Entegris

NT® INTEGRATED FLOW CONTROLLER WITH DEVICENET™ COMMUNICATION

User Guide

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Introduction

This manual is for use with standard NT® Integrated Flow Controllers with DeviceNet™ communication, Model 6500. These instruments have been designed for use in high-purity applications in the semiconductor industry. The wetted parts are constructed with PTFE, PFA or other similar high-purity inert materials.

WARNING!
Attempting to install or operate standard NT® Integrated Flow Controllers without reviewing the instructions contained in this manual could result in personal injury or equipment damage.

Identifying Nonstandard Product Configurations

This User Guide applies to product manufactured as the standard NT® Integrated Flow Controller. Entegris also manufactures nonstandard product to meet the needs of specific applications. Nonstandard product may have different materials of construction, accuracy specifications, performance and other specifications that differentiate the nonstandard product from the standard offering.

NOTE: Nonstandard NT® Integrated Flow Controllers may be identified by the model number found on the product label. Specifications for nonstandard NT® Integrated Flow Controllers are available by contacting Entegris.

Nonstandard NT® Integrated Flow Controllers, Model 6500 product line, are identified with an "**M**" followed by a number code.

Example part number:
6500-T2-F02-AM6-D-P1-U1-M02

The "M02" designates the product as a nonstandard product manufactured to certain specifications designated under the "M02" code.

Principle of Operation

The user provides a set point signal that corresponds to the desired amount of flow. The standard NT® Integrated Flow Controller compares the set point to the actual flow signal from the flow module. If the actual flow is greater than the set point, the unit closes the valve. If the actual flow is less than the set point, the unit opens the valve. The flow controller does this in a precise manner until the actual flow signal is equal to the set point.

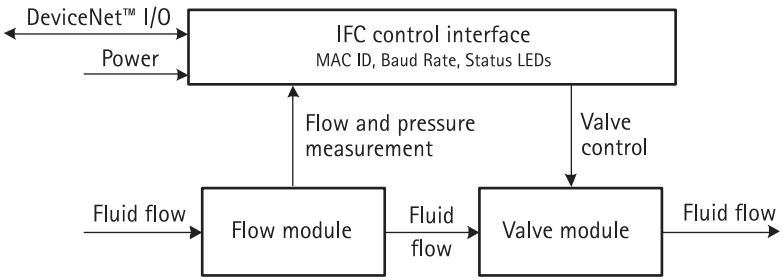


Figure 1: System block diagram

Factory Configured

The standard NT® Integrated Flow Controller is pre-configured from the factory for the flow range specified by the user. The specified flow range is found on the label of the unit. The unit control algorithm uses pressure and flow measurements to ensure proper operation within specification.

Control Mode Functions

There are two types of control mode functions defined for this product:

Normal Operation: A set point input of <5% of full scale will cause the valve to close to a leak tight seal. This is for batch applications where the user is dispensing a given flow rate for a given period of time.

Actuator Override: An actuator override DeviceNet™ communication message is sent to suspend control and leave the valve in its present position, regardless of set point input value.

Autozero Function

If autozero is enabled and the set point is set to <5%, the valve closes and the flowmeter will enter into the re-zero routine. Upon application of a set point greater than or equal to 5%, a new differential pressure (DP) zero value will be stored in non-volatile memory and the unit will immediately resume operation. Autozero is a selectable option through DeviceNet™ communication messaging with a default setting of 'enabled'. It will not increase system response time. The autozero routine will determine DP zero values based on a weighted average routine.

Calibration Reference Conditions

Unless otherwise noted, the specifications listed for the NT® Integrated Flow Controller with DeviceNet™ communication are referenced under the following operating conditions:

PARAMETER	REFERENCE CONDITION
Process fluid	Deionized water
Process temperature	73°F, ± 5°F (23°C, ± 3°C)
Ambient temperature	73°F, ± 5°F (23°C, ± 3°C)
Relative humidity	50% RH, ± 10% RH
Process pressure	20-30 PSIG (138–207 kPa)
Supply voltage	24 VDC, ± 10%
Warm-up time	5 minutes
Orientation	Horizontal
Operation	Flowmeter zeroed

General Considerations

NOTE: The flow controller has been factory sealed. Do not attempt to remove the cover of the unit. Any attempt at removal of the unit cover will void the warranty.

Line Pressure

The system line pressure (measured at the inlet of the unit) must be between 10 and 60 PSIG (69 to 414 kPa). The minimum operating pressure is 10 PSIG (69 kPa).

Pressure Drop

The minimum pressure drop (differential pressure) required for the unit is 10 PSID (69 kPa).

For example, if the flow controller is operating at an inlet pressure of 15 PSIG (103 kPa) and outputs the flow to a pressurized canister, which is pressurized to 10 PSID (69 kPa), the pressure available to the unit will be 5 PSID (15 PSIG [103 kPa] inlet pressure minus 10 PSIG [69 kPa] canister pressure). This scenario does **not** meet the pressure drop requirement of 10 PSID (69 kPa) and the unit may not perform within specification. For this example, either increase the inlet pressure or decrease the canister pressure to obtain a 10 PSID (69 kPa) pressure drop.

Ambient Temperature Range

The flow controller is designed to operate in room temperature cleanroom environments: 50° to 86°F (10° to 30°C). The unit must be re-zeroed at operating temperature conditions for the accuracy specifications to apply.

