

DeviceNet™ Supplemental Manual

GF40/GF80 Series Mass Flow Controllers & Meters

BROOKS®
INSTRUMENT

Beyond Measure

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Introduction

This document and the DeviceNet Statement of Compliance (SOC) from the Open DeviceNet Vendors Association (ODVA) provide a complete interoperability specification for the GF40/GF80 Series Digital Mass Flow Controller device from Brooks. This device is defined by the ODVA specification in the Device Profiles chapter, section entitled “Enhance Mass Flow Controller, Type: 27_{hex}”. The primary difference in this profile from the original Mass Flow Controller profile, type = 1A_{hex}, is that this device profile supports a flow and temperature instance of the S-Analog Sensor Object. Information contained in this document was derived from the following sources:

DeviceNet Specification Enhancements for the S-Device Supervisor Objects:

S-Device Supervisor Object (DSE-93-01)¹

S-Analog Sensor Object (DSE-93-02)²

S-Analog Actuator Object (DSE-93-03)³

S-Single Stage Controller Object (DSE-93-04)⁴

S-Gas Calibrator Object (DSE-93-05)⁵

ODVA Mass Flow Controller Device Profile (DSE 93-06)⁶

ODVA DeviceNet Specifications Version 2.0⁷

ODVA Enhanced Mass Flow Controller Device Profile (Edition 3.4, CIP Spec.)

AMAT (various docs)

This device also complies with the ODVA Semiconductor SIG Interface Guidelines for DeviceNet Devices on Semiconductor Manufacturing Tools. The GF40/GF80 Series Digital Mass Flow Controller (hereafter referred to as GF40/GF80 Series) supports the following DeviceNet objects: Identity, DeviceNet, Connection, and Assembly. In addition, support is also provided for the S-Device Supervisor, S-Analog Sensor, S-Analog Actuator, S-Single Stage Controller, and S-Gas Calibration objects. Supported objects are summarized in the following table.

| Object Class | Subclass | | Optional/Required | # of Instances |
|----------------------------|----------|------|----------------------------------|--------------------------------------|
| | Class | Inst | | |
| Identity | | | Required | 1 |
| Message Router | | | Required | 1 |
| DeviceNet | | | Required | 1 |
| Connection | | | Required (note 1) | at least 1 I/O Polled and 1 Explicit |
| Acknowledge Handler Object | | | Conditional (note 2) | 1 |
| Assembly | | | Required | at least 1 Input and 1 Output |
| S-Device Supervisor | | | Required | 1 |
| S-Gas Calibration | | 01 | Optional (Supported) | 0 or More |
| S-Analog Sensor | | 01 | Required (note 3) | 3 |
| S-Analog Actuator | | | Conditional (note 4) (Supported) | 1 |
| S-Single Stage Controller | | | Conditional (note 4) (Supported) | 1 |

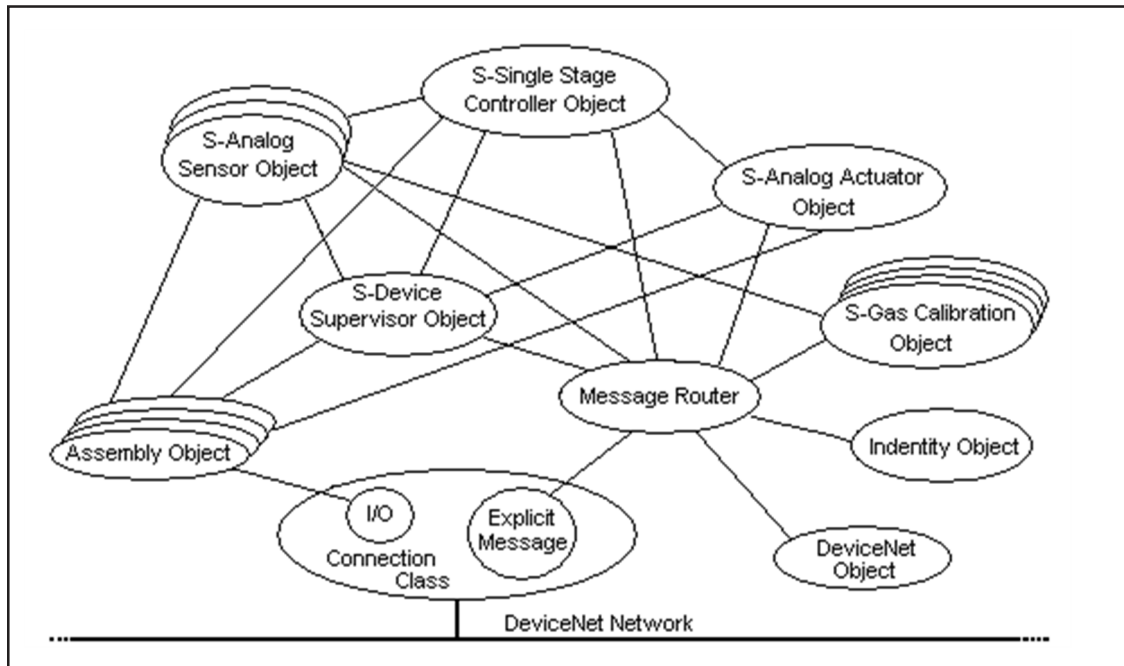
Notes:

1. GF40/GF80 Series supports one I/O Polled and one Explicit Connection
2. Required for Change-of-State/Cyclic I/O connection support. (Not supported).
3. The GF40/GF80 Series supports three instances of the S-Analog Sensor object; instance 1 for flow, instance 2 for pressure and instance 3 for temperature. This conforms to the Enhanced MFC profile, device type = 27_{hex}.
4. Required for a Mass Flow Controller, a device that contains a Valve and a Controller. Not supported in a Mass Flow Meter Device (an MFC without a Valve or a Controller).

Device Profile –Enhanced Mass Flow Controller Device (Type 0x27)

A Mass Flow Controller is a device that measures and controls the mass flow rate of gas or liquid. The MFC contains three principle components: a mass flow rate sensor, a metering valve, and a closed-loop controller. The sensor can consist of a variety of types, including thermal or pressure-based. Flow can be regulated by a variety of actuator types, including solenoid, voice coil, or piezoelectric transducer. The closed-loop controller accepts a setpoint from the host and controls the flow to that setpoint. Control is accomplished by monitoring the flow and adjusting the valve position to reduce the error between the setpoint flow value and actual flow value.

Object Model for Mass Flow Controller



Object Model for the MFC Device

How Objects Affect Behavior

| Object | Effect on behavior |
|---------------------------|--|
| Identity | Supports the Reset service. Upon receipt of a Reset Service Request of any Type, the Identity Object sends a Reset Service Request to the S-Device Supervisor. |
| Message Router | No effect |
| DeviceNet | Configures port attributes (node address, data rate, and BOI) |
| Connection Class | Contains the number of logical ports into or out of the device |
| Acknowledge Handler | Used to manage the reception of I/O message acknowledgements. (Not used or required in the GF40/ GF80 Series). |
| Assembly | Defines input/output and configuration data format |
| S-Device Supervisor | Supports the Stop, Start, Reset, Abort, Recover and Perform_Diagnostic services for ALL Application Objects in the device and consolidates the Exception Conditions and Application Objects' Status. This object behaves differently from the Identity Object in that the S-Device Supervisor object provides a single point of access to the Application Objects only; it does not effect the DeviceNet specific objects (i.e., Identity, DeviceNet, Connection, etc.). |
| S-Gas Calibration | Modifies the correction algorithm of the S-Analog Sensor object which includes the selection mechanism to enable an S-Gas Calibration object instance. |
| S-Analog Sensor | Feeds the process variable to the Single Stage Controller object |
| S-Single Stage Controller | Feeds the control variable to the Analog Actuator object |
| S-Analog Actuator | Operates the Flow Control Valve of the device |

The Identity Object provides general information about the identity of a device. This object is summarized in the following tables.

Instance Attributes

| Attribute ID | Need in Implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|------------------------|-------------|---------------|---------------------|---|
| 1 | Required | Get | Vendor ID | UINT | ODVA Assigned Vendor Number = 41 (0x29) |
| 2 | Required | Get | Device Type | UINT | ODVA Assigned Device Number = 26 (0x1A) |
| 3 | Required | Get | Product Code | UINT | Brooks Assigned Product Number = 726 |
| 4 | Required | Get | Revision | STRUCT of: | Product Revision |
| | | | Major Rev | USINT | (byte) |
| | | | Minor Rev | USINT | (byte) |
| 5 | Required | Get | Status | WORD | DeviceNet Status |
| 6 | Required | Get | Serial Number | UDINT | DeviceNet Device Serial Number |
| 7 | Required | Get | Product Name | SHORT STRING | "GF40" of "GF80" (1-32 Characters) |

Common Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|--|------------------------|----------|-----------------------|--|
| | Class | Instance | | |
| 0E _{hex} 14 _{dec} | Conditional | Required | Get_Attributes_Single | Returns the contents of the specified attribute. |
| 05 _{hex} 05 _{dec} | n/a | Required | Reset | Resets the device to the Self-Testing state. |

RESET Request Service Data Field Parameters

| Parameter | Required | Data Type | Description | Semantics of Values |
|-----------|----------|-----------|---------------|--|
| Type | Required | USINT | Type of Reset | 0 = Power Cycle type [default if parameter omitted] 1 = Out-of-Box type |

The DeviceNet Object maintains configuration and status of physical attachments to DeviceNet. It also allocates and releases connection instances associated with the Predefined Master/Slave Connection Set.

Instance Attributes

| Attribute ID | Need in implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|-------------------------|-------------|-----------------------------------|---------------------|---|
| 1 | Required | Set | MAC ID | USINT (byte) | Values 0-63 or "P" (Programmable Mac Id) See Semantics |
| 2 | Required | Set | Baud Rate | USINT (byte) | Values 0,1,2 or "P" See Semantics |
| 3 | Required | Set | BOI | USINT (byte) | Bus Off Interrupt |
| 4 | Required | Set | Bus-off Counter | USINT (byte) | Number of times CAN chip went to bus off state |
| 5 | Required | Get | Allocation Information | USINT (byte) | Indicates whether or not the Predefined Master/Slave Connection Set has been allocated |
| 6 | Conditional (supported) | Get | MAC ID switch changed (note 1) | BOOL | Indicates the Node ID switches have changed since last power-up or reset. 0=no change, 1=change |
| 7 | Conditional (supported) | Get | Baud Rate switch changed (note 1) | BOOL | Indicates the baud rate switch has changed since last power-up or reset. 0=no change, 1=change |
| 8 | Conditional (supported) | Get | MAC ID switch value | USINT (byte) | Actual value of the Node address switches, (0-99) |
| 9 | Conditional (supported) | Get | Baud rate switch value | USINT (byte) | Actual value of the baud rate switch, (0-9) |

Note

1. When either one of these two attributes are true (=1), then the module LED will flash red to indicate the status. See section 3.4, Module LED, for more information.

Common Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|--|------------------------|----------|--|---|
| | Class | Instance | | |
| 0E _{hex} 14 _{dec} | Conditional | Required | Get_Attributes_Single | Returns the contents of the specified attribute. |
| 10 _{hex} 16 _{dec} | n/a | Required | Set_Attributes_Single | Sets the attribute to the specified value |
| 4B _{hex} 75 _{dec} | n/a | Required | Allocate_Master/ Slave_Connection_Set | This is the Service utilized to perform the allocation of the Predefined Master/Slave Connection Set. |
| 4C _{hex} 76 _{dec} | n/a | Required | Release_Master/ Slave_Connection_Set | This service is used to deallocate the Predefined Master/Slave Connection Set within a Slave |

Semantics

The MAC ID and Baud Rate are switch selectable. Baud Rate will be 125K, 250K, or 500K baud if the switch is set to 1,2,5 respectively. The MAC ID switch sets the unit's DeviceNet address to 0-63, according to the switch settings. Both switches may be placed in the "P" position, which selects "programmable" MAC ID or Baud Rate. If the switch is placed in the "P" position, the MAC ID or Baud Rate will assume the last valid value. MAC ID and Baud Rate attributes are software settable ONLY when the switches are in the "P" position. Behavior related to the MAC ID and the Baud Rate attributes conforms to the requirements defined in the [Open DeviceNet Vendor Association Semiconductor Special Interest Group \(SIG\) Interface Guidelines Conformance Test Procedure](#) (Section 5.6).

Module Status LED

The module status LED indicates the status of the MFC Module.

| Module Status | LED State | Description |
|---------------------|--------------------|---|
| Power Off | Off | No Power applied to device |
| Device Self-test | Flashing Green-Red | Device is in Self-test. The Module LED will flash Green for 250mSec, followed by RED for 250mSec. If the device passes the self-test, LED will stay Green |
| Device Operational | Green | Device is operating normally. |
| Recoverable Fault | Flashing Red | The Node (MAC ID) address or baud rate switches have changed since the last power-up/reset. |
| Unrecoverable Fault | Red | Device has detected an unrecoverable fault. |

Net Status LED

The Network status LED indicates the status of the MFC DeviceNet Connection.

| Network Status | LED State | Description |
|-----------------------|----------------|--|
| Power Off | Off | No Power applied or device is the only node on the network. |
| On-line Not Connected | Flashing Green | Device is Operating normally. It is on-line, but no connections have been established to the Device. |
| Device Operational | Green | Device is operating normally. |
| Connection Timeout | Flashing Red | One or more connections have timed out. |
| Unrecoverable Fault | Red | Device cannot communicate on the network. Duplicate MacId or Bus-off condition |

The Assembly Object groups attributes of multiple objects into a single block of data, which can be produced and consumed over an I/O connection. Various combinations of S-Device Supervisor Attributes are grouped together to form the assemblies supported by GF40/GF80. Both the MFC and EMFC device profiles do NOT allow “mixed” integer and real assemblies to be allowed at the same time. That is, it is not allowed to produce an integer assemble and consume a floating-point assembly over a polled connection. See the EMFC Device Profile in the ODVA DeviceNet specification for more detail.

