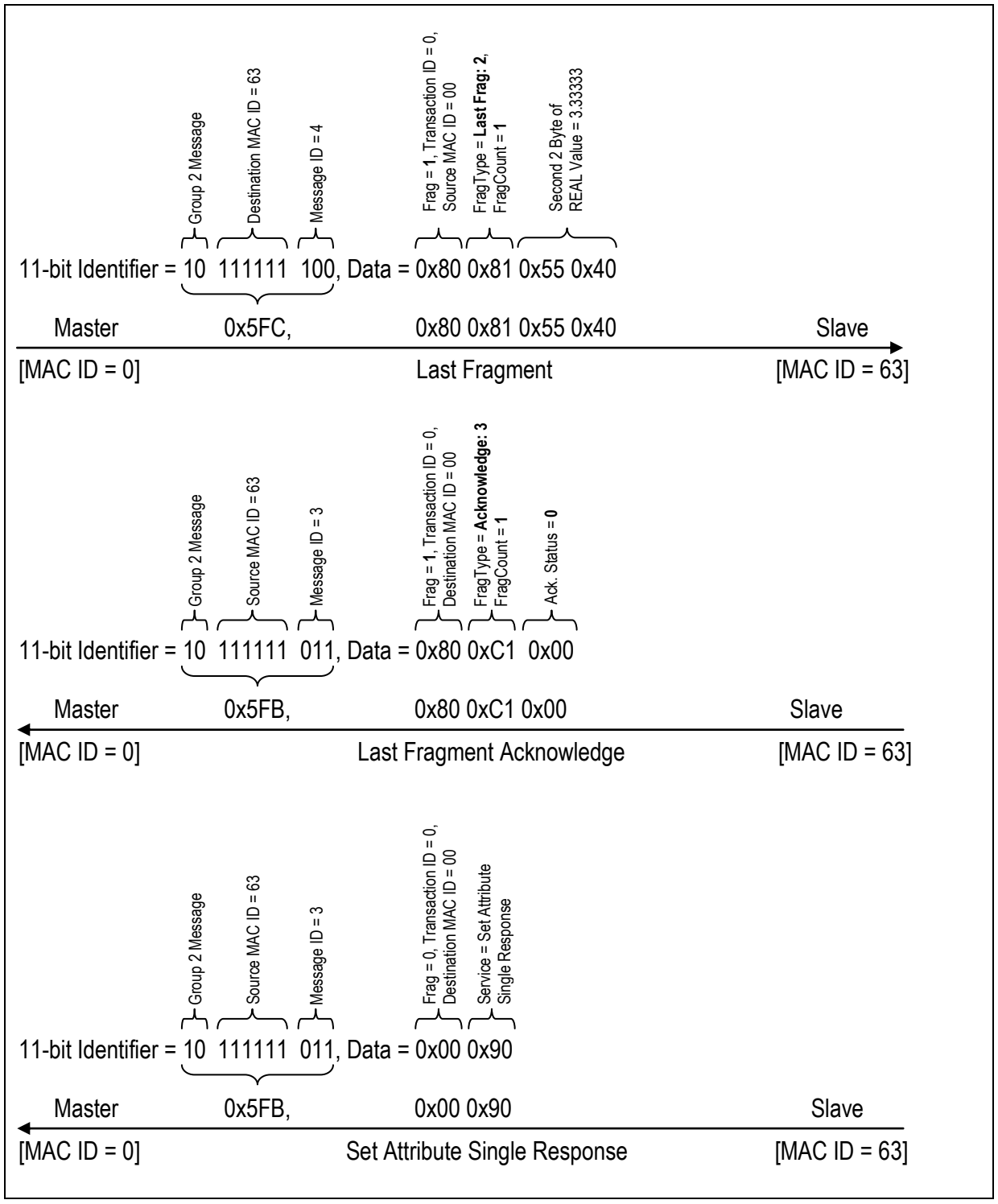
Fragment Type	
Value	Meaning
0	First Fragment
1	Middle Fragment
2	Last fragment
3	Fragment Acknowledge

Each fragment is confirmed by the MFC with an Acknowledge with the format shown in the below table.

Byte	7	6	5	4	3	2	1	0
0	Frag = 1		Destination MAC ID					
1	Fragment Type = 3		Fragment Count					
2	Ack. Status = 0							

The example below illustrates this behavioral by setting the 4-byte REAL Setpoint Attribute of the S-Single Stage Controller Object.