Process Temperature Range

The range of acceptable process temperatures is 50° to 149°F (10° to 65°C). The flow controller must be re-zeroed at operating temperature conditions for the accuracy specification to apply. PFA isolators are recommended for process temperatures higher than 122°F (50°C). Applications involving hydrofluoric acid (HF) with temperatures above 86°F (30°C) must contact the factory for recommended materials of construction. Positive pressure must be maintained at all times.

Storage Temperature Range

The flow controller will withstand storage temperatures between -40° and +122°F (-40° and 50°C) for at least a 24-hour period with no permanent effect on device performance.

Power Supply Requirements

The power supply range for the standard NT® Integrated Flow Controller is 24 VDC ±10%.

The power supply must provide continuous 1.0 A (nominal) current for each flow controller installed. Peak power consumption is 1.2 A, maximum.

The power supply to the flow controller must provide *clean* power to the unit and must be used only to power similar measurement-type devices. The power supply must not be used to power other inductive loads, such as motors, relays or solenoids. These devices may produce electrical transients that may affect unit measurements. An induced power spike, creating an interruption in power greater than 10 msec in duration, may cause the unit to reset.

DeviceNet™ Cable

The power supply range of the DeviceNet™ cable is 24 VDC ±10%, 150 mA nominal current.

In addition to providing clean power, all power communication cables must not be run within the same conduit or cable along with heavy current demands from motors, charging capacitors or other inductive loads. This may cause a voltage change within the instrumentation signal line, causing erroneous output readings from the flow controller. Loss of power will not cause the loss of any system parameters or calibration values.

DeviceNet™ Communication

The DeviceNet™ communication shall meet the physical layer communications requirements in the referenced ODVA DeviceNet™ standard. Briefly, this is a 5 wire (V+, V-, CAN_H, CAN_L, Drain) physical layer based on the CAN protocol.

DeviceNet™ Module Status LED

This LED is labeled 'Mod'.

INTEGRATED FLOW CONTROLLER STATE	LED STATE	DESCRIPTION
Power off	Off	No power is applied through DeviceNet™.
IFC self-test	Flashing red and green	IFC is in self-test.
IFC operational	Green	IFC is operating normally.
Minor fault	Flashing red	IFC has detected a recoverable fault.
Unrecoverable fault	Red	IFC has detected an unrecoverable fault.
IFC in standby	Flashing green	IFC needs commissioning due to configuration missing, incomplete or incorrect.

DeviceNet™ Network Status LED

This LED is labeled 'Net'.

INTEGRATED FLOW CONTROLLER STATE	LED STATE	DESCRIPTION
Not powered or not on-line	Off	IFC is not on-line. IFC may not be powered; look at Module Status LED.
On-line, not connected	Flashing green	IFC is on-line, but has no connection.
Link OK, on-line, connected	Green	IFC is on-line and has connection.
Connection time-out	Flashing red	Network connection is in the timed-out state.
Critical link failure	Red	IFC has detected an error and cannot communicate on the network.

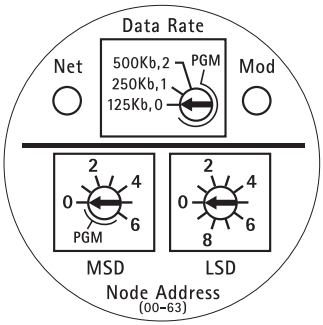


Figure 2: DeviceNet™ switches and status LEDs located on the top side of the flow controller

DeviceNet™ Node Address Switches

Two, ten-position, rotary switches used for configuring the Media Access Control Identifier (MACID) of the flow controller. These switches specify the MACID using decimal representation. One switch specifies the most significant digit (MSD), or tens position of the MACID. The second switch specifies the least significant digit (LSD) or the ones position of the MACID. DeviceNet™ allows MACIDs with values 0–63. The "PGM" label indicates the software programmable switch positions.

DeviceNet™ Data Rate Switch

A single, ten-position rotary switch used for configuring the baud rate of the flow controller. The switch has positions for the three valid, DeviceNet™ data rates, 125, 250 and 500 Kbaud. Switch position 0 selects 125 Kb, position 1 selects 250 Kb, and position 2 selects 500 Kb. The "PGM" label indicates the software programmable switch positions.

Electrical Isolation

The degree of electrical isolation between power and DeviceNet™ communication is as listed below:

From:	Power, 24 VDC
To:	DeviceNet™ Comm
Isolation degree:	>500 VAC/VDC

Reverse Polarity Protection

The flow controller is reverse polarity protected; connecting the 24 VDC power to the incorrect positive and ground wires will not harm the unit. To operate properly, the polarity must be correct.

Over-Voltage on any Wire (DC)

The flow controller will withstand the continuous application of 30 VDC on any wire without compromising the unit. The flow controller will withstand the momentary application of 40 VDC on any wire without compromising the unit.

Over-Voltage on any Wire (AC)

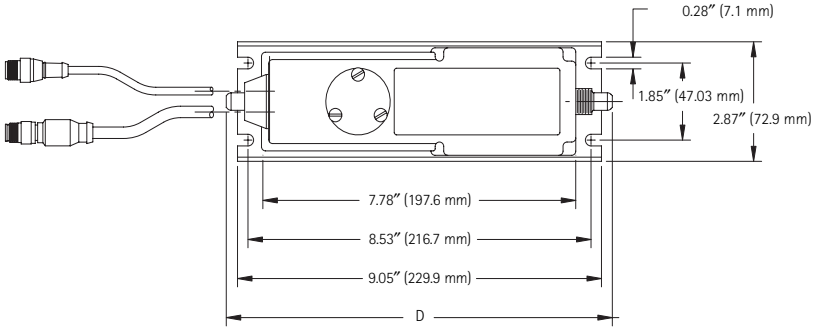
The flow controller is **not** designed to withstand the accidental application 110/220 VAC to any wire. Application of AC voltage will damage the unit.