Instance Attributes

| Number | Required | Supported | Type | # Bytes | Name |
|--------|-------------|-----------|--------|---------|---|
| 1 | N | Y | Input | 2 | Flow |
| 2 | Y (default) | Y | Input | 3 | Status and Flow |
| 3 | N | Y | Input | 5 | Status, Flow and Valve |
| 4 | N | Y | Input | 5 | Status, Flow, and Setpoint |
| 5 | N | Y | Input | 7 | Status, Flow, Setpoint and Valve |
| 6 | Y | Y | Input | 8 | Status, Flow, Setpoint, Override and Valve |
| 7 | Y (default) | Y | Output | 2 | Setpoint |
| 8 | Y | Y | Output | 3 | Override and Setpoint |
| 9 | N | Y | Input | 1 | Status |
| 10 | N | Y | Input | 8 | Exception Detail Alarm |
| 11 | N | Y | Input | 8 | Exception Detail Warning |
| 12 | N | Y | Input | 15 | Exception Detail Alarm and Exception Detail Warning |
| 13 | N | Y | Input | 4 | FP Flow |
| 14 | Y | Y | Input | 5 | Status. FP Flow |
| 15 | N | Y | Input | 9 | Status, FP Flow and FP Valve |
| 16 | N | Y | Input | 9 | Status, FP Flow, and FP Setpoint |
| 17 | N | Y | Input | 13 | Status, FP Flow, FP Setpoint and FP Valve |
| 18 | Y | Y | Input | 14 | Status, FP Flow, FP Setpoint, Override and FP Valve |
| 19 | Y | Y | Output | 4 | FP Setpoint |
| 20 | Y | Y | Output | 5 | Override and FP Setpoint |

The number of bytes indicates how many data bytes are produced or consumed for each assembly. The “FP” abbreviation is for Floating Point, or real data. Each real data value will consist of 4 bytes of IEEE 754 single precision data.

Common Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|--|------------------------|----------|-----------------------|--|
| | Class | Instance | | |
| 0E _{hex} 14 _{dec} | Conditional | Required | Get_Attributes_Single | Returns the contents of the specified attribute. |

Object Instances

Producing Object Instances must be one of the following: 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 17, or 18. These instances send data to the master. Consuming Object Instances must be one of the following: 7, 8, 19, or 20. These instances receive data from the master. As mentioned before, both the Produced and Consumed Paths must reference either integer OR real assemblies. The following section details each assembly and its data type. The “FP” designation will indicate a real, floating point value. Otherwise, the data will be an integer or, in the case of the “status” byte, a bit-mapped value.

I/O Assembly Object Instance Data Attribute Format

The manufacturer of a Mass Flow Controller Device must specify which Assembly instances are supported by the device. GF40/GF80 supports the following assemblies.

The I/O Assembly DATA attribute has the format shown below.

| Instance | Byte | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|----------|------|----------------------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 0 | Flow (low byte) | | | | | | | |
| | 1 | Flow (high byte) | | | | | | | |
| 2 | 0 | Status | | | | | | | |
| | 1 | Flow (low byte) | | | | | | | |
| | 2 | Flow (high byte) | | | | | | | |
| 3 | 0 | Status | | | | | | | |
| | 1 | Flow (low byte) | | | | | | | |
| | 2 | Flow (high byte) | | | | | | | |
| | 3 | Valve (low byte) | | | | | | | |
| | 4 | Valve (high byte) | | | | | | | |
| 4 | 0 | Status | | | | | | | |
| | 1 | Flow (low byte) | | | | | | | |
| | 2 | Flow (high byte) | | | | | | | |
| | 3 | Setpoint (low byte) | | | | | | | |
| | 4 | Setpoint (high byte) | | | | | | | |
| 5 | 0 | Status | | | | | | | |
| | 1 | Flow (low byte) | | | | | | | |
| | 2 | Flow (high byte) | | | | | | | |
| | 3 | Setpoint (low byte) | | | | | | | |
| | 4 | Setpoint (high byte) | | | | | | | |
| | 5 | Valve (low byte) | | | | | | | |
| | 6 | Valve (high byte) | | | | | | | |

| Instance | Byte | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|----------|------|---|-------|-------|-------|-------|-------|-------|-------|
| 6 | 0 | Status | | | | | | | |
| | 1 | Flow (low byte) | | | | | | | |
| | 2 | Flow (high byte) | | | | | | | |
| | 3 | Setpoint (low byte) | | | | | | | |
| | 4 | Setpoint (high byte) | | | | | | | |
| | 5 | Override | | | | | | | |
| | 6 | Valve (low byte) | | | | | | | |
| | 7 | Valve (high byte) | | | | | | | |
| 7 | 0 | Setpoint (low byte) | | | | | | | |
| | 1 | Setpoint (high byte) | | | | | | | |
| 8 | 0 | Status | | | | | | | |
| | 1 | Flow (low byte) | | | | | | | |
| | 2 | Flow (high byte) | | | | | | | |
| 9 | 0 | Status | | | | | | | |
| 10 | 0 | Status | | | | | | | |
| | 1 | Exceptional Detail Alarm 0 (size, common) | | | | | | | |
| | 2 | Exceptional Detail Alarm 1 (common 0) | | | | | | | |
| | 3 | Exceptional Detail Alarm 2 (common 1) | | | | | | | |
| | 4 | Exceptional Detail Alarm 3 (size, common) | | | | | | | |
| | 5 | Exceptional Detail Alarm 4 (device 0) | | | | | | | |
| | 6 | Exceptional Detail Alarm 5 (size, manufacturer) | | | | | | | |
| | 7 | Exceptional Detail Alarm 6 (manufacturer, 0) | | | | | | | |
| 11 | 0 | Status | | | | | | | |
| | 1 | Exceptional Detail Warning 0 (size, common) | | | | | | | |
| | 2 | Exceptional Detail Warning 1 (common 0) | | | | | | | |
| | 3 | Exceptional Detail Warning 2 (common 1) | | | | | | | |
| | 4 | Exceptional Detail Warning 3 (size, device) | | | | | | | |
| | 5 | Exceptional Detail Warning 4 (device 0) | | | | | | | |
| | 6 | Exceptional Detail Warning 5 (size, manufacturer) | | | | | | | |
| | 7 | Exceptional Detail Warning 6 (manufacturer, 0) | | | | | | | |

| Instance | Byte | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|----------|--|---|-------|-------|-------|-------|-------|-------|-------|
| 12 | 0 | Status | | | | | | | |
| | 1 | Exception Detail Alarm 0 (size, common) | | | | | | | |
| | 2 | Exception Detail Alarm 1 (common 0) | | | | | | | |
| | 3 | Exception Detail Alarm 2 (common 1) | | | | | | | |
| | 4 | Exception Detail Alarm 3 (size, device) | | | | | | | |
| | 5 | Exception Detail Alarm 4 (device 0) | | | | | | | |
| | 6 | Exception Detail Alarm 5 (size, manufacturer) | | | | | | | |
| | 7 | Exception Detail Alarm 6 (manufacturer, 0) | | | | | | | |
| | 8 | Exception Detail Warning 0 (size, common) | | | | | | | |
| | 9 | Exception Detail Warning 1 (common 0) | | | | | | | |
| | 10 | Exception Detail Warning 2 (common 1) | | | | | | | |
| | 11 | Exception Detail Warning 3 (size, device) | | | | | | | |
| | 12 | Exception Detail Warning 4 (device 0) | | | | | | | |
| | 13 | Exception Detail Warning 5 (size, manufacturer) | | | | | | | |
| 14 | Exception Detail Warning 6 (manufacturer, 0) | | | | | | | | |
| 13 | 0 | FP Flow (low byte) | | | | | | | |
| | 1 | FP Flow | | | | | | | |
| | 2 | FP Flow | | | | | | | |
| | 3 | FP Flow (high byte) | | | | | | | |
| 14 | 0 | Status | | | | | | | |
| | 1 | FP Flow (low byte) | | | | | | | |
| | 2 | FP Flow | | | | | | | |
| | 3 | FP Flow | | | | | | | |
| | 4 | FP Flow (high byte) | | | | | | | |

| Instance | Byte | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|----------|------|-------------------------|-------|-------|-------|-------|-------|-------|-------|
| 15 | 0 | Status | | | | | | | |
| | 1 | FP Flow (low byte) | | | | | | | |
| | 2 | FP Flow | | | | | | | |
| | 3 | FP Flow | | | | | | | |
| | 4 | FP Flow (high byte) | | | | | | | |
| | 5 | FP Valve (low byte) | | | | | | | |
| | 6 | FP Valve | | | | | | | |
| | 7 | FP Valve | | | | | | | |
| | 8 | FP Valve (high byte) | | | | | | | |
| 16 | 0 | Status | | | | | | | |
| | 1 | FP Flow (low byte) | | | | | | | |
| | 2 | FP Flow | | | | | | | |
| | 3 | FP Flow | | | | | | | |
| | 4 | Flow (high byte) | | | | | | | |
| | 5 | FP Setpoint (low byte) | | | | | | | |
| | 6 | FP Setpoint | | | | | | | |
| | 7 | FP Setpoint | | | | | | | |
| | 8 | FP Setpoint (high byte) | | | | | | | |

| Instance | Byte | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|----------|----------------------|-------------------------|-------|-------|-------|-------|-------|-------|-------|
| 17 | 0 | Status | | | | | | | |
| | 1 | FP Flow (low byte) | | | | | | | |
| | 2 | FP Flow | | | | | | | |
| | 3 | FP Flow | | | | | | | |
| | 4 | FP Flow (high byte) | | | | | | | |
| | 5 | FP Setpoint (low byte) | | | | | | | |
| | 6 | FP Setpoint | | | | | | | |
| | 7 | FP Setpoint | | | | | | | |
| | 8 | FP Setpoint (high byte) | | | | | | | |
| | 9 | FP Valve (low byte) | | | | | | | |
| | 10 | FP Valve | | | | | | | |
| | 11 | FP Valve | | | | | | | |
| | 12 | FP Valve (high byte) | | | | | | | |
| 18 | 0 | Status | | | | | | | |
| | 1 | FP Flow (low byte) | | | | | | | |
| | 2 | FP Flow | | | | | | | |
| | 3 | FP Flow | | | | | | | |
| | 4 | FP Flow (high byte) | | | | | | | |
| | 5 | FP Setpoint (low byte) | | | | | | | |
| | 6 | FP Setpoint | | | | | | | |
| | 7 | FP Setpoint | | | | | | | |
| | 8 | FP Setpoint (high byte) | | | | | | | |
| | 9 | Override | | | | | | | |
| | 10 | FP Valve (low byte) | | | | | | | |
| | 11 | FP Valve | | | | | | | |
| | 12 | FP Valve | | | | | | | |
| 13 | FP Valve (high byte) | | | | | | | | |

| Instance | Byte | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|----------|------|-------------------------|-------|-------|-------|-------|-------|-------|-------|
| 19 | 0 | FP Setpoint (low byte) | | | | | | | |
| | 1 | FP Setpoint | | | | | | | |
| | 2 | FP Setpoint | | | | | | | |
| | 3 | FP Setpoint (high byte) | | | | | | | |
| 20 | 0 | Override | | | | | | | |
| | 1 | FP Setpoint (low byte) | | | | | | | |
| | 2 | FP Setpoint | | | | | | | |
| | 3 | FP Setpoint | | | | | | | |
| | 4 | FP Setpoint (high byte) | | | | | | | |

The Connection Class allocates and manages internal resources associated with both I/O and Explicit Messaging connections. The Explicit and I/O Connection Objects manage the communication aspects associated with a particular application to application network relationships. The GF40/GF80 supports both the Explicit and Polled or I/O Connections.

Instance Attributes (Explicit Connection, Instance 1)

| Attribute ID | Need in implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|-------------------------|-------------|-------------------------------|---------------------|--|
| 1 | Required | Get | State | USINT (byte) | State of the object |
| 2 | Required | Get | Instance Type | USINT (byte) | Indicates either I/O or Messaging Connection |
| 3 | Required | Get | Transport Class Trigger | Byte | Defines behavior of the Connection |
| 4 | Required | Get | Produced Connection ID | UINT | Placed in CAN Identifier Field when connection transmits |
| 5 | Required | Get | Consumed Connection ID | UINT | CAN Identifier Field value that denotes message to be received |
| 6 | Required | Get | Initial Comm. Characteristics | Byte | Defines the Message Group(s) across which productions and consumptions associated with this Connection occur |
| 7 | Required | Get | Produced Connection Size | UINT | Maximum number of bytes transmitted across this connection |
| 8 | Required | Get | Consumed Connection Size | UINT | Maximum number of bytes transmitted across this connection |
| 9 | Required | Set | Expected Packet Rate | UINT | Defines timing associated with this Connection |
| 12 | Required | Set | Watchdog time-out Action | USINT (byte) | Defines how to handle Inactivity/Watchdog timeouts |
| 13 | Required | Get | Produced Path Length | UINT | Number of bytes in the produced_connection_path length |
| 14 | Required | Get | Produced Connection Path | Array of USINT | Specifies the Application Object(s) whose data is to be produced by this Connection Obj. |
| 15 | Required | Get | Consumed Path Length | UINT | Number of bytes in the consumed_connection_path attr. |
| 16 | Required | Get | Consumed Connection Path | Array of USINT | Specifies the Application Objs that are to receive data consumed by this Connection Obj. |
| 17 | Conditional (supported) | Get | Production Inhibit time | UINT | Defines minimum time between new data production. This attribute is required for I/O Client Connections. (default = 0) |

Instance Attributes (Polled Connection, Instance 2)

| Attribute ID | Need in implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|-------------------------|-------------|-------------------------------|---------------------|--|
| 1 | Required | Get | State | USINT (byte) | State of the object |
| 2 | Required | Get | Instance Type | USINT (byte) | Indicates either I/O or Messaging Connection |
| 3 | Required | Get | Transport Class Trigger | Byte | Defines behavior of the Connection, (server, class 2) |
| 4 | Required | Get | Produced Connection ID | UINT | Placed in CAN Identifier Field when connection transmits |
| 5 | Required | Get | Consumed Connection ID | UINT | CAN Identifier Field value that denotes message to be received |
| 6 | Required | Get | Initial Comm. Characteristics | Byte | Defines the Message Group(s) across which productions and consumptions associated with this Connection occur |
| 7 | Required | Get | Produced Connection Size | UINT | Maximum number of bytes transmitted across this connection |
| 8 | Required | Get | Consumed Connection Size | UINT | Maximum number of bytes transmitted across this connection |
| 9 | Required | Set | Expected Packet Rate | UINT | Defines timing associated with this Connection |
| 12 | Required | Get | Watchdog time-out Action | USINT (byte) | Defines how to handle Inactivity/ Watchdog timeouts |
| 13 | Required | Get | Produced Path Length | UINT | Number of bytes in the produced_connection_path length |
| 14 | Required | Set (*) | Produced Connection Path | Array of USINT | Specifies the Application Object(s) whose data is to be produced by this Connection Obj. |
| 15 | Required | Get | Consumed Path Length | UINT | Number of bytes in the consumed_connection_path attr. |
| 16 | Required | Set(*) | Consumed Connection Path | Array of USINT | Specifies the Application Objs that are to receive data consumed by this Connection Obj. |
| 17 | Conditional (supported) | Get | Production Inhibit time | UINT | Defines minimum time between new data production. This attribute is required for I/O Client Connections. (default = 0) |

(*) Note:

Produced and Consumed Connection Path attributes are settable ONLY when the I/O connection is in the "Configuring" State. These attributes must reference consistent data types at the time the I/O connection transitions to the Established State. See MFC Device Profile, Version J for more information regarding consistent data types.