Group 2 Message
Destination MAC ID = 63
Message ID = 4
Frag = 1, Transaction ID = 0, Source MAC ID = 00
FragType = Last Frag: 2, FragCount = 1
Second 2 Byte of REAL Value = 3.33333
11-bit Identifier = 10 111111 100, Data = 0x80 0x81 0x55 0x40
Master
0x5FC,
0x80 0x81 0x55 0x40
Slave
[MAC ID = 0]
Last Fragment
[MAC ID = 63]
Group 2 Message
Source MAC ID = 63
Message ID = 3
Frag = 1, Transaction ID = 0, Destination MAC ID = 00
FragType = Acknowledge: 3 FragCount = 1
Ack. Status = 0
11-bit Identifier = 10 111111 011, Data = 0x80 0xC1 0x00
Master
0x5FB,
0x80 0xC1 0x00
Slave
[MAC ID = 0]
Last Fragment Acknowledge
[MAC ID = 63]
Group 2 Message
Source MAC ID = 63
Message ID = 3
Frag = 0, Transaction ID = 0, Destination MAC ID = 00
Service = Set Attribute Single Response
11-bit Identifier = 10 111111 011, Data = 0x00 0x90
Master
0x5FB,
0x00 0x90
Slave
[MAC ID = 0]
Set Attribute Single Response
[MAC ID = 63]

4.5 POLLED I/O CONNECTION

The Polled I/O Connection is optimized to read and write repeatedly the same data sets in an efficient way. Which data are exchanged, can be configure by the user.

By default, the MFC puts the incoming data to the Data of Assembly Instance #7 and returns the Data from Assembly Instance #2. In this configuration the Polled I/O Connection can be used to write the MFC's Setpoint as 16-bit integer value and read the Exception Status byte as well as the measured Flow value also as 16-bit integer value.

Assembly Instance #7		
Byte	0	1
Type	INT	
Data	Setpoint	

Assembly Instance #2			
Byte	0	1	2
Type	BYTE	INT	
Data	Exception Status	Flow	

To read or write values other than the defaults, the Produce/Consume Connection Path of the Polled I/O Connection needs to be overwritten.

4.5.1 SET PRODUCE/CONSUME CONNECTION PATH OF POLLED I/O CONNECTION

Allocate first both, the Explicit Message and the Polled I/O Connection, to set the Produce/Consume Connection Path of the Polled I/O Connection

The Produce (0x0E) respectively the Consume (0x10) Connection Path Attribute for the Polled I/O Connection is located in the Connection Object (0x05) at Instance 0x02. The Connection Path has the following format:

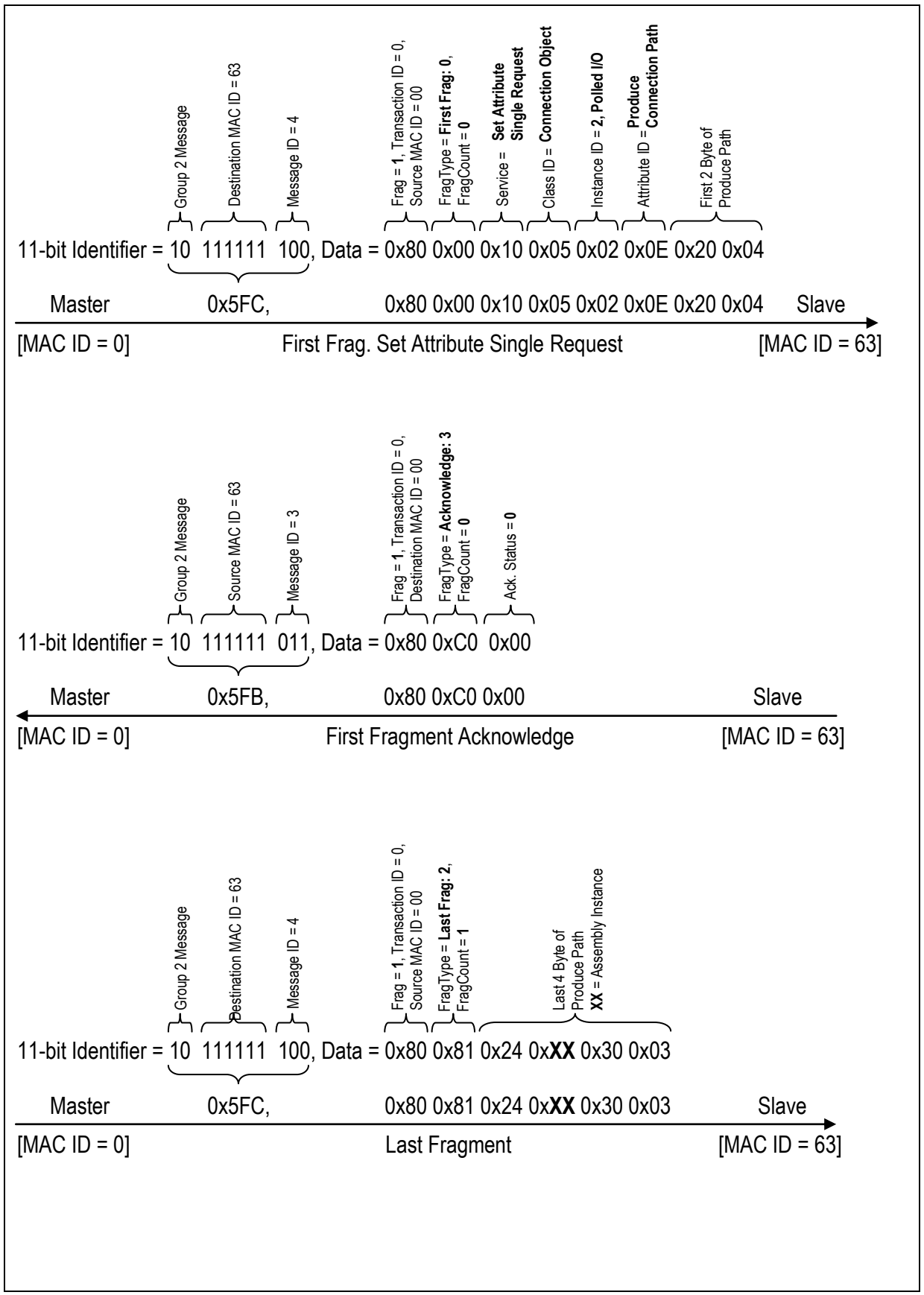
Produce/Consume Connection Path						
Description:	Logical Segment Type: Class	Class ID = 4 Assembly-Object	Logical Segment Type: Instance	Assembly Instance Number **XX**	Logical Segment Type: Attribute ID	Attribute ID = 3 Data
Data:	0x20	0x04	0x24	0x**XX**	0x30	0x03