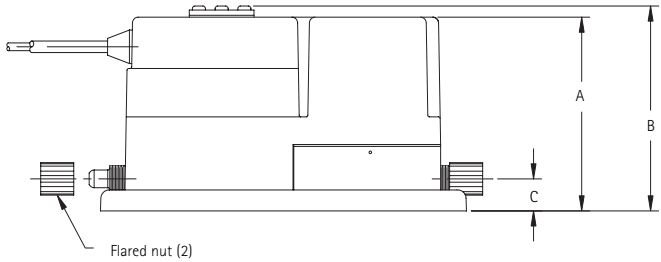
Short Protection

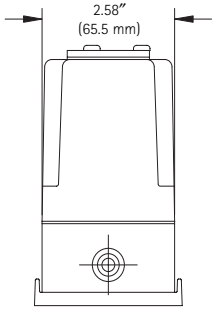
The flow controller will not be damaged or compromised in any way if any combination of wires are shorted together.

Dimensions

NT® Integrated Flow Controller with DeviceNet™ Communication



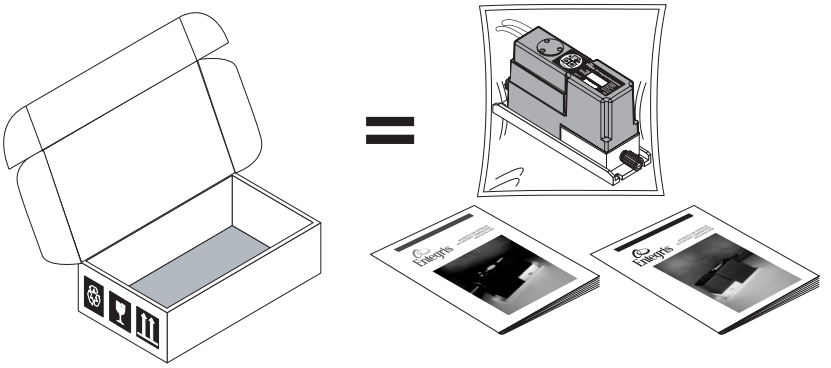




FITTING	A	B	C	D
1/4″ F02	4.63″ (117.5 mm)	4.89″ (124.2 mm)	0.76″ (19.4 mm)	9.60″ (243.8 mm)
3/8″ F03	4.63″ (117.5 mm)	4.89″ (124.2 mm)	0.76″ (19.4 mm)	9.75″ (247.7 mm)
1/2″ F04	4.72″ (119.9 mm)	4.98″ (126.5 mm)	0.85″ (21.6 mm)	9.91″ (251.7 mm)
3/4″ F06	5.02″ (127.5 mm)	5.28″ (134.1 mm)	1.01″ (25.7 mm)	10.15″ (257.8 mm)

Installation

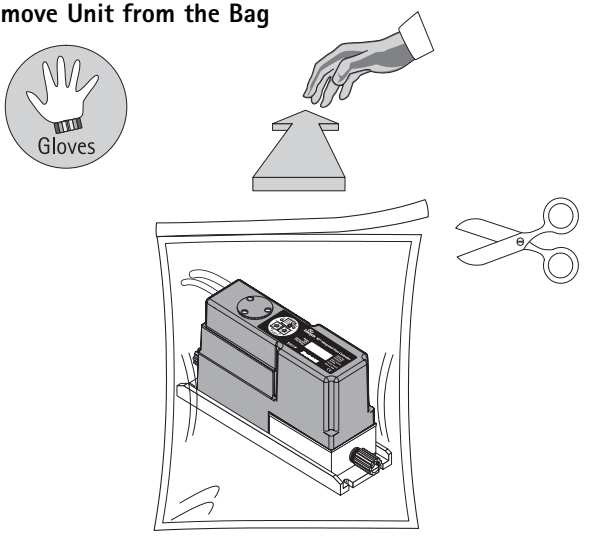
Provided Equipment



CAUTION!
Do not tighten the nuts that protect the flared tube connections during shipment. (See *Prepare Fluid Lines* **on page 11). Tightening these nuts without the proper tubing installed may damage the unit's flared tube connections.**

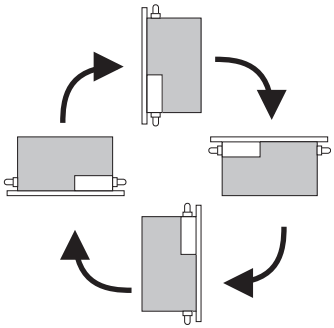
NOTE: This unit has been assembled and double-bagged under cleanroom conditions. To maintain purity, only open under cleanroom conditions.

Remove Unit from the Bag



Mounting Requirements

The flow controller may be mounted in any orientation. The unit does not require straight lengths of tubing at the inlet or the outlet connection.