Common Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|--|------------------------|-------------------------|-----------------------|--|
| | Class | Instance | | |
| 0E _{hex} 14 _{dec} | Conditional | Required | Get_Attributes_Single | Returns the contents of the specified attribute. |
| 10 _{hex} 16 _{dec} | n/a | Required | Set_Attributes_Single | Sets the attribute to the specified value |
| 05 _{hex} 05 _{dec} | n/a | Optional (supported) | Reset | Dependent on watchdog timeout action. |

This object models the interface, functions and behavior associated with the management of application objects for devices within the “*Hierarchy of Semiconductor Equipment Devices*”. Throughout this DeviceNet Standard, objects belonging to this hierarchy are identified as such by a naming convention that includes a prefix of “S-” in the object class name. This “*Hierarchy of Semiconductor Equipment Devices*” is completely defined in this object definition such that all objects belonging to this hierarchy require the existence of an S-Device Supervisor object to manage its functions and behaviors.

The S-Device Supervisor object centralizes application object state definitions and related status information, exception status indications (alarms and warnings), and defines a behavior model which is assumed by objects identified as belonging to the *Hierarchy of Semiconductor Equipment Devices*. If a reset is requested of the S-Device Supervisor object instance, it will reset this object instance as well as all of its associated application objects.

Similarly, the Identity object provides an interface to the S-Device Supervisor object. A reset request to the Identity object (of any type) causes a reset request to the S-Device Supervisor object. Further relationships are specified in the Behavior section below.

Additionally, some device attributes are defined which are required in order to specify device models such that they are compliant with the SEMI S/A Network Standard*, from which the *Hierarchy of Semiconductor Equipment Devices* is derived. Objects defined to exist within the *Hierarchy of Semiconductor Equipment Devices* are done so in order to simplify the management and description of object behavior while insuring compliance with the SEMI Standard.

NOTE: By association with this object, the Start, Stop, Reset, Abort, Recover and Perform_Diagnostic Services are inherently supported by all objects within the *Hierarchy of Semiconductor Equipment Devices*. These services are not accessible over the network for the associated object instances.

* Semiconductor Equipment and Materials International, Mountain View CA, Standard E54: *Sensor/Actuator Network Common Device Model*.

S-Device Supervisor Class Attributes

The Object Class Attribute ID 1-7 are reserved. See DeviceNet Volume II, Section 5-4.1. for more specification detail on these attributes.

| Attribute ID | Need in implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|---|-------------|----------|---------------------|---|
| 1 thru 7 | These class attributes are either optional or conditional and are described in chapter 5 of this specification. | | | | |
| 97 & 98 | Reserved by DeviceNet | | | | |
| 99 | Conditional* (Not Supported) | Get | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The subclasses for this object are specified at the end of this object specification section. |

* If the value of Subclass is 00 which identifies “no subclass”, then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

S-Device Supervisor Instance Attribute

DeviceNet reserves Attribute ID 100-199 (64_{hex}-C7_{hex}) for Vendor Defined Attributes. See Volume II, Section 7 for more information on Object Definitions.

| Attr ID | Need in implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute |
|---------|------------------------|-------------|-----|------------------------------|------------------------|--|
| 1 | Optional (Supported) | Get | NV | Number of Attributes | USINT (byte) | Number of Attributes supported by the object instance |
| 2 | Optional (Supported) | Get | NV | Attribute List | Array of USINT (bytes) | List of attributes supported by the object instance |
| 3 | Required | Get | NV | Device Type | SHORT STRING | ASCII Text, Max. 8 Characters, see "Semantics" section |
| 4 | Required | Get | NV | SEMI Standard Revision Level | SHORT STRING | Specifies the revision level of the SEMI S/A Network Standard to which the device complies. For this revision, this attribute must be: "E54-0997" |
| 5 | Required | Get | NV | Manufacturer's Name | SHORT STRING | ASCII Text, Max. 20 Characters, see "Semantics" section |
| 6 | Required | Get | NV | Manufacturer's Model Number | SHORT STRING | ASCII Text, Max. 20 Characters, Manufacturer Specified |
| 7 | Required | Get | NV | Software Revision Level | SHORT STRING | ASCII Text, Max. 6 Characters, see "Semantics" section |
| 8 | Required | Get | NV | Hardware Revision Level | SHORT STRING | ASCII Text, Max. 6 Characters, see "Semantics" section |
| 9 | Optional (Supported) | Get | NV | Manufacturer's Serial Number | SHORT STRING | ASCII Text, Max. 30 Characters, Manufacturer Specified, see "Semantics" section |
| 10 | Optional (Supported) | Get | NV | Device Configuration | SHORT STRING | ASCII Text, Max. 50 Characters, Manufacturer Specified. Optional additional information about the device configuration. |
| 11 | Required | Get | V | Device Status | USINT (byte) | See "Semantics" section |
| 12 | Required | Get | V | Exception Status | BYTE | See "Semantics" section |

* NV = Nonvolatile; attribute value is maintained through power cycles; V = Volatile.

Note: All required attributes are supported. Optional attributes are indicated as (Supported) or (Not Supported).

| Attr ID | Need in implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute |
|---------|---|-------------|-----|--------------------------------------|---------------------|--|
| 13 | Conditional based on Exception Status Bit 7 (Supported) | Get | V | Exception Detail Alarm | STRUCT of: | A Structure of three Structures containing a bit mapped representation of the alarm detail |
| | | | | Common Exception Detail | STRUCT of: | |
| | | | | Size | USINT (byte) | Number of Common Detail Bytes (size = 2) |
| | | | | Detail | ARRAY of: | See "Semantics" section |
| | | | | Detail n | BYTE | See "Semantics" section |
| | | | | Device Exception Detail | STRUCT of: | |
| | | | | Size | USINT (byte) | Number of Device Detail Bytes (size = 1) |
| | | | | Detail | ARRAY of: | See Device Profile |
| | | | | Detail n | BYTE | See Device Profile |
| | | | | Manufacturer Exception Detail | STRUCT of: | |
| | | | | Size | USINT (byte) | Number of Manufacturer Detail Bytes (size = 1) |
| | | | | Detail n | BYTE | Manufacturer Specified |

* NV = Nonvolatile; attribute value is maintained through power cycles; V = Volatile.

Note:
 The GF40/GF80 Series Device Profile specifies two bytes of Common Detail, two bytes of Device Exception Detail, and one byte of Manufacturer Specified Detail. See Semantics for more information.

| Attr ID | Need in implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute |
|---------|---|-------------|-----|--------------------------------------|---------------------|--|
| 14 | Conditional based on Exception Status Bit 7 (Supported) | Get | V | Exception Detail Warning | STRUCT of: | A Structure of three Structures containing a bit mapped representation of the warning detail |
| | | | | Common Exception Detail | STRUCT of: | |
| | | | | Size | USINT (byte) | Number of Common Detail Bytes (size = 2) |
| | | | | Detail | ARRAY of: | See "Semantics" section |
| | | | | Detail n | BYTE | See "Semantics" section |
| | | | | Device Exception Detail | STRUCT of: | |
| | | | | Size | USINT (byte) | Number of Device Detail Bytes (size = 1) |
| | | | | Detail | ARRAY of: | See Device Profile |
| | | | | Detail n | BYTE | See Device Profile |
| | | | | Manufacturer Exception Detail | STRUCT of: | |
| | | | | Size | USINT (byte) | Number of Manufacturer Detail Bytes (size = 1) |
| | | | | Detail n | BYTE | Manufacturer Specified |

* NV = Nonvolatile; attribute value is maintained through power cycles; V = Volatile.

Note:

The GF40/GF80 Series Device Profile specifies two bytes of Common Detail, two bytes of Device Exception Detail, and one byte of Manufacturer Specified Detail. See Semantics for more information.

| Attr ID | Need in implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute |
|---------|--|-------------|-----|---|---------------------|---|
| 15 | Required | Set | NV | Alarm Enable | BOOL | See "Semantics" section |
| 16 | Required | Set | NV | Warning Enable | BOOL | See "Semantics" section |
| 17 | Optional (Not Supported) | Set | ** | Time | DATE_AND_TIME | The value of the device's internal real-time clock. See "Semantics" section |
| 18 | Optional (Not Supported) | Get | NV | ** Clock Behavior | USINT (byte) | 0 = [default] clock always resets during power cycle 1 = clock value is stored in non-volatile memory at power down 2 = clock is battery-backed and runs without device power. 3-255 - not defined |
| 19 | Optional (Not Supported) | Get | NV | Last Maintenance Date | DATE | The date on which the device was last serviced. |
| 20 | Optional (Not Supported) | Get | NV | Next Scheduled Maintenance Date | DATE | The date on which it is recommended that the device next be serviced. |
| 21 | Optional (Not Supported) | Get | NV | Scheduled Maintenance Expiration Timer | INT | See "Semantics" section |
| 22 | Conditional – Required if Calibration Expiration is supported (Not Supported) | Set | NV | Scheduled Maintenance Expiration Warning Enable | BOOL | See "Semantics" section |
| 23 | Optional (Not Supported) | Get | NV | Run Hours | UDINT | An indication of the number of hours that the device has had power applied. It has a resolution of 1 hour. This value shall be maintained in nonvolatile memory. |

* NV = Nonvolatile; attribute value is maintained through power cycles; V = Volatile.

** If the value of Subclass is 00 which identifies "no subclass", then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

| Attr ID | Need in implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute |
|---------|----------------------------------|-------------|-----|----------|---------------------|---|
| 97-98 | Reserved by DeviceNet | | | | | |
| 99 | Conditional** (Not Supported) | Get | NV | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The subclasses for this object are specified at the end of this object specification section. |

* NV = Nonvolatile; attribute value is maintained through power cycles; V = Volatile.

** If the value of Subclass is 00 which identifies "no subclass", then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

Semantics

Device Type

The Device Type attribute identifies the Specific Device Model to which the device is modeled within the Hierarchy of Semiconductor Equipment Devices. The value returned for this attribute is "MFC" or "MFM", depending upon the configuration of the device.

Manufacturer's Name

The Manufacturer's Name attribute identifies the manufacturer of the device. The value returned for this attribute is "Brooks Instrument".

The Device Manufacturer attribute is not guaranteed, by specification, to be unique. Therefore, it is not a substitute for the corresponding attribute of the Identity Object and should not be used for identification purposes.

Software Revision Level

This is an ASCII coded text string representing the revision of the software corresponding to the specific device identified by the Identity object and the S-Device Supervisor object.

Hardware Revision Level

This is an ASCII coded text string representing the revision of the hardware, which is identified by the Identity object and the S-Device Supervisor object.

Manufacturer's Serial Number

This attribute is a string representation of the serial number of the device. This is not the same as the Identity Object's serial number, which is used to uniquely identify the device in the network environment.

Device Status

This attribute represents the current state of the device. Its value changes as the state of the device changes. The following values are defined:

| Attribute Value | State |
|-----------------|-----------------------------|
| 0 | Undefined |
| 1 | Self Testing |
| 2 | Idle |
| 3 | Self-Test Exception |
| 4 | Executing |
| 5 | Abort |
| 6 | Critical Fault |
| 7-50 | Reserved by DeviceNet |
| 51-99 | Device Specific (None Used) |
| 100-255 | Vendor Specific (None Used) |

Exception Status

A single byte attribute whose value indicates that the status of the alarms and warnings for the device. This indication may be provided in one of two methods: Basic or Expanded. The GF40/ GF80 Series Devices always report the Exception status in the Expanded Method For the Expanded Method, bit seven of Exception Status attribute is set to one; exceptions are reported through the communication of this Exception Status attribute, formatted as specified in the table below. In addition, the Exception Detail attributes are supported. The Exception Status bits are determined by a logical “OR” of the related Exception Detail bits, as indicated.

| Exception Status Bit Map, Bit 7 set to 1 | |
|--|------------------------------|
| bit | Function |
| 0 | ALARM/device-common* |
| 1 | ALARM/device-specific |
| 2 | ALARM/manufacture-specific |
| 3 | reserved -- set to 0 |
| 4 | WARNING/device-common* |
| 5 | WARNING/device-specific |
| 6 | WARNING/manufacture-specific |
| 7 | 1 == Expanded Method |

* The alarm or warning is not specific to the device type or device type manufacturer.

Exception Detail Alarm and Exception Detail Warning

The formats of these two attributes are identical. Therefore, they are described together here:

Attributes that relate the detailed status of the alarms or warnings associated with the device. Each attribute is a structure containing three members; these three members respectively relate the detailed status of exceptions that are common (i.e., not device-specific), device-specific but not manufacturer-specific, and manufacturer-specific. The common detail is defined below. The device-specific detail is defined in the appropriate Device Profile. The manufacturer defines the manufacturer-specific detail. A SIZE value of zero indicates that no detail is defined for the associated exception detail structure.