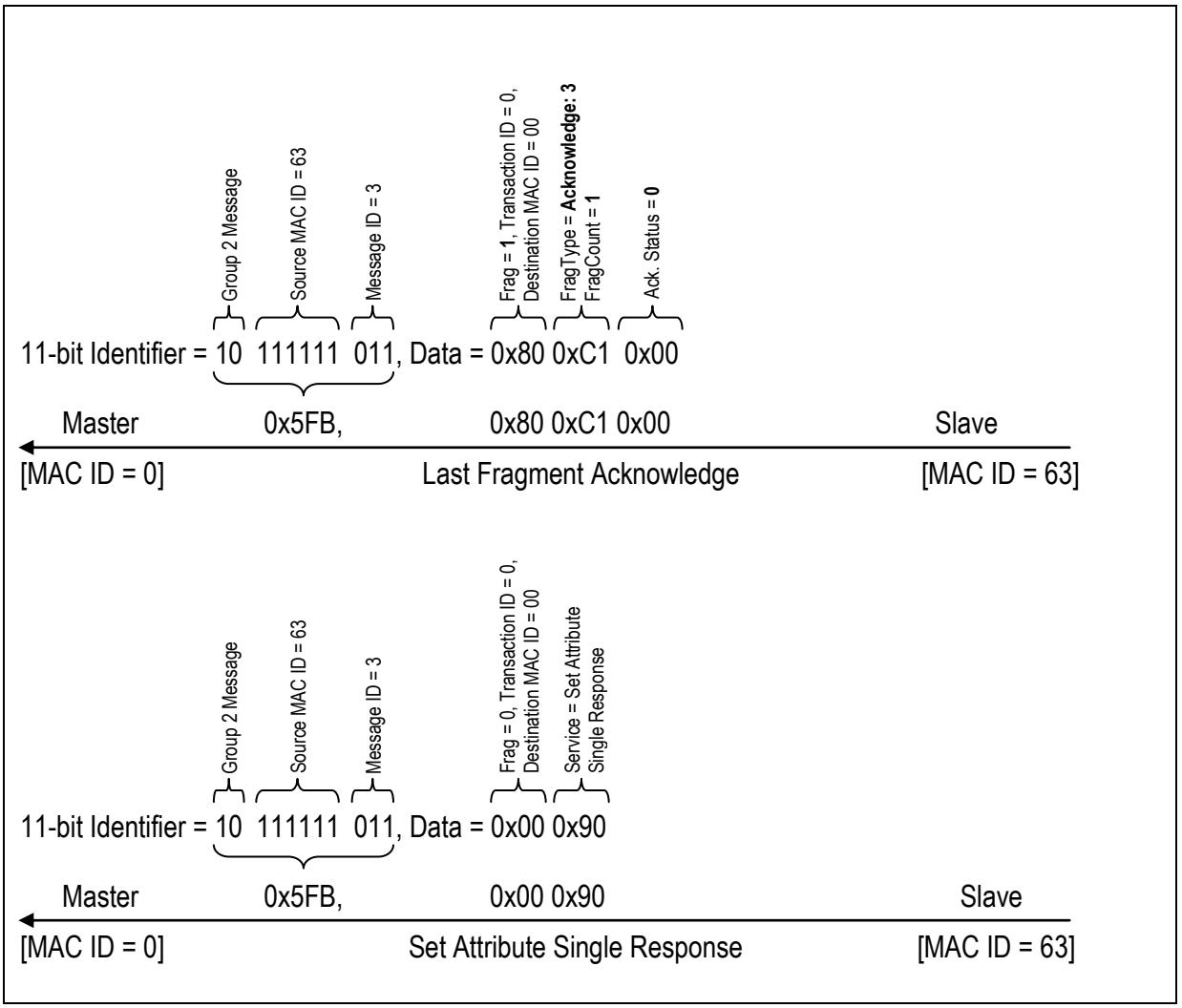
The Produce Connection Path defines which data is produced by the MFC and can be read by the Master and vice versa the Consume Connection Path defines which date is consumed by the MFC and has do be written by the Master. For the Consume Connection Path, the Output Assemblies can be used and for the Produce Connection Path, the Input Assemblies.