Mount the Unit

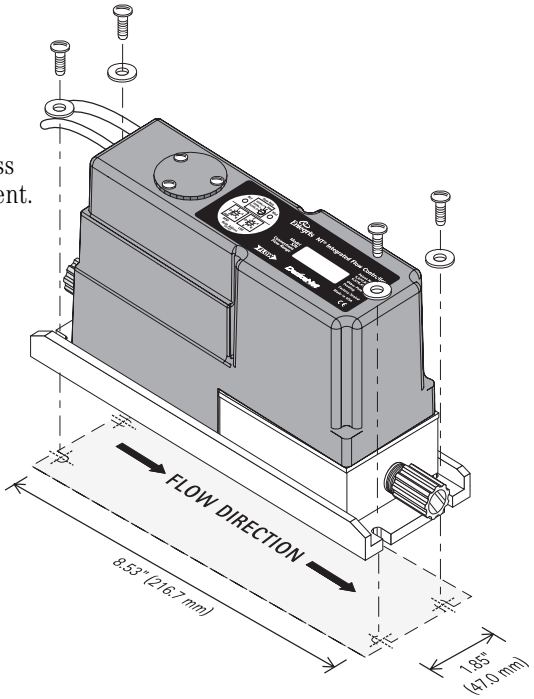
The flow controller and base bracket assembly must be mounted to a solid surface to ensure stability. Verify the valve and the electrical cable are free from mechanical stress from the surrounding equipment.

NOTE: The flow controller requires mounting in the direction of the fluid flow.

Recommended hardware

#10 (M4)
Pan head

#10 (M4)
Flat washer



Mechanical Installation

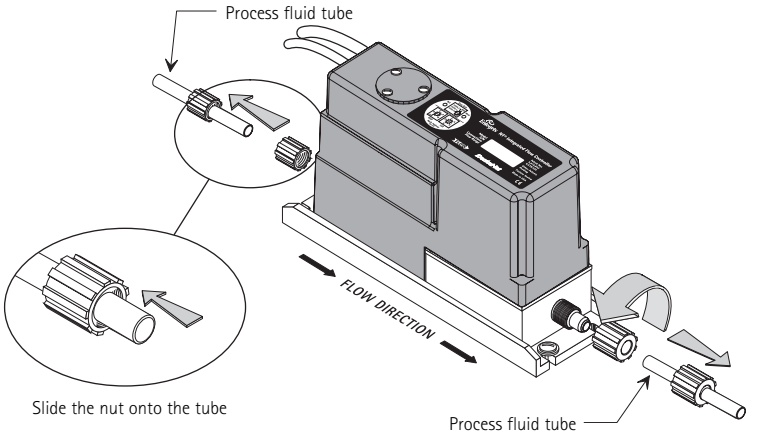
The standard NT® Integrated Flow Controller must be used with the proper tubing size and fittings.

To prepare the fluid lines, begin by sliding the supplied nuts onto the fluid tube.

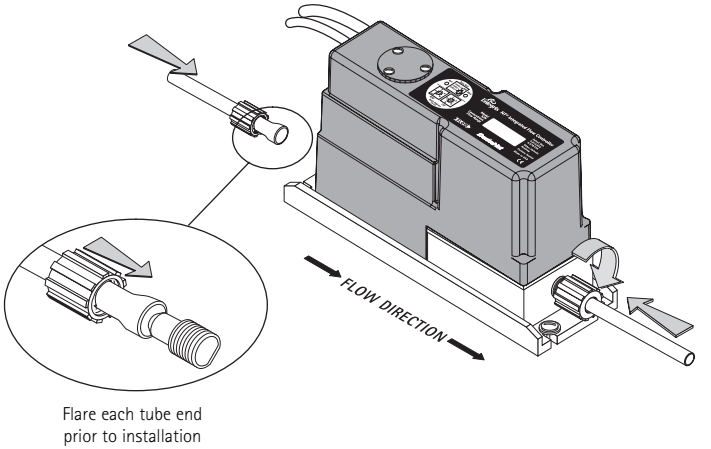
NOTE: Flare each tube end prior to installation onto the valve fitting.

CAUTION!
Over-tightening of the nuts will result in damage to the fitting.

Prepare Fluid Lines



Connect Fluid Lines



When installing flared tubing to the flow controller, the flared tube is pushed over the valve's fitting until the fitting reaches the smaller tube diameter. The amount of torque required to tighten the nut is dependent upon the size of the fitting.

FITTING SIZE	1/4"	3/8"	1/2"	3/4"
Torque (in•lbs.)	5	8	11	14
Torque (N•m)	0.56	0.90	1.24	1.58

Care should be taken when installing the flow controller to avoid fluid leaks. Do not use excessive torque or subject the unit to high heat during installation. The unit and base bracket assembly must be mounted to a solid surface to ensure stability. Verify the body and the electrical cable are free from mechanical stress from the surrounding equipment.