Each of the three structure members is defined as a structure containing an ordered list (i.e., array) of bytes of length SIZE, and an unsigned integer whose value is SIZE. Each of the bytes in each array has a specific mapping. This mapping is formatted as 8 bits, which represents 8 independent conditions. A value of 1 indicates that the condition is set (or present), and a value of 0 indicates that the condition is cleared (or not present). Note that if a device does not support an exception detail, the corresponding bit is never set. The bitmaps for alarms and warnings in the corresponding attributes are structured in parallel so that a condition may have either alarm or warning set depending on severity. If a condition inherently cannot be both alarm and warning, then the parallel bit position corresponding to the other state will remain "0." The existence of an exception detail variable structure is dependent on the value of the Exception Status Attribute. The existence of an exception detail variable structure is only required if bit seven of the Exception Status attribute is set to 1, indicating the Expanded method reporting. Bits 0-6 of the Exception Status attribute correspond to the particular exception type.

Common Exception Detail

This structure relates exception conditions (i.e., alarms or warnings) which are common to all devices within the Hierarchy of Semiconductor Equipment Devices. The Detail element of the structure is an ordered list (i.e., array) of bytes of length [SIZE], which is the value of the structure element Size. For each byte in the Detail field, all bits not identified are reserved for future standardization.

The first byte in this attribute is CommonExceptionDetail[0]. Additional exception details, if provided, are named CommonExceptionDetail[1], . . . CommonExceptionDetail[SIZE]. The specific exception associated with each of the bitmaps is given in the table below. The SIZE for this revision is one, (1). The criteria details for each exception condition are outside the scope of this document. If a device does not support an exception detail, the corresponding bit is never set.

Common Exception Detail Attribute Values

| <i>Bit</i> | <i>Common Exception Detail [0]</i> |
|------------|------------------------------------|
| 0 | Internal Diagnostic Exception |
| 1 | Microprocessor Exception |
| 2 | EPROM Exception |
| 3 | EEPROM Exception (**) |
| 4 | RAM Exception |
| 5 | Reserved by DeviceNet |
| 6 | Internal Realtime Exception |
| 7 | Reserved by DeviceNet |

** Exception Supported

| <i>Bit</i> | <i>Common Exception Detail [1]</i> |
|------------|------------------------------------|
| 0 | Power Supply Overcurrent |
| 1 | Reserved Power Supply |
| 2 | Power Supply Output Voltage (**) |
| 3 | Power Supply Input Voltage |
| 4 | Scheduled Maintenance Due |
| 5 | Notify Manufacturer |
| 6 | Reset Exception |
| 7 | Reserved by DeviceNet |

** Exception Supported

Device Exception Detail

This structure, similar in form to Common Exception Detail, relates exception conditions, which are specific to individual devices on the network and are defined in their respective device profiles. The Detail element of the structure is an ordered list (i.e., array) of bytes of length [SIZE], which is the value of the structure element size. For a detailed description of this attribute, consult the appropriate specific device profile.

Manufacturer Exception Detail

This structure, similar in form to Common Exception Detail, relates exception conditions, which are specific to the manufacturers of individual devices on the network and are defined by them in their product documentation. The Detail element of the structure is an ordered list (i.e., array) of bytes of length [SIZE], which is the value of the structure element Size.

Exception Detail Format Summary

| Data Component | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|------------------------------------|--------------|--------------|------------------------------|----------------------------|--|---------------------------|--------------------------|------------------------------------|
| MFC Device Exception Detail Size | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| MFC Device Exception Detail Byte 0 | Reserved 0 | Reserved 0 | Valve High S-Analog Actuator | Valve Low SAnalog Actuator | Flow Control S-Single Stage Controller | Flow High S-Analog Sensor | Flow Low S-Analog Sensor | Not Reading Valid* S-Analog Sensor |
| Manufacturer Exception Detail Size | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Manufacturer Exception Detail | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

* Only used in the Warning Exception Detail, this bit is always = 0 in the Alarm Exception Detail

Valve High indicates that the Actuator current has exceeded the upper alarm or warning limit.

Valve Low condition never occurs, because low valve current is not an alarm or warning condition.

Flow Control indicates that the closed-loop control system is not able to control the flow within the desired specification. GF40/GF80 Series only supports the alarm condition.

Flow High indicates that the flow value reported by the S-Analog Sensor Object, Instance 1 has exceeded the upper alarm or warning limit.

Flow Low indicates that the flow value reported by the S-Analog Sensor Object, Instance 1 has fallen below the lower alarm or warning limit.

Alarm Enable and Warning Enable

These Boolean attributes are used to enable (1) or disable (0) the S-Device Supervisor object's process of setting Exception bits. When disabled, corresponding bits are never set; and, if they were set, disabling clears them. Also, alarm and warning states are not retained; when enabled, bits will be set only if the corresponding condition is true.

The default-state for these Enable attributes is enabled (1).

Time

This optional attribute represents the value of the time and date as maintained by the device's realtime clock with a resolution of one millisecond. The default value for the Time attribute is zero (0), corresponding to 12:00AM, January 1, 1972, as specified by DeviceNet Volume I, Appendix J.

Scheduled Maintenance Expiration Timer

This attribute, with a resolution of one hour, is used to cause a warning, which indicates that a device calibration is due. A S-Device Supervisor timer decrements this attribute once per hour while power is applied. When the attribute is no longer positive and the Scheduled Maintenance Expiration Warning Enable attribute is set to enabled, a Scheduled Maintenance Expiration Warning condition is generated. This causes the Scheduled Maintenance Due Warning bit to be set.

The attribute will not wrap; when the attribute reaches its most negative value, it no longer decrements. The attribute will continue to decrement irrespective of the state of the Scheduled Maintenance Expiration Warning Enable attribute. The value shall be maintained in nonvolatile memory.

Scheduled Maintenance Expiration Warning Enable

This Boolean attribute is used to enable (1) or disable (0) the S-Device Supervisor object's process of setting the Scheduled Maintenance Due Exception bit. When disabled, the corresponding bit is never set; and, if it was set, disabling clears it. When enabled, the bit will be set only if the corresponding condition is true.

The default-state for this Enable attribute is enabled (1).

S-Device Supervisor Common Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|----------------|------------------------|--------------------|-----------------------|--|
| | Class | Instance | | |
| 0Ehex 14dec | Conditional | Required | Get_Attributes_Single | Returns the contents of the specified attribute. |
| 10hex 16dec | n/a | Required | Set_Attributes_Single | Modifies an attribute value. |
| 5 | n/a | Required | Reset | Resets the device to the Self-Testing state. |
| 6 | n/a | Required | Start | Starts the device execution by moving the device to the Executing state. Equivalent to SEMI S/A Network Execute Service |
| 7 | n/a | Optional Supported | Stop | Moves the device to the Idle state |

See the DeviceNet Communication Model and Protocol for definitions of these common services.

S-Device Supervisor Common Object-Specific Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|----------------|------------------------|----------|---------------------|--|
| | Class | Instance | | |
| 4Bhex 75dec | n/a | Required | Abort | Moves the device to the Abort state |
| 4Chex 76dec | n/a | Required | Recover | Moves the device out of the Abort state |
| 4Ehex 78dec | n/a | Required | Perform_Diagnostics | Causes the device to perform a setof diagnostic routines |

DS Object Service Parameter Dictionary

| <i>Parameter</i> | <i>Form</i> | <i>Description</i> |
|------------------|--------------|---|
| TestID | USINT (byte) | Type and possibly detail of diagnostic test to be performed |

Abort - Used to transition the device application objects to the aborted state. This service request may be (and generally will be) originated internally, from application objects.

Recover - Used to transition the device application objects from the abort state to the idle state. This service request may be originated internally, from application objects.

Perform_Diagnostics - Used to instruct the S-Device Supervisor object to perform a diagnostic test. A diagnostic test is either of type common or device-dependent. Common diagnostic tests include RAM, EPROM, non-volatile memory, and communications. Common diagnostic tests are implementation-specific. All detail of device-dependent diagnostics is outside the scope of this document.

TestID Parameter

The following values are defined for the TestID parameter for the Perform_Diagnostics Service Request:

| Attribute Value | State |
|-----------------|---|
| 0 | Standard |
| 1-63 | Reserved |
| 64-127 | Device Specific (defined in Device Profile) |
| 128-255 | Manufacturer Specific (defined by manufacturer) |

Type "Standard" is specified if there is only one type of diagnostic defined or if there is more than one including a type standard. Additional diagnostic types may be defined in the device profile or by the manufacturer.

The S-Analog Sensor Object models the acquisition of a reading from a physical sensor in a device. Associated with an analog sensor is a reading that has been acquired and corrected with an offset and a gain coefficient, optionally, settable in the object. Additional correction algorithms may be specified by other objects identified in the device profile or as extensions specified by the manufacturer.

The GF40/GF80 Series supports two instances of the S-Analog Sensor Object. Instance 1 is associated with the flow sensor. Instance 3 is associated with the temperature sensor.

This object is a member of the Hierarchy of Semiconductor Equipment Devices. The S-Device Supervisor Object manages the behavior of the S-Analog Sensor Object. See Section 6 of this document.

S-Analog Sensor Class Attributes

The Object Class Attribute ID 1-7 are reserved. See DeviceNet Volume II, Section 5-4.1. for more specification detail on these attributes.

| Attribute ID | Need in Implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|---|-------------|----------|---------------------|---|
| 1 thru 7 | These class attributes are either optional or conditional and are described in chapter 5 of this specification. | | | | |
| 97 & 98 | Reserved by DeviceNet | | | | |
| 99 | Conditional* (Not Supported) | Get | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The subclasses for this object are specified at the end of this object specification section. |

* If the value of Subclass is 00, which identifies “no subclass”, then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

S-Analog Sensor Instance Attributes

All required attributes must be supported as specified. All listed attributes are supported for all instances, unless otherwise noted.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|------------------------|--------------------------------|-----|---|--|---|---|
| 1 | Optional (Supported) | Get | NV | Number of Attributes | USINT (byte) | Number of attributes supported | The number of attributes supported by this object instance |
| 2 | Optional (Supported) | Get | NV | Attribute List | ARRAY OF USINT (bytes) | List of attributes supported by this object instance | List of attributes supported by this object instance |
| 3 | Optional (Supported) | See Semantics Set ¹ | NV | Data Type | USINT (byte) | Determines the Data Type of Value and all related attributes as specified in this table | See Semantics section [default] = INT (0xC3) INT and Real supported |
| 4 | Optional (Supported) | See Semantics Set ¹ | NV | Data Units | UINT | Determines the Units context of Value and all related attributes | See Semantics section [default] = Counts (0x1001) Counts or SCCM supported |
| 5 | Required | Get | V | Reading Valid | BOOL | Indicates that the Value attribute contains a valid value | 0 = invalid 1 = valid (invalid: e.g., not warmed up yet) |
| 6 | Required | Get | V | Value (Dependent of instance - see Semantics section) | INT or specified by Data Type if supported | Analog input value | The corrected, converted, calibrated final value of the sensor. Default range is: 0-6000H (0-100%) See Semantics section |
| 7 | Required | Get | V | Status | BYTE | Alarm / Warning State of this object instance | See Semantics section |
| 8 | Optional (Supported) | Set | NV | Alarm Enable | BOOL | Enables the setting of the Alarm Status Bits | 0 = disable [default] 1 = enable |

* NV = Nonvolatile; attribute value is maintained through power cycles; V = Volatile.

1 Data Type and Data Units are ONLY settable under certain conditions (see Semantics).

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|---|-------------|-----|----------------------|--|--|--|
| 9 | Optional (Supported) | Set | NV | Warning Enable | BOOL | Enables the setting of the Warning Status Bits | 0 = disable [default] 1 = enable |
| 10 | Optional (Supported) | Get | NV | Full Scale | INT or specified by <i>Data Type</i> if supported | The <i>Value</i> of Full Scale for the sensor. | The value of attribute <i>Value</i> corresponding to the Full Scale calibrated measurement of the sensor. [default] = maximum allowable value for the <i>Data Type</i> See Semantics section |
| 11 | Optional (Supported) | Get | NV | Offset-A Data Type | USINT (byte) | Determines the Data Type of attribute <i>OffsetA</i> | See Semantics section [default] = INT |
| 12 | Optional (Supported) | Set | NV | Offset-A | INT or specified by <i>Offset-A Data Type</i> if supported | An amount added prior to <i>Gain</i> to derive <i>Value</i> | See Semantics section 0 = [default] |
| 13 | Required if "Gain" is other than REAL (Supported) | Get | NV | Gain Data Type | USINT (byte) | Determines the Data Type of attribute <i>Gain</i> | See Semantics section [default] = REAL |
| 14 | Optional (Supported) | Set | NV | Gain | REAL or specified by <i>Gain Data Type</i> if supported | An amount scaled to derive <i>Value</i> | See Semantics section 1.0 = [default] |
| 15 | Required if "Gain" is other than REAL (Not Supported) | Get | NV | Unity Gain Reference | REAL or specified by <i>Gain Data Type</i> if supported | Specifies the value of the <i>Gain</i> attribute equivalent to a gain of 1.0 | Used for normalizing the <i>Gain</i> attribute. [default] = 1.0 e.g., for an UINT type <i>Gain</i> , a Unity Gain Reference may be 10000, allowing a gain of 0.0001 to 6.5535. |
| 16 | Optional (Not Supported) | Set | NV | Offset-B | INT or specified by <i>Data Type</i> if supported | An amount added to derive <i>Value</i> | See Semantics section 0 = [default] |