A table of all available assemblies can be found at: 3.5 Assembly Object, Class Code 0x04.

The Produce/Consume Connection Path is stored in the non-volatile memory and will persist after a power down or Reset (Type 0).

The graphics below shows the communication flow between the **M**aster and **S**lave (MFC) to set the Produce Connection Path Attribute (**0x0E**) of the Polled I/O Connection, where **XX** is the selected Assembly. Since the message will not fit in a frame they split into two fragments.




Group 2 Message
Source MAC ID = 63
Message ID = 3
Frag = 1, Transaction ID = 0, Destination MAC ID = 00
FragType = Acknowledge: 3
FragCount = 1
Ack. Status = 0
11-bit Identifier = 10 111111 011, Data = 0x80 0xC1 0x00
Master
0x5FB,
0x80 0xC1 0x00
Slave
[MAC ID = 0]
Last Fragment Acknowledge
[MAC ID = 63]
Group 2 Message
Source MAC ID = 63
Message ID = 3
Frag = 0, Transaction ID = 0, Destination MAC ID = 00
Service = Set Attribute Single Response
11-bit Identifier = 10 111111 011, Data = 0x00 0x90
Master
0x5FB,
0x00 0x90
Slave
[MAC ID = 0]
Set Attribute Single Response
[MAC ID = 63]