Electrical Connections

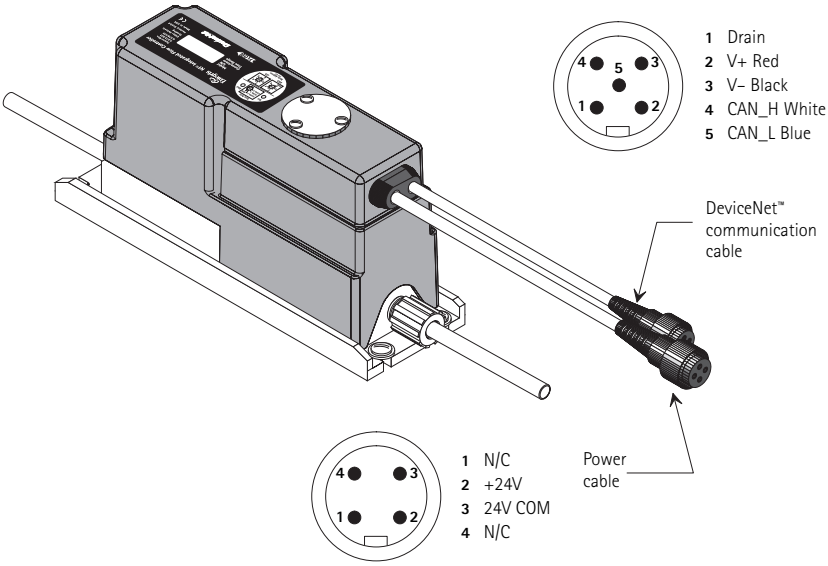
Connect cable to flow controller

The cable mounting receptacles are physically "keyed", making it impossible to insert the connector improperly. Press it into the mounting receptacle and rotate the outer coupling ring to lock the connector in place. To remove the connector, rotate the coupling ring in the opposite direction.

Power Cable

Cable materials are constructed with 22 AWG wire and a PVC jacket. The connector is a 4-pin, 12 mm, male type.

FUNCTION	PIN ASSIGNMENT	COLOR
No connection	1	Brown
+24V	2	White
24V common	3	Blue
No connection	4	Black

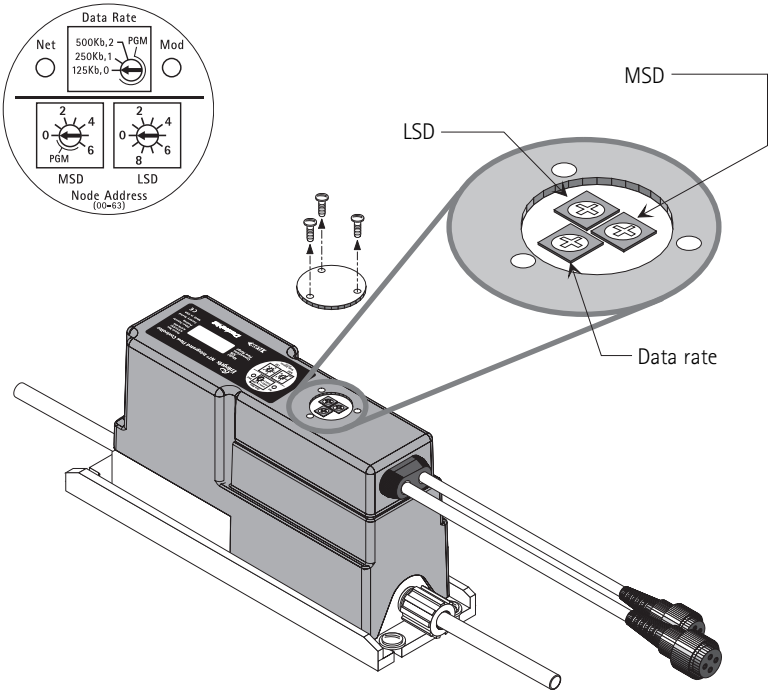


DeviceNet™ Cable

Cable materials are constructed with 22 AWG wire and a PVC jacket. The connector is a 5-pin, micro-style, 12 mm, male type.

FUNCTION	PIN ASSIGNMENT	COLOR
Drain	1	Bare wire
V+	2	Red
V-	3	Black
CAN_H	4	White
CAN_L	5	Blue

NOTE: The allowable torque on the 8-32 × 1/2" PVDF screws used to secure the clear switch access cover is 7 Newton-centimeters.



Unit Operation

Operating Environment

Operating Temperature

The flow controller is designed to operate in ambient temperature, cleanroom environments. The unit is specified to operate at temperatures between 50° and 149°F (10° and 65°C).

When the process fluid is above ambient temperatures 73°F (23°C), the system will experience slight accuracy errors due to instrument warm-up and changes in viscosity and specific gravity of the liquid. The unit **must** be re-zeroed after any temperature change. Please see the *Maintenance Section* on page 19 to perform the re-zero.

Effects of Fluid Viscosity and Specific Gravity

The flow controller has been factory calibrated using deionized water. Fluids with viscosities and/or specific gravity different from the calibration fluid (water) will cause slight accuracy errors. Correction factors for viscosity and specific gravity changes may be obtained from Entegris by calling or following the sensing and control product links at *entegrisfluidhandling.com.*

Power-up Characteristics

When power is first applied to the flow controller, the flow will be within 2% of the set point value in less than 10 seconds and within specification after 5 minutes. As part of the power-up routine, the unit will perform a homing routine that re-establishes the unit's fully closed position. This routine requires the valve to shut completely for no more than 8 seconds, then to the position dictated by the set point input.

Unit Enclosure

The standard NT® Integrated Flow Controller cover is factory sealed and should not be tampered with or opened. Spray-down or temporary immersion will not compromise the performance of the unit.

NOTE: Any attempt to remove, tamper or open the flow controller cover will void the warranty.

Performance

Operating Pressure Requirements

The flow rate is calculated using Entegris' differential pressure flow technology. The minimum operating pressure is 10 PSIG (69 kPa). The minimum pressure drop (differential pressure) required for the flow controller is 10 PSID (69 kPa).

CAUTION!
The flow controller may be damaged if it is subjected to any level of vacuum pressure (less than atmospheric pressure).

NOTE: To perform within specification, the available inlet pressure must be 10 PSID (69 kPa) greater than the outlet pressure (10 PSID [69 kPa] differential pressure).