* NV = Nonvolatile; attribute value is maintained through power cycles.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|------------------------|-------------|-----|-------------------------|---|---|--|
| 17 | Optional (Supported) | Set | NV | Alarm Trip Point High | INT or specified by <i>Data Type</i> if supported | Determines the Value above which an Alarm Condition will occur | See Semantics section [default] = Maximum value for its data type |
| 18 | Optional (Supported) | Set | NV | Alarm Trip Point Low | INT or specified by <i>Data Type</i> if supported | Determines the Value below which an Alarm Condition will occur | See Semantics section [default] = Minimum value for its data type |
| 19 | Optional (Supported) | Set | NV | Alarm Hysteresis | INT or specified by <i>Data Type</i> if supported | Determines the amount by which the <i>Value</i> must recover to clear an Alarm Condition | See Semantics section [default] = 0 |
| 20 | Optional (Supported) | Set | NV | Alarm Settling Time | UINT | Determines the time that the <i>Value</i> must exceed the Trip Point before the exception condition is generated. | Time in milliseconds see Semantics section [default] = 0 |
| 21 | Optional (Supported) | Set | NV | Warning Trip Point High | INT or specified by <i>Data Type</i> if supported | Determines the <i>Value</i> above which a Warning Condition will occur | see Semantics section [default] = Maximum value for its data type |
| 22 | Optional (Supported) | Set | NV | Warning Trip Point Low | INT or specified by <i>Data Type</i> if supported | Determines the <i>Value</i> below which a Warning Condition will occur | see Semantics section [default] = Minimum value for its data type |
| 23 | Optional (Supported) | Set | NV | Warning Hysteresis | INT or specified by <i>Data Type</i> if supported | Determines the amount by which the <i>Value</i> must recover to clear a Warning Condition | See Semantics section [default] = 0 |

* NV = Nonvolatile; attribute value is maintained through power cycles

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|--------------------------|-------------|-----|-----------------------|---|--|---|
| 24 | Optional (Supported) | Set | NV | Warning Settling Time | UINT | Determines the time that the <i>Value</i> must exceed the Trip Point before the exception condition is generated | Time in milliseconds see Semantics section [default] = 0 |
| 25 | Optional (Not Supported) | Set | NV | Safe State | USINT (byte) | Specifies the behavior for the <i>Value</i> for states other than Execute | see Semantics section [default] = 0 |
| 26 | Optional (Not Supported) | Set | NV | Safe Value | INT or specified by <i>Data Type</i> if supported | The Value to be used for Safe State = Safe Value | see Semantics section [default] = 0 |
| 27 | Optional (Supported) | Set | NV | Autozero Enable | BOOL | Enables the Auto Zero | see Semantics section 0 = disable [default] 1 = enable |
| 28 | Optional (Supported) | Get | V | Autozero Status | BOOL | Indicates the status of the automatic nulling | see Semantics section [default] = 0 |
| 29 | Optional (Not Supported) | Set | NV | Autorange Enable | BOOL | Enables the automatic range switching | see Semantics section 0 = disable [default] 1 = enable |
| 30 | Optional (Not Supported) | Get | V | Range Multiplier | REAL | Indicates the current range multiplier | see Semantics section [default] = 1.0 |
| 31 | Optional (Not Supported) | Set | NV | Averaging Time | UINT | Specifies the time over which analog samples are averaged | Time in Milliseconds of a moving-window average 0 = disable averaging [default] Values less than the sample rate of the device also disable averaging |

* NV = Nonvolatile; attribute value is maintained through power cycles; V = Volatile.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|--------------------------------------|-------------|-----|---------------------------------|---|---|---|
| 32 | Optional (Supported) | Get | NV | Ovrrange | INT or specified by <i>Data Type</i> if supported | Specifies the highest valid <i>Value</i> | The value above which attribute <i>Reading Valid</i> is set to invalid. [default] = maximum allowable value for the <i>Data Type</i> |
| 33 | Optional (Supported) | Get | NV | Underrange | INT or specified by <i>Data Type</i> if supported | Specifies the lowest valid <i>Value</i> | The value below which attribute <i>Reading Valid</i> is set to invalid |
| 34 | Optional (Not Supported) | Set | NV | Produce Trigger Delta | INT or specified by <i>Data Type</i> if supported | The amount by which <i>Value</i> must change before a Change of State Production is triggered | 0 = Disabled [default] See Semantics section |
| 35 | Conditional ² (Supported) | Set | NV | Gas Calibration Object Instance | UINT | Indicates which Gas Calibration object instance is active for this object | 0 = Disabled [default] See Semantics section |
| 97-98 | Reserved by DeviceNet | | | | | | |
| 99 | Conditional ³ (Supported) | Get | NV | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The subclasses for this object are specified at the end of this object specification section. | 0 = No subclass n = subclass as defined herein Instance 1, subclass = 1 see section 7.7 Instance 3 subclass = 0 |
| 110 | Optional (Not Supported) | Get | NV | Full Scale | Struct: REAL, UINT | Full scale amount (REAL) and data units (UINT) | Default = 0,0 |

* NV = Nonvolatile; attribute value is maintained through power cycles; V = Volatile.

² Attribute is settable; however, it should only be set while in the Idle state (see Semantics).

³ If the value of Subclass is 00, then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

Semantics

Data Type

All Data Type attributes, including *Data Type*, *Offset-A Data Type* and *Gain Data Type*, use the enumerated values specified in DeviceNet Vol. I, Appendix C-6.1.

The *Data Type* attribute is settable only in the *Idle State* and only if no attribute belonging to the object instance is the endpoint of an I/O connection in the *Established State*.

The *Data Type* attribute may change automatically based upon established I/O connections. See Behavior section for more information on this mechanism.

Data Units

Specifies the context of *Value* and related attributes (such as, offset and trip points) for this object instance. See the following table for a list of valid values for each object instance. A request to set attribute to an unsupported value will return an error response.

The *Data Units* attribute is settable only in the *Idle State*.

| Instance | Supported Data Units |
|-----------------|----------------------------|
| 1 - Flow | Counts (0x1001) |
| | Percent (0x1007) |
| | SCCM (0x1400) |
| | SLM (0x1401) |
| 3 - Temperature | Counts (0x1001) |
| | Percent (0x1007) |
| | Degree Celsius (0x1200) |
| | Degree Fahrenheit (0x1201) |
| | Kelvin (0x1202) |
| | Degree Rankine (0x1203) |

Value, Offset (A and B) and Gain

An S-Analog Sensor object instance derives a reading from a physical analog sensor. The reading is converted to the data type and units specified for the Value attribute. The Offset-A, Offset-B and Gain attributes are applied to the sensor reading as specified by the following formula:

$$\text{Value} = \text{Gain} * (\text{Sensor Reading} + \text{Offset-A}) + \text{Offset-B}$$

Typically, the Offset-A or Offset-B attributes are modified by the Zero-Adjust service and the Gain attribute is modified by the Gain_Adjust services; particularly, when the device utilizes a non-linear conversion algorithm. However, support of these services is not required. See the Behavior section.

Value, flow, instance 1

The flow value is normalized based on the rated maximum flow for the device. When Data Units are set to Counts, the default range 0 to 0x6000 defines the 0 to 100% of rated flow.

Data Type values supported are Integer (0xC3) and Real (0xCA). Data Units supported are Counts (0x1001), SCCM (0x1400), and SLM (0x1401). Both Data Type and Data Units attributes are settable. The full-scale range for indicated flow is determined by the full-scale attribute (31H, 1,10).

Value, temperature, instance 3

The temperature instance is scaled so that the maximum reported count value of 0x6000 will equal 500 degrees Kelvin when Data Units are set to Counts or Percent.

Status

A bit mapped byte, which indicates the Alarm and Warning Exception status of the object instance. The following definition applies:

| Bit | Definition |
|-----|--|
| 0 | High Alarm Exception: 0 = cleared; 1 = set |
| 1 | Low Alarm Exception: 0 = cleared; 1 = set |
| 2 | High Warning Exception: 0 = cleared; 1 = set |
| 3 | Low Warning Exception: 0 = cleared; 1 = set |
| 4 | Reserved |
| 5 | Reserved |
| 6 | Reserved |
| 7 | Reserved |

Trip Points, Hysteresis and Settling Time

Trip Point High is the level above which the Value attribute will cause an Alarm or Warning exception condition.

Trip Point Low is the level below which the Value attribute will cause an Alarm or Warning exception condition.

A Hysteresis value specifies the amount by which the Value attribute must transition in order to clear an Alarm or Warning condition. For example: A Trip Point High value of 100 and a hysteresis value of 2 will result in an exception condition being set when the Value is above 100 and cleared when the Value drops below 98. Similarly, A Trip Point Low value of 100 and a hysteresis value of 2 will result in an exception condition being set when the Value is below 100 and cleared when the Value increases above 102.

The Settling Time determines the amount of time that the Value attribute must exceed the Trip Point before the exception condition is generated. The Settling Time also applies to the clearing of the condition.

Safe State

This attribute specifies what value will be held in Value for states other than Executing. See the S-Device Supervisor object definition in Section 6 for a description of object states. The purpose of this mechanism is to allow other devices, that may be using this Value, to transition to, or remain in, a safe state in the event of this device transitioning to a FAULT, IDLE, or ABORT state. The following values are defined:

| Attribute Value | State |
|-----------------|-----------------|
| 0 | Zero |
| 1 | Full Scale |
| 2 | Hold Last Value |
| 3 | Use Safe Value |
| 4-50 | Reserved |
| 51-99 | Device Specific |
| 100-255 | Vendor Specific |

Safe Value

For Safe State set to Use Safe Value, this attribute holds the value to which the Value attribute will be set for object instance states other than Executing.

Autozero Enable and Autozero Status

When the autozero is enabled, the device will automatically invoke a Zero_Adjust service request (no parameter) contingent upon a set of conditions specified by the manufacturer. These conditions may be determined by the value of an attribute (e.g., setpoint) or some other mechanism defined by the manufacturer. See Zero_Adjust service.

GF40/GF80 Series uses the Autozero Status attribute to convey the status of the Zero-Adjust Service operation. If the device receives an explicit message from the host to perform a Zero-Adjust Service, the GF40/GF80 Series will perform the service and set the Autozero Status to 1 for the duration of the service. After the Zero-Adjust service has completed, the Autozero Status will be set to zero. The MFC Device Profile appears to indicate that the Autozero Status attribute is only to be used for an internally triggered Zero-Adjust Service; however, the GF40/GF80 Series uses the Autozero Status to convey the status of the Zero-Adjust Service, no matter how the service was triggered.

Autorange Enable and Range Multiplier

When the autorange is enabled, the device will automatically switch full scale range based on a set of conditions specified by the manufacturer. The Range Multiplier indicates the range scale. An example of how Autorange may work is: when the Value is less than 9% with a Range Multiplier of 1.0, the Range Multiplier switches to 10.0 (the Value then reads 90% of the 10X range). When the Value then reaches 100% with a Range Multiplier of 10.0, the Range Multiplier returns to 1.0 (the Value then reads 10% of the 1X range).

Produce Trigger Delta

This attribute is used in conjunction with the “Change of State” production trigger type. Upon transition of the associated connection object instance (any Change of State connection pointing to the S-Analog Sensor object Value attribute) to the established state, a production is immediately triggered and this reported Value is stored internally for the determination of the next production trigger. When the Value changes by an amount of at least the Produce Trigger Delta (i.e., the Value as compared to the internally stored previously produced Value), a new production is triggered, and this reported Value becomes the new internally stored Value for the determination of the next production trigger.

Gas Calibration Object Instance

This attribute is used to select an instance of the S-Gas Calibration object. The selected S-Gas Calibration object instance provides the data with which an S-Analog Sensor object instance enacts the appropriate calibration algorithm for a given gas type.

A Set_Attribute_Single request, specifying a value not supported, will return an “invalid attribute value” error response. A list of acceptable values for this attribute is derived from a class level service request to the S-Gas Calibration object.

Conditionally Required: If a device profile specifies an S-Gas Calibration object relationship for an S-Analog Sensor object instance, then this attribute is required.

See the S-Gas Calibration object definition for more information.

Caution:

Care should be taken when changing the gas instance. The Thermal Mass Flow Device profile allows the user to change the gas instance at any time; however, the attribute should only be changed when the device is Idle. Unpredictable results may occur if the gas instance is changed while the Thermal Mass Flow Device is in the Execute State.

S-Analog Sensor Common Services

The S-Analog Sensor Object provides the following Common Services:

| Service Code | Need in Implementation | | Service Name | Description of Service |
|----------------|------------------------|----------|----------------------|--|
| | Class | Instance | | |
| 0Ehex 14dec | Conditional* | Required | Get_Attribute_Single | Returns the contents of the specified attribute. |
| 10hex 16dec | N/A | Required | Set_Attribute_Single | Modifies an attribute value. |

*The Get_Attribute_Single service is REQUIRED if any attributes are implemented.

See the DeviceNet Communication Model and Protocol for definitions of these common services.

S-Analog Sensor Object-Specific Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|----------------|------------------------|-----------------------------|--------------|---|
| | Class | Instance | | |
| 4Bhex 75dec | N/A | Optional (Supported) | Zero_Adjust | Causes the device to modify attribute Offset-A and/or Offset-B such that attribute Value equals the Target Value sent with the request. |
| 4Chex 76dec | N/A | Optional (Not Supported) | Gain_Adjust | Causes the device to modify attribute Gain, such that attribute Value, equals the Target Value sent with the request. |

The Zero_Adjust and Gain_Adjust services are used to cause the S-Analog Sensor Object device to modify its Offset-A and/or Offset-B and Gain attribute values based upon manufacturer specific algorithms. The target value specified in the service request represents the actual parametric measurement that the physical sensor should be reporting at the time of the request.

There are no state transitions associated with the invocation of these services. It is, therefore, incumbent upon the user to establish the device into the desired configuration prior to, and during, the execution of these services. This will generally involve exposing the sensor to a known environment and treating the values read during execution of the services accordingly.

A success service response indicates that the service was accepted and the application process started.

Zero_Adjust Request Service Data Field Parameters

| Parameter | Required | Data Type | Description | Semantics of Values |
|--------------|-------------------------|---|---|--|
| Target Value | Optional (Supported) | Specified by the value of attribute Data Type | The target value for the zero calibration | The value to which the Value attribute will be set. If not specified, the default value of zero is used. |

Gain_Adjust Request Service Data Field Parameters

| Parameter | Required | Data Type | Description | Semantics of Values |
|--------------|----------|---|---|---|
| Target Value | Required | Specified by the value of attribute Data Type | The target value for the gain calibration | The value to which the Value attribute will be set. |

Note: Support of the Zero Adjust Service - target Value must be zero. To invoke Zero Adjust, the user should put the MFC in a steady-state condition with zero flow, prior to sending the Service.