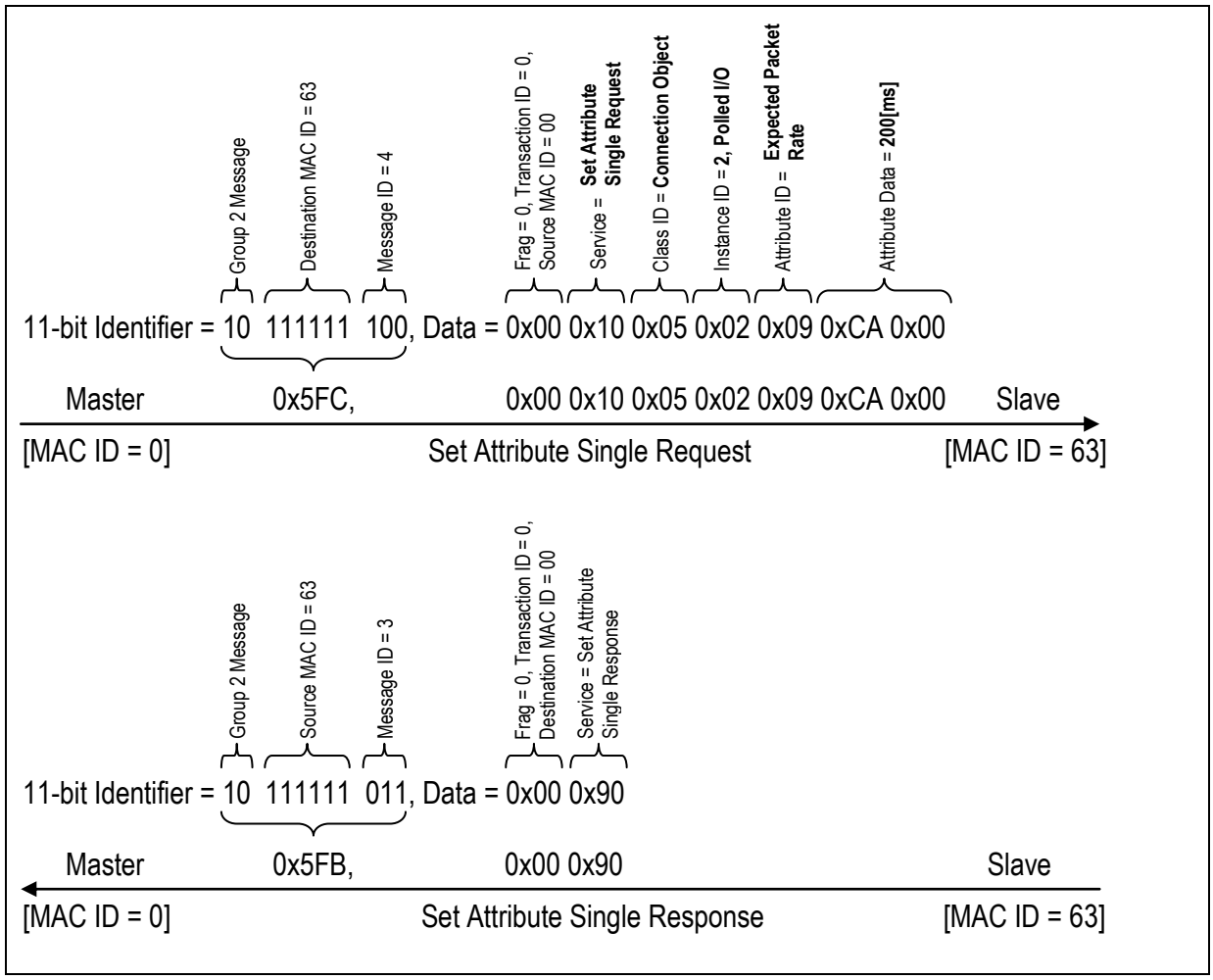
4.5.2 SET EXPECTED PACKET RATE

Allocate first both, the Explicit Message and the Polled I/O Connection, to set the Expected Packet Rate of the Polled I/O Connection

Before data can be transferred trough the Polled IO connection, the expected data exchange interval in milliseconds must be specified. If this interval is exceeded by four times the connection timed out.

The Expected Packet Rate Attribute (0x09) for the Polled I/O Connection is located at the Connection Object (0x05) at Instance 0x02. The Expected Packet Rate Attribute has the data type UINT.

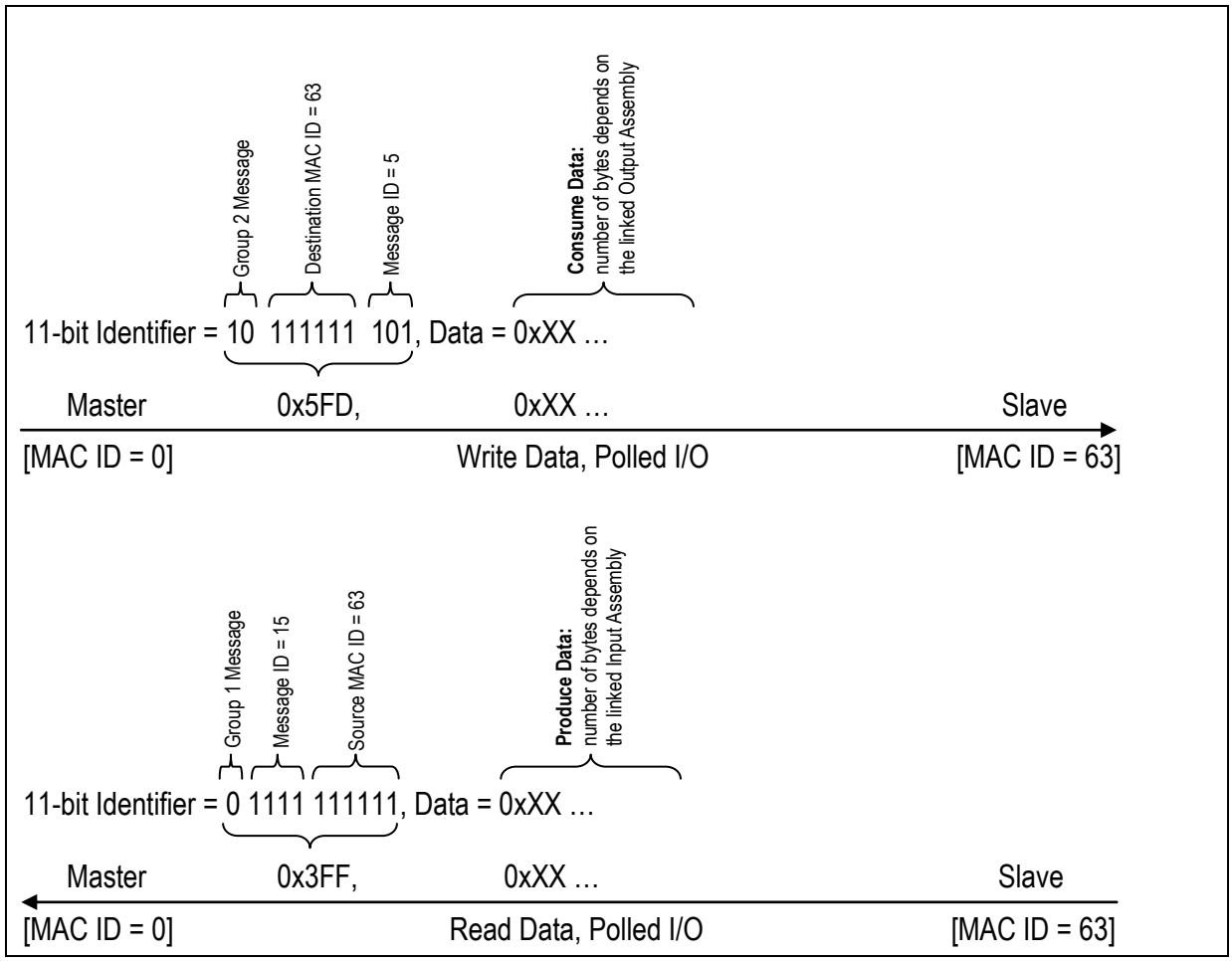
The graphics below shows how to set the Expected Packet to 200ms:



4.5.3 READ/WRITE DATA

For data exchange, a Polled I/O Connection must be allocated.

The graphics below shows how to read/write data through a polled I/O connection. The content of the data depends on the linked assemblies.



5 EXAMPLES

Below are some examples that show the communication sequences for the elementary functions.

For all examples it is assumed that the **M**aster has **MAC ID 0** and the **S**lave (Mass Flow Controller) the default **MAC ID 63**. If the master has another MAC ID the first data-byte must be adjusted accordingly and if the slave has a different MAC ID the Identifier must be adjusted accordingly.

5.1 SET SETPOINT (EXPLICIT MESSAGE)

The Setpoint can be written both as an INT as well as a REAL value, depending on how the Data Type Attribute is set.

Set Data Type			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 10, 33, 01, 03, TYP	No Fragmentation, Master MAC ID = 0: 00 Set Attribute Single: 10 S-Single Stage Controller Object: 33 Instance #1: 01 Attribute Data Type: 03 C3 = INT, CA = REAL TYP
M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

Set Setpoint (INT)			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 10, 33, 01, 06, LSB, MSB	No Fragmentation, Master MAC ID = 0: 00 Set Attribute Single: 10 S-Single Stage Controller Object: 33 Instance #1: 01 Attribute Setpoint: 06 Setpoint as INT: LSB, MSB
M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

Set Setpoint (REAL)			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	80, 00, 10, 33, 01, 06, LSB, XX	Frag. Message, Master MAC ID = 0: 80 First Fragment, FragCount = 0 00 Set Attribute Single: 10 S-Single Stage Controller Object: 33 Instance #1: 01 Attribute Setpoint: 06 First 2 bytes Setpoint as REAL: LSB, XX
M ← S	5FB	80, C0, 00	Frag. Message, Master MAC ID = 0 80 Fragment Acknowledge, FragCount = 0: C0 Acknowledge Status = 0 00
M → S	5FC	80, 81, XX, MSB	Frag. Message, Master MAC ID = 0: 80 Last Fragment, FragCount = 1: 81 Last 2 bytes Setpoint as REAL : XX, MSB
M ← S	5FB	80, C1, 00	Frag. Message, Master MAC ID = 0 80 Fragment Acknowledge, FragCount = 1: C1 Acknowledge Status = 0 00

M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

5.2 GET FLOW VALUE (EXPLICIT MESSAGE)

The Flow Value can be read both as an INT as well as a REAL value, depending on how the Data Type Attribute is set.

Set Data Type			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 10, 31, 01, 03, TYP	No Fragmentation, Master MAC ID = 0: 00 Set Attribute Single: 10 S-Analog Sensor Object : 31 Instance #1: 01 Attribute Data Type: 03 C3 = INT, CA = REAL TYP
M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

Get Flow Value (INT)			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 0E, 31, 01, 06	No Fragmentation, Master MAC ID = 0: 00 Get Attribute Single: 10 S-Analog Sensor Object: 31 Instance #1: 01 Attribute Sensor Value: 06
M ← S	5FB	00, 8E, LSB, MSB	Master MAC ID = 0: 00 Get Attribute Single Response: 90 Flow Value as INT: LSB, MSB

Get Flow Value (REAL)			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 0E, 31, 01, 06	No Fragmentation, Master MAC ID = 0: 00 Get Attribute Single: 10 S-Analog Sensor Object: 31 Instance #1: 01 Attribute Sensor Value: 06
M ← S	5FB	00, 8E, LSB, XX, XX, MSB	Master MAC ID = 0: 00 Get Attribute Single Response: 90 Flow Value as REAL: LSB, XX, XX, MSB