Flow Accuracy

The accuracy of the flow measurement is ±1% of full scale from 20-100% of the flow range. The accuracy of the flow measurement is ±2.5% of full scale from 10-20% of the flow range. The accuracy specification includes the effects of linearity, hysteresis and repeatability, using deionized water at 73°F (23°C). The accuracy between 0-10% of full scale flow range is not specified.

Flow accuracy is verified by testing the unit at stable conditions for a period of 20 seconds or longer.

To meet the accuracy specification, a re-zero is required for every 10 PSIG (69 kPa) change in line pressure.

Response Time

Response time is defined as the length of time required for the measured flow rate to be within the full scale (FS) accuracy specification. The typical response time is within 3 seconds.

The flow controller will respond to set point changes within 50 msec of receiving the new set point value.

When power is first applied to the unit, such as during a start-up sequence, the flow rate will be controlled to within 1% FS of the set point value within 10 seconds.

Pressure Measurement Accuracy

The accuracy of the pressure output is ±1% of full scale. These calculations include the effects of linearity, hysteresis and repeatability, measured at 73°F (23°C).

Minimum Operating Pressure

The unit will operate within specification at any inlet pressure within the range of 10-60 PSIG (69 to 414 kPa) and a minimum pressure drop of 10 PSID (69 kPa).

Pulsating Inlet Pressure

Some applications use pumps (diaphragm pumps for example) that can cause significant and rapid change in pressure. The flow controller shall meet the accuracy specification under the following conditions: pressure pulsation frequency 0-2 Hz, pressure pulsation amplitude 10 PSIG (69 kPa) and 60 second batch test.

Temperature Increase of Flow Controller Enclosure

The temperature increase within the unit enclosure will be less than 86°F (30°C). The temperature increase at the exterior of the unit cover will be less than 77°F (25°C).

The temperature increase of the process fluid will be less than 5°F (3°C) at 10% of flow and less than 0.9°F (0.5°C) at 100% of flow range for T1, T2, T3 and T4 flow ranges. For all other flow ranges, the temperature rise of the process fluid is negligible, less than 0.9°F (0.5°C), at all flows. Under extended static flow conditions (i.e., no flow for >24 hours) the temperature increase of the process fluid will be less than 27°F (15°C).

Warm-up Time

The flow controller requires a warm-up time of 10 minutes after power is applied. Warm-up time is typically not required if the unit was operated within 3 hours.

Reliability Information

Redundant Process Seals

All internal process wetted seals are redundant, i.e., there is a secondary seal that prevents process fluid from reaching the interior of the device in the case of a primary seal failure. Weep holes are provided from the secondary containment regions.

Long-term Reliability

The valve system can withstand 3.5 million open/close cycles before the control performance is compromised.

Enclosure Integrity

Momentary immersion and spray down of the flow controller will not affect the performance per NEMA 5 and IP56.

Drop and Topple

If the unit topples over from a 45-degree angle onto a bench top, the performance will not be compromised and the unit will not be externally damaged.

Cable Pull

The cable will withstand a static pull test of 20 lbs (9.1 kg) straight and 10 lbs (4.5 kg) at 90 degrees without being damaged.

Diagnostic Guide

SYMPTOM	POSSIBLE CAUSES	SUGGESTIONS
1. Flow reading is very low.	The unit is installed backwards.	Install the unit so the inlet flow is plumbed on the same side as the electrical connection.
	Insufficient line pressure.	The inlet pressure must be at least 10 PSIG (69 kPa) greater than the outlet pressure. Verify the inlet pressure using the pressure signal from the flow controller.
2. Flow reading above zero when set point is zero and no flow is present.	The unit needs to be re-zeroed.	Perform a zero adjust service or enable the autozero function.
3. Flow output is extremely noisy	The actual fluid flow conditions are noisy.	Flow turbulence may be caused by "noisy" pumps used in a system. Examples of noisy pumps are diaphragm pumps without pulsation dampeners and peristaltic pumps operating at low flow rates. Please contact Entegris for additional information.
4. Unit resets.	The supply power (+24V) is noisy.	If the power supply is shared with other systems, components such as solenoids, DC motors, valves, etc., the unit may be receiving "dirty" power. Extreme noise spikes will cause the unit to reset. Connect the unit to a separate power source.
5. Flow output does not correspond to set point for high flow rates.	Inlet pressure is not 10 PSIG (69 kPa) greater than the outlet pressure at the high flow conditions.	Measure the inlet pressure. Also measure the fluid pressure at the outlet of the unit using a pressure gauge or pressure transducer. Verify the inlet pressure is at least 10 PSIG (69 kPa) greater than the outlet pressure.

Diagnostic Guide *(continued)*

SYMPTOM	POSSIBLE CAUSES	SUGGESTIONS
6. Flow rate is not meeting desired set point within 10 seconds or longer.	The unit is receiving a set point signal with no fluid flow present. The flow controller valve is moved to the full-open position. Depending upon flow range, the unit may require 10–15 seconds or more to move from the full-open position to the correct set point position.	Do not send a set point signal to the unit when no fluid flow is available.
	Inlet pressure is not 10 PSIG (69 kPa) greater than outlet pressure.	(see above, Symptom 5)
7. Flow output is not responsive to changes in set point signal.	Valve in full-open position. If the unit is plumbed between two closed valves, the unit may stall in the full-open position when the unit is commanded to close. Since a fixed volume of fluid is incompressible, the unit may stall when attempting to close if upstream and downstream valves are closed.	Avoid conditions of simultaneously closed valves upstream and downstream of the unit. The unit can be returned to normal operation by performing a re-zero, or by cycling power.
8. Net LED flashes green. Valve goes to safe position, default position is closed.	Network down	Reconnect to network

Maintenance

Normal Operation

During normal operation, the standard NT® Integrated Flow Controller with DeviceNet™ communication requires no maintenance, other than a periodic re-zero of the unit.