Example: Using the Zero Adjust Service

If Data Type is Integer:

ServiceCode=4BH, Class=31H, Instance=1, service data or Target Value = (00 00).

If Data Type is Real:

ServiceCode=4BH, Class=31H, Instance=1, service data or Target Value = (00 00 00 00).

Behavior

The S-Device Supervisor Object manages the behavior of the S-Analog Sensor Object. See section 6 of this document.

An S-Analog Sensor object instance acquires a reading from a physical sensor, as identified by the application of the object, and applies an algorithm to modify the reading into the appropriate Data Type and Data Units. Optionally, additional corrective algorithms are applied to further correct for various calibration effects. These additional algorithms are specified in other objects, as identified in the device profile, or as extensions, specified by the manufacturer.

All Full Scale, Trip Point, Overrange and Underrange calculations, as specified above, utilize the Value attribute.

Data Type

If the implementation of this object specifies more than one valid Data Type value, in the device profile or by vendor, then the following behavior with respect to Data Type applies: The Data Type value will be set automatically based upon the first valid I/O connection established by the device. This configuration will then remain in effect for this object instance, even after all I/O connections are lost. For devices that support only one Data Type, this behavior is not supported.

If no established I/O connections exist, which include an attribute from this object, then the Data Type attribute is settable provided that the object is in the Idle State.

The following example demonstrates this behavior:

A device profile specifies an instance of the S-Analog Sensor object as well as two static Assembly object instances, both with data attribute components mapped to this object instance. Assembly object instance ID 1 specifies INT data types and Assembly object instance ID 2 specifies REAL data types.

After the device is On-Line, it is configured with an I/O connection to

Assembly instance ID 2. When the connection transitions to the Established State, this object instance attribute Data Type is automatically set with the value for REAL before any data is communicated to, or from, the object instance.

S-Analog Sensor Object Instance Subclass 01

The following specification applies to a subclass of this object for application in Mass Flow Controller devices.

Subclass 01 Instance Attributes

The following Instance Attributes are specified for this object subclass.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|--------------------------|-------------|-----|----------------|---------------------|--|--|
| 95 | Optional (Supported) | Get | NV | Flow Totalizer | ULINT | Total gas flowed through the device since this value was last set to zero | Units are Standard CCs see Behavior section default = 0 |
| 96 | Optional (Not Supported) | Set | NV | Flow Hours | UDINT | Total time device has been powered and flowing gas since this value was last set to zero | Resolution is one hour see Behavior section default = 0 |

* NV = Nonvolatile; attribute value is maintained through power cycles.

Subclass 01 Services

There are no additions or restrictions to the Object Services for this object subclass.

Subclass 01 Behavior**Flow Totalizer and Flow Hours Process**

The factory configured out-of-box values for the Flow Totalizer and Flow Hours attributes are both zero. The attributes are only modifiable with set_attribute_single service requests; they are not altered by the Reset service, including power-cycle, of either the Identity or the S-Device Supervisor objects.

The Flow Totalizer attribute is incremented, at a rate of once every cubic centimeter of gas flow, by the S-Analog Sensor object instance to reflect the amount of gas that has flowed through the device. Upon reaching its maximum value, the Flow Totalizer value is no longer incremented and remains at its maximum value.

The Flow Hours attribute is incremented, at a rate of once every hour, by the S-Analog Sensor object instance to reflect the amount of time that gas has flowed through the device. This condition is determined by the Value attribute being greater than 0.5% of full scale. Upon reaching its maximum value, the Flow Hours value is no longer incremented and remains at its maximum value.

The S-Analog Actuator Object models the interface to a physical actuator in a device. Associated with an analog actuator is a value, which is corrected with an offset and a gain coefficient, optionally settable in the object before it is output to the physical actuator. Manufacturers may specify additional correction algorithms as extensions to this object.

Additionally, the S-Analog Actuator Object provides two sets of trip-point definitions. The behavior associated with these trip points is described in sections below.

This object is a member of the Hierarchy of Semiconductor Equipment Devices. The S-Device Supervisor manages the behavior of the S-Analog Actuator Object. See Section 6 of this document.

S-Analog Actuator Class Attributes

The Object Class Attribute ID 1-7 are reserved. See DeviceNet Volume II, Section 5-4.1. for more specification detail on these attributes.

| Attribute ID | Need in Implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|--|-------------|----------|---------------------|---|
| 1 thru 7 | These class attribute are either optional or conditional and are described in chapter 5 of this specification. | | | | |
| 97 & 98 | Reserved by DeviceNet | | | | |
| 99 | Conditional* (Supported) | Get | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The subclasses for this object are specified at the end of this object specification section. |

* If the value of Subclass is 00, which identifies "no subclass", then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

S-Analog Actuator Instance Attributes

Certain minimal implementations may support any optional “Set” attributes as “Get” only and still be compliant with this object specification. All required attributes must be supported as specified.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|------------------------|--------------------------------|-----|----------------------|---|--|--|
| 1 | Optional (Supported) | Get | NV | Number of Attributes | USINT (byte) | Number of supported attributes | The number of attributes supported by this object instance |
| 2 | Optional (Supported) | Get | NV | Attribute List | ARRAY OF USINT (byte) | List of supported attribute | List of attributes supported by this object instance |
| 3 | Optional (Supported) | See Semantics Set ¹ | NV | Data Type | USINT (byte) | Determines the Data Type of <i>Value</i> and all related attributes as specified in this table | See Semantics section [default] = INT INT or Real supported |
| 4 | Optional (Supported) | See Semantics Set ¹ | NV | Data Units | UINT | Determines the context of <i>Value</i> | See Semantics section [default] = Counts Counts or Percent supported |
| 5 | Required | Set | V | Override | USINT (byte) | Specifies an override for the physical actuator. For values other than zero (normal control), the <i>Value</i> attribute is ignored. | 0 = normal [default] See Semantics section |
| 6 | Required | Set | V | Value | INT or specified by <i>Data Type</i> if supported | Analog output value | The uncorrected value. See Semantics section [default] = 0 |
| 7 | Required | Get | V | Status | BYTE | Alarm and Warning State of this object instance | See Semantics section [default] = 0 |
| 8 | Optional (Supported) | Set | NV | Alarm Enable | BOOL | Enables the setting of the Alarm Bit | 0 = disable [default] 1 = enable |

*NV = Nonvolatile; value is maintained through power cycle; V = Volatile.

¹Data Type and Data Units Attribute are settable ONLY under certain conditions (see Semantics).

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|---|-------------|-----|-----------------------|---|---|---|
| 9 | Optional (Supported) | Set | NV | Warning Enable | BOOL | Enables the setting of the Warning Bit | 0 = disable [default] 1 = enable |
| 10 | Optional (Not Supported) | Set | NV | Offset | INT or specified by <i>Data Type</i> if supported | An amount to be added to <i>Value</i> prior to the application of gain | See Semantics section 0 = [default] |
| 11 | Optional (Not Supported) | Set | NV | Bias | INT or specified by <i>Data Type</i> if supported | An amount to be added to <i>Value</i> prior to the application of gain | See Semantics section 0 = [default] |
| 12 | Required if Attribute "Gain" is other than REAL (Not Supported) | Get | NV | Gain Data Type | USINT (byte) | Determines the Data Type of attribute <i>Gain</i> | See Semantics section [default] = REAL |
| 13 | Optional (Not Supported) | Set | NV | Gain | REAL or specified by <i>Gain Data Type</i> if supported | An amount by which <i>Value</i> is scaled prior to driving the physical actuator | See Semantics section 1.0 = [default] |
| 14 | Required if Attribute 12 is other than REAL (Not Supported) | Get | NV | Unity Gain Reference | REAL or specified by <i>Gain Data Type</i> if supported | Specifies the value of the <i>Gain</i> attribute equivalent to a gain of 1.0 | Used for normalizing the <i>Gain</i> attribute. See Semantics section [default] = 1.0 |
| 15 | Optional (Supported) | Set | NV | Alarm Trip Point High | INT or specified by <i>Data Type</i> if supported | Determines the Value above which an Alarm Condition will occur | See Semantics section [default] = Minimum value for its data type. |
| 16 | Optional (Supported) | Set | NV | Alarm Trip Point Low | INT or specified by <i>Data Type</i> if supported | Determines the Value below which an Alarm Condition will occur | See Semantics section [default] = Minimum value for its data type. |
| 17 | Optional (Supported) | Set | NV | Alarm Hysteresis | INT or specified by <i>Data Type</i> if supported | Determines the amount by which the Value must recover to clear an Alarm Condition | See Semantics section [default] = 0 |

*NV = Nonvolatile; value is maintained through power cycle; V = Volatile.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|--------------------------------------|-------------|-----|-------------------------|---|---|---|
| 18 | Optional (Supported) | Set | NV | Warning Trip Point High | INT or specified by Data Type if supported | Determines the Value above which a Warning Condition will occur | See Semantics section [default] = Maximum value for its data type. |
| 19 | Optional (Supported) | Set | NV | Warning Trip Point Low | INT or specified by <i>Data Type</i> if supported | Determines the Value below which a Warning Condition will occur | See Semantics section [default] = Minimum value for its data type. |
| 20 | Optional (Supported) | Set | NV | Warning Hysteresis | INT or specified by <i>Data Type</i> if supported | Determines the amount by which the Value must recover to clear a Warning Condition | See Semantics section [default] = 0 |
| 21 | Optional (Supported) | Set | NV | Safe State | USINT (byte) | Specifies the behavior of the physical actuator for states other than Execute | See Semantics section 0 = [default] |
| 22 | Optional (Supported) | Set | NV | Safe Value | INT or specified by <i>Data Type</i> if supported | The Value to be used for Safe State = Safe Value | See Semantics section 0 = [default] |
| 97-98 | Reserved by DeviceNet | | | | | | |
| 99 | Conditional ² (Supported) | Get | NV | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The subclasses for this object are specified at the end of this object specification section. | 0 = No subclass n = subclass as defined herein |

*NV = Nonvolatile; value is maintained through power cycle; V = Volatile.

²If the value of Subclass is 00, then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

Semantics

Data Type

All Data Type attributes, including Data Type and Gain Data Type, use the enumerated values specified in DeviceNet Vol. I, Appendix J-6.1.

The Data Type attribute is settable only in the Idle State and only if no attribute belonging to the object instance is the endpoint of an I/O connection in the Established State.

The Data Type attribute may change automatically based upon established I/O connections. See Behavior section for more information on this mechanism.

Data Units

Specifies the context of Value and related attributes (such as, offset and trip points) for this object instance. See Appendix K for a list of values. A request to set attribute to an unsupported value will return an error response.

The Data Units attribute is settable only in the Idle State.

Value, Offset, Gain, Bias and Unity Gain Reference

The Offset, Gain and Bias attributes are applied to the Value attribute to derive the actual signal, which drives the physical actuator. The gain is normalized using the Unity Gain Reference attribute value. (For example, for an UINT type Gain, a Unity Gain Reference value may be 10000, allowing an effective gain of 0.0001 to 6.5535.)

The following formula applies:

$$\text{physical actuator drive signal} = \text{Gain}_N \cdot (\text{Value} + \text{Offset}) + \text{Bias}$$

where: $\text{Gain}_N = \text{Gain} / \text{Unity Gain Reference}$

There may be additional nonlinear conversions applied to the drive signal as specified by the manufacturer.

Status

A bit mapped byte, which indicates the Alarm and Warning Exception status of the object instance. The following definition applies:

| Bit | Definition |
|-----|--|
| 0 | High Alarm Exception: 0 = cleared; 1 = set |
| 1 | Low Alarm Exception: 0 = cleared; 1 = set |
| 2 | High Warning Exception: 0 = cleared; 1 = set |
| 3 | Low Warning Exception: 0 = cleared; 1 = set |
| 4 | Reserved |
| 5 | Reserved |
| 6 | Reserved |
| 7 | Reserved |

Trip Points and Hysteresis

Trip Point High is the level above which the Value attribute will cause an Alarm or Warning exception condition.

Trip Point Low is the level below which the Value attribute will cause an Alarm or Warning exception condition.

A Hysteresis value specifies the amount by which the Value attribute must transition in order to clear an Alarm or Warning condition.

For example: A Trip Point High value of 90 and a Hysteresis value of 2 will result in an exception condition being set when the Value is above 90 and cleared when the Value drops below 88. Similarly, A Trip Point Low value of 90 and a Hysteresis value of 2 will result in an exception condition being set when the Value is below 90 and cleared when the Value increases above 92.

Override

This attribute is used to override the function of the Value attribute in driving the physical actuator. The primary application of this feature is in devices where the object instance is being driven by another object such as an S-Single Stage Controller object instance.

The Safe State attribute provides a mechanism for override depending upon object state and will take precedents over this. That is, if an object instance implements the Safe State attribute and related behavior, then this Override attribute and related behavior will only function in the Executing State.

| Attribute Value | State |
|-----------------|--------------------------|
| 0 | Normal (Supported) |
| 1 | Off / Closed (Supported) |
| 2 | On / Open (Supported) |
| 3 | Hold |
| 4 | Safe State |
| 5-63 | Reserved |
| 64-127 | Device Specific |
| 128-255 | Vendor Specific |

Safe State

This attribute specifies the behavior of the drive to the physical actuator for states other than Executing. See the S-Device Supervisor object definition in Section 6 for a description of object states. The following values are defined:

| Attribute Value | State |
|-----------------|------------------------|
| 0 | Zero / Off / Closed |
| 1 | Full Scale / On / Open |
| 2 | Hold Last Value |
| 3 | Use Safe Value |
| 4-63 | Reserved |
| 64-127 | Device Specific |
| 128-255 | Vendor Specific |

The device supports the Safe State Attribute as a Get Only attribute that returns a value of zero or “closed”.

Safe Value

For Safe State set to “Use Safe Value”, this attribute holds the value to which the actuator will be driven for object instance states other than Executing. Specifically, this attribute value will become the value of the Value attribute. Therefore, the correction formula specified above applies.