5.3 SET SETPOINT AND READ FLOW VALUE (POLLED I/O)

The exact data format to write the set point and read the flow value, depends on the used Assemblies. See: 3.5 Assembly Object, Class Code 0x04 and 4.5.1 Set Produce/Consume Connection Path of Polled I/O Connection

Get Flow Value (INT), Assemblies: Input #2, Output #7			
Direction	Identifier (hex)	Data (hex)	Description
M→ S	5FD	LSB, MSB	Setpoint as INT: LSB, MSB
S→M	3FF	STAT, LSB, MSB	Exception Status: STAT Flow Value as INT: LSB, MSB

Get Flow Value (REAL), Assemblies: Input #14, Output #19			
Direction	Identifier (hex)	Data (hex)	Description
M→ S	5FD	LSB, XX, XX, MSB	Setpoint as REAL: LSB, XX, XX, MSB
S→M	3FF	STAT, LSB, XX, XX, MSB	Exception Status: STAT Flow Value as INT: LSB, XX, XX, MSB

5.4 CHANGE FLOW UNIT (EXPLICIT MESSAGE)

The set Data Unit applies to both the Setpoint and for the read Flow Value. The units are encoded in so-called engineering units. A table of all available engineering units can be found here: 6.1.2 Engineering Units

Change Flow Unit			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 10, 33, 01, 04, LSB, MSB	No Fragmentation, Master MAC ID = 0: 00 Set Attribute Single: 10 S-Single Stage Controller Object: 33 Instance #1: 01 Attribute Data Unit: 04 ENGUNIT: LSB, MSB
M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

5.5 CHANGE GAS CALIBRATION (EXPLICIT MESSAGE)

If the Mass Flow Controller was calibrated for multiple gases, the calibration to be used can be changed. To determine which calibrations are available, the Service Get_All_Instances from the S-Calibration Object can be used.

Change Flow Unit			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 10, 31, 01, 23, LSB, MSB	No Fragmentation, Master MAC ID = 0: 00 Set Attribute Single: 10 S-Analog Sensor: 31 Instance #1: 01 Attribute Gas Calibration Object Instance: 23 Calibration Nr. as UINT: LSB, MSB
M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

5.6 CHANGE BAUD RATE (EXPLICIT MESSAGE)

The Baud Rate can be set to 125 kbps, 250 kbps or 500 kbps. The new set Baud Rate becomes active after a Reset Type 0 or after a power down.

Set Expected Packet Rate			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 10, 03, 01, 02, **0X**	No Fragmentation, Master MAC ID = 0: 00 Set Attribute Single: 10 DeviceNet Object: 03 Instance #1: 01 Attribute Baud Rate: 02 0 = 125 kbps, 1 = 250 kbps, 2 = 500 kbps: **0X**
M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

5.7 CHANGE MAC ID (EXPLICIT MESSAGE)

The MAC ID can be set to any value between 0 and 63. Within a DeviceNet network, however, each device should have a unique MAC ID. The MAC ID is changed immediately after the response.

Set Expected Packet Rate			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 10, 03, 01, 01, XX	No Fragmentation, Master MAC ID = 0: 00 Set Attribute Single: 10 DeviceNet Object: 03 Instance #1: 01 Attribute MAC ID: 01 MAC ID 0…63 as USINT: XX
M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

5.8 RESET (EXPLICIT MESSAGE)

The mass flow controller supports three different resets: A normal reset in which only the system is restarted, a reset which sets all settings to factory defaults and a reset in which all settings are set to the factory defaults except the Baud Rate and the MAC ID.

Types of Reset
0 = Reset
1 = Load default Values (Factory Reset) + Reset
2 = Load default Values (Factory Reset), expect Baud Rate and MAC ID + Reset

The reset is performed immediately after the response.

Set Expected Packet Rate			
Direction	Identifier (hex)	Data (hex)	Description
M → S	5FC	00, 05, 01, 01, 0X	No Fragmentation, Master MAC ID = 0: 00 Reset: 05 Identity Object: 01 Instance #1: 01 Reset Type as USINT: 0X
M ← S	5FB	00, 90	Master MAC ID = 0: 00 Set Attribute Single Response: 90

6 APPENDIX

6.1 DATA TYPES

6.1.1 TABLE OF ALL DATA TYPES USED BY THE SFC5XXX

Data Type Name	Description
BOOL	Logical Boolean with values 0 = FALSE and 1 = TRUE
INT	Signed 16–bit integer value
USINT	Unsigned 8–bit integer value
UINT	Unsigned 16–bit integer value
REAL	32–bit floating point value, *IEEE-754 single-precision floating-point*
BYTE	Bit string - 8-bits
SHORT_STRING	character sting (1 byte per character, 1 byte length indicator)
EPATH	CIP path segments
ENGUNIT	Engineering Units