Re-zero Function

The no flow calibration of the flow controller can be re-zeroed, meaning that the flow output that corresponds to zero flow may be reset.

NOTE: When executing the re-zero function, there must be at least 1 PSIG (7 kPa) of static pressure. Optimum pressure for re-zero is the operation pressure, typically greater than 10 PSIG (69 kPa).

NOTE: The following procedure must be followed precisely to ensure proper flow controller re-zero.

The no flow calibration of the flow controller can be re-zeroed, meaning that the flow output that corresponds to zero flow may be internally reset. This is done with DeviceNet™ service requests. The 'Zero_Adjust' service command in the Analog Sensor Object is sent to begin a re-zero process. The 'Stop_Zero_Adjust' service command in the Analog Sensor Object is sent to stop the re-zero process.

When the re-zero function is activated, the flow controller valve module will close fully to ensure that fluid is not flowing. The unit will verify the no-flow condition, and then re-zero the flow module. The entire re-zero function is completed in 10 seconds.

In order to obtain best performance, the re-zero function should be performed, at minimum if possible, every 30 days of service when operating at ambient temperature conditions. The re-zero function should be performed more often if operating at higher temperature. It is also recommended to perform a re-zero after start-up and after fluid temperature changes of greater than 9°F (5°C). Best performance will be achieved by re-zeroing between each dispense cycle.

Autozero Function

The no flow calibration of the flow controller can be autozeroed, meaning that the flow output that corresponds to zero flow may be automatically, internally reset whenever the set point is zero. Selecting the 'enabled' setting of the 'Autozero Enable' attribute in the Analog Sensor Object does this. This is the default setting.

Reference

Physical Specifications

PART	CONSTRUCTION MATERIALS
Wetted parts:	
Body:	PTFE
Diaphragms:	PTFE
Sensor interface:	PFA or CTFE
O-rings:	Kalrez® 4079
Nonwetted parts:	Polypropylene cover and base plate, Viton® plugs
Connection type:	Flaretek® tube fitting
Enclosure:	NEMA 5/IP54

Power Cable Specifications

Input voltage:	24 VDC, ±10%
Input current:	1.0 A nominal, 1.2 A peak
Electrical connection:	6′, 12′ lengths with 22 ga wire PVC-jacketed wire

DeviceNet™ Cable Specifications

Input voltage:	24 VDC, ±10%
Input current:	150 mA nominal
Electrical connection:	6′, 12′ lengths with 22 ga wire PVC-jacketed wire

Performance Specifications

Flow accuracy:	±1.0% FS at 20% to 100% of flow range, ±2.5% FS at 10% to 20% of flow range. Accuracy defined for 10 seconds average, using DI water at 73°F (23°C). Accuracy not specified 0% to 10% of flow range.
Pressure accuracy:	±1.0% FS (full scale is 60 PSIG [414 kPa])
Repeatability:	±0.5% FS at 20% to 100% of flow range ±1.0% FS at 10% to 20% of flow range
Response time:	<3 seconds to within 5% of new set point value
Process temperature:	50° to 149°F (10° to 65°C)
Storage temperature:	-40° to 122°F (-40° to 50°C)
Operating pressure:	10 to 60 PSIG (69 to 414 KPA)
Over-pressure limit:	100 PSIG (690 KPA)

NOTE: Specifications are subject to change without notice. Please consult the factory for the most current information.

Ordering Information

MODEL	PRODUCT DESCRIPTION
6500	Integrated Flow Controller

CODE	FLOW RANGE
T0	0-50 ml/min.
T1	0-125 ml/min.
T2	0-250 ml/min.
T3	0-500 ml/min.
T4	0-1250 ml/min.
T5	0-2.5 l/min.
T6	0-5 l/min.
T7	0-10 l/min.
T8	0-20 l/min.
T9	0-40 l/min.*

CODE	PROCESS CONNECTION
F02	1/4″ Flaretek® tube fitting
F03	3/8″ Flaretek® tube fitting
F04	1/2″ Flaretek® tube fitting
F06	3/4″ Flaretek® tube fitting

CODE	ELECTRICAL CONNECTOR TYPE
AM6	PVC-jacketed 6′ cable set
AM12	PVC-jacketed 12′ cable set

CODE	SET POINT INPUT SIGNAL, CONTROLLER TYPE
D	DeviceNet™ communication

CODE	SENSOR INTERFACE
P1	CTFE
P2	PFA

CODE	PRIMARY / SECONDARY SEAL
U1	Kalrez® 4079 / Viton® (default)
U2	Kalrez® 1050 LF / Viton®
U3	Kalrez® 6375 UP / Viton®

* Please consult factory for operating pressure requirement.