S-Analog Common Services

The S-Analog Actuator Object provides the following Common Services:

| Service Code | Need in Implementation | | Service Name | Description of Service |
|----------------|------------------------|----------|----------------------|--|
| | Class | Instance | | |
| 0Ehex 14dec | Conditional* | Required | Get_Attribute_Single | Returns the contents of the specified attribute. |
| 10hex 16dec | N/A | Required | Set_Attribute_Single | Modifies an attribute value. |

*The Get_Attribute_Single service is REQUIRED if any attributes are implemented.

See the DeviceNet Communication Model and Protocol for definitions of these common services.

S-Analog Actuator Object-Specific Services

The S-Analog Actuator Object provides no Object-Specific services.

S-Analog Actuator Behavior

The S-Device Supervisor Object manages the behavior of the S-Analog Actuator Object. See Section 6-48.5.

An S-Analog Actuator object instance modifies the Value by applying the formula specified above with the associated attribute values. Value is specified as Data Type and Data Units. Optionally, additional corrective algorithms are applied to further correct for various calibration effects. These additional algorithms are specified in other objects, as identified in the device profile, or as extensions, specified by the manufacturer.

All Trip Point calculations, as specified above, utilize the Value attribute before the application of Offset and Gain.

Data Type

If the implementation of this object specifies more than one valid Data Type value, in the device profile or by vendor, then the following behavior with respect to Data Type applies. The Data Type value will be set automatically based upon the first valid I/O connection established by the device. This configuration will then remain in effect for this object instance, even after all I/O connections are lost. For devices that support only one Data Type, this behavior is not supported.

If no established I/O connections exist, which include an attribute from this object, then the Data Type attribute is settable provided that the object is in the Idle State.

The following example demonstrates this behavior:

A device profile specifies an instance of the S-Analog Actuator object as well as two static Assembly object instances, both with data attribute components mapped to this object instance. Assembly object instance ID 1 specifies INT data types and Assembly object instance ID 2 specifies REAL data types.

After the device is On-Line, it is configured with an I/O connection to Assembly instance ID 2. When the connection transitions to the Established State, this object instance attribute Data Type is automatically set with the value for REAL before any data is communicated to, or from, the object instance.

GF40/GF80 Series Implementation

Data Type values supported are Integer (0xC3) and Real (0xCA). Data Units supported are Counts (0x1001) and Percent (0x1007). Data Type and Data Units attributes are settable. The supported combinations of Data Type and Data Units on the device are Integer-Counts (default), Real-Percent, Integer-Percent, and Real-Counts. The Real-Percent values range from 0.0 to 100.0, where the value represents percent of full-scale that the actuator is being driven. Integer-Percent value range is 0 to 100 integer. Integer-Counts value range is 0 to 0x7FFF. Typical count range is 0 to 24576, (0x6000).

The S-Single Stage Controller Object models a closed-loop control system within a device. Associated with a single stage controller is a Process Variable, a Setpoint and a Control Variable. As normally described by classic control theory, a closed-loop controller will drive the Control Variable in order to affect the value of the Process Variable such that it is made to equal the Setpoint. See the Semantics section, below, for more information regarding these variable definitions. Manufacturers may specify additional correction algorithms as extensions to this object.

This object is a member of the Hierarchy of Semiconductor Equipment

Devices. The S-Device Supervisor Object manages the behavior of the

S-Single Stage Controller Object. See Section 6.

S-Single Stage Controller Object (Class 0x33)

The Object Class Attribute IDs 1-7 are reserved. See DeviceNet Volume II, Section 5-4.1 for more specification detail on these attributes.

| Attribute ID | Need in Implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|---|-------------|----------|---------------------|---|
| 1 thru 7 | These class attributes are either optional or conditional and are described in chapter 5 of this specification. | | | | |
| 97 & 98 | Reserved by DeviceNet | | | | |
| 99 | Conditional* (Supported) | Get | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The subclasses for this object are specified at the end of this object specification section. |

* If the value of Subclass is 00, which identifies “no subclass”, then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

S-Single Stage Controller Instance Attributes

Certain minimal implementations may support any optional “Set” attributes as “Get” only and still be compliant with this object specification. All required attributes must be supported as specified.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|------------------------|--------------------------------|-----|----------------------|---|---|--|
| 1 | Optional (Supported) | Get | NV | Number of Attributes | USINT (byte) | Number of supported attributes | Number of attributes supported in this object instance |
| 2 | Optional (Supported) | Get | NV | Attribute List | ARRAY OF USINT (byte) | Attribute List | List of attributes supported in this object instance |
| 3 | Optional (Supported) | See Semantics Set ¹ | NV | Data Type | USINT (byte) | Determines the Data Type of <i>Setpoint</i> , <i>Process Variable</i> and related attributes | See Semantics section [default] = INT INT and Real supported |
| 4 | Optional (Supported) | See Semantics Set ¹ | NV | Data Units | UINT | Determines the context of the Process related variables such as Setpoint and Process Variable | See Appendix K [default] = Counts Counts and SCCM supported |
| 5 | Optional (Supported) | Set | NV | Control Mode | USINT (byte) | Specifies the operational mode of the controller | See Semantics section [default] = Normal (0) |
| 6 | Required | Set | V | Setpoint | INT or specified by <i>Data Type</i> if supported | The setpoint to which the process variable will be controlled | See Semantics section. See Behavior section. 0 = [default] Range is one of: 0-6000H (0 - 100%) 0-7FFFH (0 - 100%) |

*NV = Nonvolatile; value is retained through power cycle; V = Volatile.

¹ Data Type and Data Units Attribute are settable ONLY under certain conditions (see Semantics).

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|---|-------------|-----|---------------------|--|---|--|
| 7 | Conditional ² (Not Supported - not applicable to device profile 0x27) | Set | V | Process Variable | INT or specified by <i>Data Type</i> if supported | The measured process parameter | The device profile must specify the data connection for this attribute. It may be internally linked to a sensor. See Semantics section. 0 = [default] |
| 8 | Optional (Not Supported) | Get | NV | CV Data Type | USINT (byte) | Determines the Data Type of <i>Control Variable</i> | See Semantics section [default] = INT |
| 9 | Optional ² (Not Supported) | Get | V | Control Variable | INT or specified by <i>CV Data Type</i> if supported | The drive signal output of this object. The algorithm by which this attribute is calculated is manufacturer specific. | The device profile must specify the data connection for this attribute. It may be internally linked to an actuator. [default] = 0 See Semantics section. |
| 10 | Required | Get | V | Status | BYTE | Alarm and Warning State of this object instance | See Semantics section [default] = 0 |
| 11 | Optional (Supported) | Set | NV | Alarm Enable | BOOL | Enables the setting of the Alarm Status Bit | 0 = disable [default] 1 = enable |
| 12 | Optional (Supported) | Set | NV | Warning Enable | BOOL | Enables the setting of the Warning Status Bit | 0 = disable [default] 1 = enable |
| 13 | Optional (Supported) | Set | NV | Alarm Settling Time | UINT | Number of Milliseconds allowed for the control-loop to settle to within the error band | See Behavior section [default] = 0 |
| 14 | Optional (Supported) | Set | NV | Alarm Error Band | INT or specified by <i>Data Type</i> if supported | The amount by which the <i>Setpoint</i> must equal the Process Variable | See Behavior section [default] = 0 |

*NV = Nonvolatile; value is retained through power cycle; V = Volatile.

² The Process Variable is only optional if this device includes an internal sensor. Otherwise, the Process Variable is required. Similarly, the Control Variable is only optional if this device includes an internal actuator. Otherwise, the Control Variable is required.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|-----------------------------------|-------------|-----|-----------------------|---|--|---|
| 15 | Optional (Supported) | Set | NV | Warning Settling Time | UINT | Number of Milliseconds allowed for the controlloop to settle to within the Error Band | See Behavior section [default] = 0 |
| 16 | Optional (Supported) | Set | NV | Warning Error Band | INT or specified by <i>Data Type</i> if supported | The amount by which the <i>Setpoint</i> must equal the <i>Process Variable</i> | See Behavior section [default] = 0 |
| 17 | Optional (Supported) | Set | NV | Safe State | USINT (byte) | Specifies the Control Variable behavior for states other than Execute | See Semantics section 0 = [default] |
| 18 | Optional (Supported) | Set | NV | Safe Value | INT or specified by <i>Data Type</i> if supported | The value to be used for Safe State = Safe Value | See Semantics section 0 = [default] |
| 19 | Optional (Supported) | Set | NV | Ramp Rate | UDINT (4-bytes) | Time in Milliseconds to reach Setpoint | 0 = Disabled [default] x = value in milliseconds Where: 0 < x < 7FFF DeviceNet specifies 4 bytes of data, but only 2 are used. See Behavior section |
| 97-98 | Reserved by DeviceNet | | | | | | |
| 99 | Optional ³ (Supported) | Get | NV | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The sub-classes for this object are specified at the end of this object specification section. | 0 = No subclass n = subclass as defined herein |

*NV = Nonvolatile; value is retained through power cycle.

³ If the value of Subclass is 00, then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

Semantics

Data Type

All *Data Type* attributes, including *Data Type* and *CV Data Type*, use the enumerated values specified in DeviceNet Vol. I, Appendix J-6.1.

The *Data Type* attribute is settable only in the *Idle State* and only if no attribute belonging to the object instance is the endpoint of an I/O connection in the *Established State*.

The *Data Type* attribute may change automatically based upon established I/O connections. See Behavior section for more information on this mechanism.

Data Units

Specifies the context of *Setpoint* and *Process Variable* and related attributes (such as, offset and trip points) for this object instance. See Appendix K for a list of values. A request to set attribute to an unsupported value will return an error response.

The *Data Units* attribute is settable only in the *Idle State*.

In applications where this object is used in a relationship with an S-Analog Sensor object, this attribute may be specified as Get only, by the device profile or the vendor, where the value mirrors that of the S-Analog Sensor object *Data Units* attribute.

Setpoint, Process Variable and Control Variable

These three attributes compose the primary aspects of basic closed-loop control. The *Process Variable* is the measured parameter of the process or system being controlled. The *Setpoint* is the desired value for the measured parameter. By affecting the value of the *Control Variable*, the closed-loop controller drives the process or system to the desired state of:

Process Variable = Setpoint

The *Control Variable* is, therefore, connected to the process or system in such a way that it affects the value of the *Process Variable*. Examples of *Control Variable / Process Variable* combinations include: heater / temperature; valve / flow; or regulator / pressure.

Status

A bit mapped byte, which indicates the Alarm and Warning Exception status of the object instance. The following definition applies:

| Bit | Definition |
|-----|---|
| 0 | Alarm Exception: 0 = cleared; 1 = set |
| 1 | Warning Exception: 0 = cleared; 1 = set |
| 2 | Reserved |
| 3 | Reserved |
| 4 | Reserved |
| 5 | Reserved |
| 6 | Reserved |
| 7 | Reserved |

Control Mode

This attribute is used to override the value of the *Control Variable* attribute. Further, it may cause the object to modify the internal control algorithm such that a smooth, or “bumpless” transitions occurs upon activating control to setpoint.

The *Safe State* attribute provides a mechanism for override depending upon object state and will take precedents over this. That is, if an object instance implements the *Safe State* attribute and related behavior, then this *Override* attribute and related behavior will only function in the Executing State.

| Attribute Value | State |
|-----------------|---|
| 0 | Normal |
| 1 | Zero / Off / Closed |
| 2 | Full / On / Open |
| 3 | Hold |
| 4 | Safe State |
| 5-63 | reserved |
| 64-127 | Device Specific (specified by device profile) |
| 128-255 | Vendor Specific |

Safe State

This attribute specifies what value will be held in the Control Variable attribute for states other than Executing. See the S-Device Supervisor object definition in Section 6-48 for a description of object states. The following values are defined:

| Attribute Value | State |
|-----------------|---|
| 0 | Zero / Off |
| 1 | Full Scale / On |
| 2 | Hold Last Value |
| 3 | Use Safe Value |
| 4-63 | Reserved |
| 64-127 | Device Specific (specified by device profile) |
| 128-255 | Vendor Specific |

Safe Value

For Safe State set to Use Safe Value, this attribute holds the value to which the Control Variable attribute will be set for object instance states other than Executing.

Ramp Rate

The ramp rate is limited to values 0 through 32,767. See the Behavior section.

S-Single Stage Controller Common Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|----------------|------------------------|----------|----------------------|--|
| | Class | Instance | | |
| 0Ehex 14dec | Conditional* | Required | Get_Attribute_Single | Returns the contents of the specified attribute. |
| 10hex 16dec | N/A | Required | Set_Attribute_Single | Modifies an attribute value. |

*The Get_Attribute_Single service is REQUIRED if any attributes are implemented.

See the DeviceNet Communication Model and Protocol for definitions of these common services.

S-Single Stage Controller Object-Specific Services

The S-Single Stage Controller Object provides no Object-Specific services.

Behavior

The S-Device Supervisor Object manages the behavior of the S-Single Stage Controller Object. See Section 6. Additionally, this object exhibits the following behavior:

Alarm and Warning Exception Conditions

While in the Executing State as defined by the S-Device Supervisor Object: Immediately upon detecting that the Setpoint does not equal the Process Variable by an amount plus-or-minus the associated (alarm or warning) Error Band, a timer is started. This internal timer is incremented as long as the above condition exists. If the timer exceeds the amount indicated by the associated (alarm or warning) Settling Time and the associated (alarm or warning) Exception Enable is set, then the appropriate (alarm or warning) Exception Condition is set. Note that two internal timers are required in order to support both Alarm and Warning Exception reporting.

This behavior is modified for Ramp Rate values not equal to zero. In such cases, the timer is not enabled until after the expiration of the Ramp Time (see Behavior description below).

Ramp Rate

For Ramp Rate values other than zero, the S-Single Stage Controller Object internally modifies the Setpoint value in such a way that the Process Variable is “ramped” to its final value. An example follows. A Ramp Rate of 1000 is set and a new Setpoint is sent to the MFC. The setpoint feed to the controller will be internally (transparently) modified, in whatever time increments the object is able to sustain, in order to affect a smooth transition over one second from the old Setpoint to the new Setpoint, finally reaching the new Setpoint at the one second mark.

Note: GF40/GF80 Series supports Ramp Rates from 1000ms to 32767ms. Rates greater than 7FFFh will return an error. Rates below 1000ms will be accepted; however, the ramping algorithm will not be invoked.