6.1.2 ENGINEERING UNITS

ID	Symbol	Description
0x1000	-	unspecified
0x1001	-	counts
0x1007	%	percent
0x1400	sccm	standard cubic centimeter per minute
0x1401	slm	standard liter per minute
0x1406	l/s	liter per second
0x1407	ml/s	milliliter per second
0x1411	ml/min	milliliter per minute
0x1412	ml/h	milliliter per hour
0x1413	l/min	liter per minute
0x1414	l/h	liter per hour

6.2 GAS STANDARD NUMBER*

Code	Symbol	Gas Name
1	He	Helium
4	Ar	Argon
7	H2	Hydrogen
8	Air	Air
13	N2	Nitrogen
15	O2	Oxygen
110	SF6	Sulfur Hexafluoride
129	C4F8	Octafluorocyclobutane
0	-	Unknown

* for a full list, see: SEMI E52-1000 “Practice for Referencing Gases Used in Digital Mass Flow Controllers”

6.3 EDS-FILE

```
$ EZ-EDS Version 3.9 Generated Electronic Data Sheet

$ Sensirion AG
$ Electronic Data Sheet
$ DeviceNet - Mass Flow Controller
$ SFC5xxxx

$ File Description Section:
[File]
        DescText = "Sensirion AG - DeviceNet SFC5xxxx";
        CreateDate = 01-28-2014;
        CreateTime = 10:49:19;
        ModDate = 01-28-2014;
        ModTime = 10:49:21;
        Revision = 1.0;

$ Device Description Section:
[Device]
        VendCode = 1341;
        VendName = "Sensirion AG";
        ProdType = 26;
        ProdTypeStr = "Mass Flow Controller";
        ProdCode = 5400;
        MajRev = 1;
        MinRev = 1;
        ProdName = "Sensirion MFC SFC5xxxx";
        Icon = "SFC5xxxx.ico";

$ I/O Characteristics Section:
[IO_Info]
        Default = 0x0001;
        PollInfo =
                0x0001,
                1,
                1;
        Input1 =
                3,                      $ 3 bytes
                0,                      $ All bits significant
                0x0001,                 $ Poll only connection
                "Status, Flow",         $ Input Instance 2
                6,                      $ Connection Path Size 6
                "20 04 24 02 30 03",    $ Assembly Object Instance 2
                "-";                    $ Help string
        Input2 =
                8,                      $ 8 bytes
                0,                      $ All bits significant
                0x0001,                 $ Poll only connection
                "Status, Flow, Setpoint, Override, Valve",    $ Input Instance 6
                6,                      $ Connection Path Size 6
                "20 04 24 06 30 03",    $ Assembly Object Instance 6
                "-";                    $ Help string
        Input3 =
                5,                      $ 5 bytes
                0,                      $ All bits significant
                0x0001,                 $ Poll only connection
                "Status, FP-Flow",      $ Input Instance 14
                6,                      $ Connection Path Size 6
                "20 04 24 0E 30 03",    $ Assembly Object Instance 14
                "-";                    $ Help string
        Input4 =
                14,                     $ 14 bytes
                0,                      $ All bits significant
                0x0001,                 $ Poll only connection
                "Status, FP-Flow, FP-Setpoint, Override, FP-Valve",    $ Input
Instance 18
```

```
                6,                      $ Connection Path Size 6
                "20 04 24 12 30 03",    $ Assembly Object Instance 18
                "-";                    $ Help string
        Output1 =
                2,                      $ 2 bytes
                0,                      $ All bits significant
                0x0001,                 $ Poll only connection
                "Setpoint",             $ Output Instance 7
                6,                      $ Connection Path Size 6
                "20 04 24 07 30 03",    $ Assembly Object Instance 7
                "-";                    $ Help string
        Output2 =
                3,                      $ 3 bytes
                0,                      $ All bits significant
                0x0001,                 $ Poll only connection
                "Override, Setpoint",   $ Output Instance 8
                6,                      $ Connection Path Size 6
                "20 04 24 08 30 03",    $ Assembly Object Instance 8
                "-";                    $ Help string
        Output3 =
                4,                      $ 4 bytes
                0,                      $ All bits significant
                0x0001,                 $ Poll only connection
                "FP-Setpoint",          $ Output Instance 19
                6,                      $ Connection Path Size 6
                "20 04 24 13 30 03",    $ Assembly Object Instance 19
                "-";                    $ Help string
        Output4 =
                5,                      $ 5 bytes
                0,                      $ All bits significant
                0x0001,                 $ Poll only connection
                "Override, FP-Setpoint",$ Output Instance 20
                6,                      $ Connection Path Size 6
                "20 04 24 14 30 03",    $ Assembly Object Instance 20
                "-";                    $ Help string

$ End of DeviceNet EDS File
```