Data Type

If the implementation of this object specifies more than one valid Data Type value, in the device profile or by vendor, then the following behavior with respect to *Data Type* applies. The Data Type value will be set automatically based upon the first valid I/O connection established by the device. This configuration will then remain in effect for this object instance even, after all I/O connections are lost. For devices that support only one Data Type, this behavior is not supported.

If no established I/O connections exist, which include an attribute from this object, then the *Data Type* attribute is settable provided that the object is in the *Idle State*.

The following example demonstrates this behavior:

A device profile specifies an instance of the S-Single Stage Controller object as well as two static Assembly object instances, both with data attribute components mapped to this object instance. Assembly object instance ID 1 specifies INT data types and Assembly object instance ID 2 specifies REAL data types.

After the device is On-Line, it is configured with an I/O connection to Assembly instance ID 2. When the connection transitions to the *Established State*, this object instance attribute *Data Type* is automatically set with the value for REAL before any data is communicated to, or from, the object instance.

GF40/GF80 Series Implementation

Data Type values supported are Integer (0xC3) and Real (0xCA). Data Units supported are Counts (0x1001) and SCCM (0x1400). Data Type and Data Units attributes are settable. The supported combinations of Data Type and Data Units on the GF40/GF80 Series are Integer-Counts (default), Real-SCCM, Integer-SCCM, and Real-Counts. The full-scale range for Integer-Counts is either 0x6000 or 0x7FFF, depending on the configuration. The MFC Device Profile specifies that the full-scale range for the setpoint is 0x7FFF; however, the default GF40/GF80 Series configuration supports a full-scale setpoint range of 0 to 0x6000.

Control

The application of this object is further specified in the applicable device profile; primarily, the interfaces and object relationships are defined. Generally, the *Process Variable* attribute is restricted to "Get Only" access and an internal connection is defined to another object. Similarly, the *Control Variable* is generally not supported due to internal connections.

When in the EXECUTING state, this object is running an application process designed to cause the *Process Variable* to be driven to the value of the Setpoint. In any state other than EXECUTING, the application process is stopped and the *Safe State* is activated for the output of the object.

Any fault detected by the object application process causes the object to transition to the appropriate state as defined by the managing S-Device Supervisor object.

An S-Gas Calibration Object affects the behavior of an associated S-Analog Sensor object instance; a device profile will show a relationship between these two objects where an S-Gas Calibration Object is used. The S-Analog Sensor object uses a selection attribute as the gas type selection mechanism. The S-Gas Calibration Object provides the data with which a device enacts the appropriate calibration algorithm for a given gas type. Each S-Gas Calibration Object Instance contains a set of attribute values for one particular calibration set; each identified by the Gas Standard Number.

The S-Gas Calibration class level object provides a service for retrieving a list of all valid object instances. The service response includes a list of elements. Each element includes the Instance ID, Gas Standard Number and the valid S-Analog Sensor object instance ID for which the instance is valid.

There may be more than one instance with the same Gas Standard Number. These instances may be differentiated by Full Scale, Gas Symbol, Additional Scaler and/or other parametric distinctions, including valid S-Analog Sensor object instance ID. The distinctions may, or may not, be evident in the Get_All_Instances service response, depending upon what the distinction is.

S-Gas Calibration Objects most often utilize the region of Manufacturer Specified Attributes (ID > 100) for specific calibration parameters.

This object is a member of the Hierarchy of Semiconductor Equipment Devices. As such, its behavior is managed by the Device Supervisor Object. See Section 6-48.

The S-Gas Calibration object makes use of a list of Standard Gas Type Numbers. This list is described in publication:

SEMI E52-95 “Practice for Referencing Gases Used in Digital Mass Flow Controllers”,
Semiconductor Equipment and Materials International (SEMI), Mountain View, CA 94043-4080.

NOTE: It is implied that the reference above is to the latest revision as specified by SEMI.

S-Gas Calibration Class Attributes

The Object Class Attribute IDs 1-7 are reserved. See DeviceNet Volume II, Section 5-4.1 for more specification detail on these attributes.

| Attribute ID | Need in Implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute |
|--------------|---|-------------|----------|---------------------|---|
| 1 thru 7 | These class attributes are either optional or conditional and are described in chapter 5 of this specification. | | | | |
| 97 & 98 | Reserved by DeviceNet | | | | |
| 99 | Conditional* (Supported) | Get | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The subclasses for this object are specified at the end of this object specification section. |
| 170 | Optional (Supported) | Get | Bin ID | INT | Specifies the Device Bin number. This value is vendor specific.** |

* If the value of Subclass is 00, which identifies “no subclass”, then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

** This class attribute is required for certain customer applications, such as the “multi-gas, multi-range” application.

S-Gas Calibration Instance Attributes

Certain minimal implementations may support any optional “Set” attributes as “Get” only and still be compliant with this object specification. All required attributes must be supported as specified.

The GF40/GF80 Series supports 9 instances of the S-Gas Calibration Object

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|------------------------|-------------|-----|-----------------------|---------------------|--|--|
| 1 | Optional (Supported) | Get | NV | Number of Attributes | USINT | Number of attributes supported | Number of attributes supported in this object instance |
| 2 | Optional (Supported) | Get | NV | Attribute List | ARRAY OF USINT | List of attributes supported by this object instance | List of attributes supported in this object instance |
| 3 | Required | Get | NV | Gas Standard Number | UINT | Gas Type Number | [default] = 0 (no gas type specified) See Semantics section |
| 4 | Required | Get | NV | Valid Sensor Instance | UINT | S-Analog Sensor object instance ID for which this object instance is valid | 0 = No Valid Sensor n = Instance ID See Semantics section [default] = 0 |
| 5 | Optional (Supported) | Set | NV | Gas Symbol | SHORT STRING | Gas Type Name | See Semantics section [default] = null |
| 6 | Optional (Supported) | Get | NV | Full Scale | STRUCT of: | Full Scale of the device using this object instance | See Semantics section [default] = 0,0 |
| | | | | | REAL | Amount | The amount of measured parameter corresponding to full scale. |
| | | | | | UINT | Units | The units for the above. See Data Units Appendix K. |

* NV = Nonvolatile; value is maintained through power cycle.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|-----------------------------|-------------|-----|------------------------|---------------------|---|--|
| 7 | Optional (Not Supported) | Set | NV | Additional Scaler | REAL | Additional Correction Factor | In addition to the correction algorithm, this amount is multiplied to the reading. Generally used for Gas Correction for a gas other than the type identified for the object instance by attribute 3. (e.g., scale a nitrogen object instance to measure argon). Default = 1.0 |
| 8 | Optional (Supported) | Get | NV | Calibration Date | DATE | Date of Calibration | The date this object instance was last calibrated [default] = 0 |
| 9 | Optional (Supported) | Get | NV | Calibration Gas Number | UINT | Calibration Gas | The gas number of the gas used to calibrate this object instance. [default] = 1.0 |
| 10 | Optional (Not Supported) | Get | NV | Gas Correction Factor | REAL | Gas Correction Factor For devices that support simple correction factors (as opposed to algorithms) for gas selection. | |

* NV = Nonvolatile; value is maintained through power cycle.

| Attr ID | Need in Implementation | Access Rule | NV* | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|---------|------------------------------|-------------|-----|----------|---------------------|--|---|
| 97-98 | Reserved by DeviceNet | | | | | | |
| 99 | Conditional** (Supported) | Get | NV | Subclass | UINT | Identifies a subset of additional attributes, services and behaviors. The sub-classes for this object are specified at the end of this object specification section. | 0 = No Subclass n = Subclass as defined herein |

* NV = Nonvolatile; value is maintained through power cycle.

** If the value of Subclass is 00, then this attribute is OPTIONAL in implementation, otherwise, this attribute is REQUIRED.

Semantics

Gas Standard Number

Used to identify a gas standard number, for which the object instance is currently calibrated. See Instance Application Example below.

The actual coding of the values are described in the following publication:

See introduction section (above) for reference to the SEMI publication: "Practice for Referencing Gases Used in Digital Mass Flow Controllers".

Since the actual attributes, and their context, for the parameterization of object instances for particular gas types is beyond the scope of this standard (i.e., vendor specific) the Access Rule for this attribute has been specified as Get. Vendors may choose to specify an Access Rule of Set for this attribute.

Valid Sensor Instances

This attribute specifies the S-Analog Sensor object instance for which the S-Gas Calibration object instance is valid. An S-Gas Calibration object instance will be valid for zero or one S-Analog Sensor object instances.

Gas Symbol

This optional attribute is a string-coded representation of the name of the gas for which the object instance has been configured. It is coded as a user defined text symbol or it is coded as defined in the above referenced SEMI publication.

This attribute may indicate a different gas from the one, which has been specified by the Gas Standard Number. See Instance Application Example below.

Full Scale

This optional attribute identifies the amount of measured parameter (e.g., Mass Flow) corresponding to the Full Scale of the associated S-Analog Sensor object. A primary purpose for this attribute is to allow for simple S-Analog Sensor object implementations where the Value is reported in raw units; this attribute allows a mapping to engineering units.

For example, the Full Scale for a S-Gas Calibration object may be 100

SCCM, while the Full Scale for the associated S-Analog Sensor object may be 0x6000 counts (i.e., S-Analog Sensor object Data Type = INT and Data Units = Counts).

Instance Application Example

The following is an example to demonstrate the usage of Gas Calibration object instances and their attributes:

A device has been supplied with three gas calibration object instances: nitrogen (13)*, helium (1)* and argon (4)*. The user wishes to use the device for silane (39)* and knows that a correction factor of 0.60 will properly convert a nitrogen calibration for this application. The object instance for nitrogen would be selected and the Additional Scaler attribute for this instance would be set to 0.60. To identify this modification, the Gas Symbol may be set to read “silane”, “SiH4”, or “39”.

* (Gas Standard Number)

S-Gas Calibration Common Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|----------------|------------------------|----------|----------------------|--|
| | Class | Instance | | |
| 0Ehex 14dec | Required | Required | Get_Attribute_Single | Returns the contents of the specified attribute. |
| 10hex 16dec | Required | Required | Set_Attribute_Single | Modifies an attribute value. |

See the DeviceNet Communication Model and Protocol for definitions of these common services.

S-Gas Calibration Object-Specific Services

| Service Code | Need in Implementation | | Service Name | Description of Service |
|----------------|------------------------|----------|-------------------|---|
| | Class | Instance | | |
| 4Bhex 75dec | Required | n/a | Get_All_Instances | Requests a list of all available object instances with their respective gas numbers |

If a gas instance is changed or added, the device must be reset before performing the “get_all_instances” service.

Success Response Service Data Field Parameters

| Parameter | Required | Data Type | Description | Semantics of Values |
|--------------------------|----------------------|-----------|---|--|
| Size of List | Required | UINT | Specifies the number of elements in the Array | Number of gas calibrations in the list |
| List of Gas Calibrations | Required if Size > 0 | ARRAY of | Supported List | The list of gas calibrations |
| | | STRUCT of | Supported Gas Type | |
| | | UINT | S-Gas Calibration Object Instance ID | [34-n-4], where n is the instance value 1 – 6. |
| | | UINT | Gas Standard Number | [34-n-3], where n is the instance value 1 – 6. |
| | | UINT | Valid Sensor Instance | Always =1 for the GF125. |

On the GF40/GF80 Series: Gas instance 6 is considered the “test” gas instance.

There are a total of 6 gas instances, (sometimes referred to as “gas pages”) available.

S-Gas Calibration Object Behavior

The behavior of this object is managed by the Device Supervisor Object, defined in Section 6-48.5.

S-Gas Calibration Object Instance Subclass 01

The following specification applies to a subclass of this object for application in Mass Flow Controller devices.

Subclass 01 Instance Attributes

| Attribute ID | Need in Implementation | Access Rule | Name | DeviceNet Data Type | Description of Attribute | Semantics of Values |
|--------------|-------------------------|-------------|-------------------------|---------------------|--|---|
| 95 | Optional (Supported) | Get | Calibration Pressure | REAL | The gas pressure in KiloPascal | The Standard Pressure with respect to the calibration conditions. Default = 101.32, (14.7 PSIA). |
| 96 | Optional (Supported) | Get | Calibration Temperature | REAL | The Gas Temperature in Degrees C | The Standard Temperature with respect to the calibration conditions. Default = 0.0 |
| 99 | Conditional (Supported) | Get | Subclass | UINT | Identifies subset of additional attributes, services and behaviors | 0 = no subclass 1 = standard T&P 2-65535 = reserved (default = 1) |

Subclass 01 Instance Services

There are no additions or restrictions to the Object Services for this object subclass.

Subclass 01 Behavior

There are no additions or restrictions to the Behavior for this object subclass.

References

- ¹ S-Device Supervisor Object. Open DeviceNet Vendors Association (ODVA) DeviceNet Specification Enhancement 93-01. Version J. 1/27/1999.
- ² S-Analog Sensor Object. Open DeviceNet Vendors Association (ODVA) DeviceNet Specification Enhancement 93-02. Version J. 1/27/1999.
- ³ S-Analog Actuator Object. Open DeviceNet Vendors Association (ODVA) DeviceNet Specification Enhancement 93-03. Version J. 1/27/1999.
- ⁴ S-Single Stage Controller Object. Open DeviceNet Vendors Association (ODVA) DeviceNet Specification Enhancement 93-04. Version J. 1/27/1999.
- ⁵ S-Gas Calibration Object. Open DeviceNet Vendors Association (ODVA) DeviceNet Specification Enhancement 93-05. Version J. 1/27/1999.
- ⁶ Mass-Flow Controller Device Profile. Open DeviceNet Vendors Association (ODVA) DeviceNet Specification Enhancement 93-06. Version J. 1/27/1999.
- ⁷ Open DeviceNet Vendors Association (ODVA) DeviceNet Specification, Volume 1 and 2. Version 2.0. 12/2/1998.

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Global Headquarters

Brooks Instrument
407 West Vine Street
Hatfield, PA
19440-0903 USA

Toll-Free (USA): 888-554-FLOW
T: 215-362-3500

BrooksAM@BrooksInstrument.com

A list of all Brooks Instrument locations and contact details can be found at www.BrooksInstrument.com

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