Allowed process connection and flow range combinations:

FLOW RANGE	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
1/4″ F02	✓	✓	✓	✓	✓	–	–	–	–	–
3/8″ F03	✓	✓	✓	✓	✓	✓	✓	–	–	–
1/2″ F04	–	–	–	✓	✓	✓	✓	✓	✓	–
3/4″ F06	–	–	–	–	–	–	–	✓	✓	✓

Certifications

CE Compliance

Entegris products have been tested to various test standards required by the EMC 89/336/EEC directive. The results of this testing are on file at Entegris and are available upon request.

Please contact the factory for the latest information. The most current specifications may be found on the Internet at: *http://www.entegrisfluidhandling.com.*

DeviceNet ODVA Conformance

The NT® Integrated Flow Controller with DeviceNet™ communication has successfully completed and passed Open DeviceNet Vendor Association (ODVA) approved conformance tests at the independent, authorized ODVA Training and Technology Center in Ann Arbor, MI. Entegris has been issued an official Declaration of Conformity from ODVA for this product.

DeviceNet™ Communication Integrated Flow Controller Device

Device Type: 00_{hex}

This **vendor specific device profile** is based on the DeviceNet™ Fluid Flow Controller (FFC) device profile. The device type is 00 due to the pre-release status of the FFC profile. Type 00 is a Generic Device type.

A Fluid Flow Controller (FFC) is a device that measures and controls the flow rate of a fluid (liquid or gas). It contains three principle components: a flow rate sensor that can be a virtual sensor based on other sensors, for example pressure; a fluid flow metering valve that can be actuated by one of a variety of actuator types, including, for example, solenoid or a stepper motor; and, a controller that closes the loop by receiving a set point and driving the actuator such that the fluid flow rate is controlled to the set point.

This chapter contains two primary sections. First, the device profile is specified as it appears in general DeviceNet™ specification. Second, the vendor specific attributes, services, behaviors, ranges and capabilities are specified.

Object Model

The Object Model in Table 1 represents an FFC Device. The table below indicates:

- The object classes present in this device
- Whether or not the class is required
- The number of instances present in each class

Table 1. Object Model

OBJECT CLASS	OPTIONAL/REQUIRED	# OF INSTANCES
Identity	Required	1
Message router	Required	1
DeviceNet™	Required	1
Connection	Required	at least 1 I/O and 1 explicit
Assembly	Required	at least 1 input and 1 output
S-Device supervisor	Required	1
S-Sensor calibration	Optional	0 or more
S-Analog sensor	Required	2
S-Analog actuator	Required	1
S-Single stage controller	Required	1

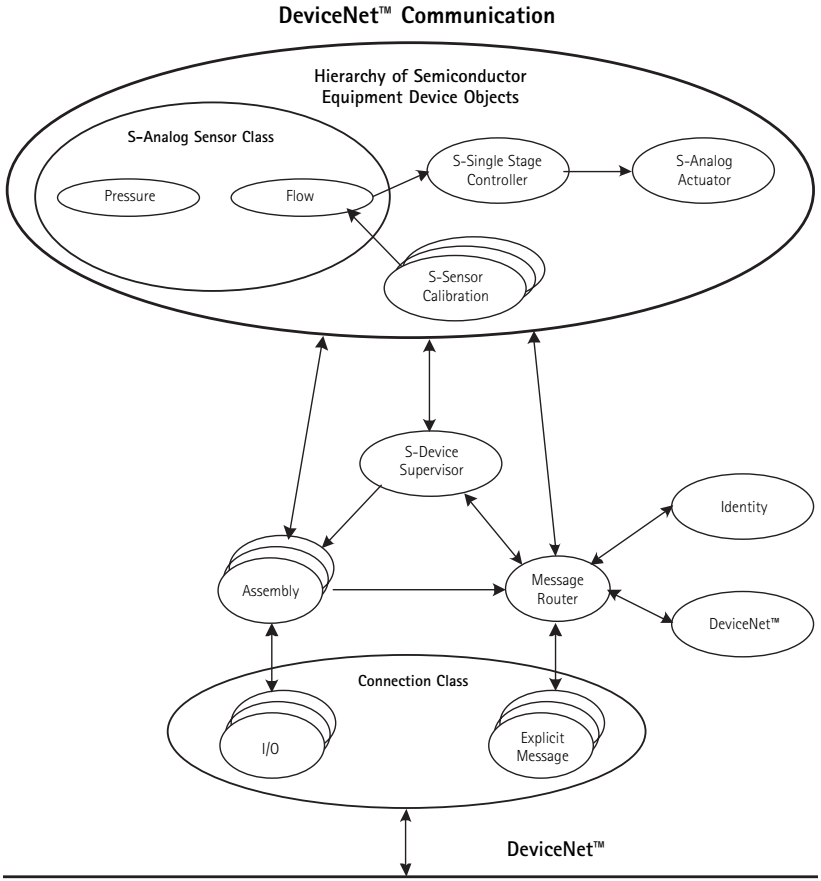


Figure 3. Object model for the FFC device

S-ANALOG SENSOR	NAME	DESCRIPTION
Instance 1	Flow	Virtual sensor that calculates the fluid flow rate based on various sensed parameters, for example, differential pressure
Instance 2	Pressure	The measured fluid pressure

How Objects Affect Behavior

OBJECT	AFFECT 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 [Bus-Off Interrupt])
Connection class	Contains the number of logical ports into or out of the device
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 affect the DeviceNet™ specific objects (i.e., Identity, DeviceNet™, Connection, etc.).
S-Sensor calibration	Modifies the correction algorithm of the Flow S-Analog Sensor object, which includes the selection mechanism to enable an S-Sensor Calibration object instance.
S-Analog Sensor	A virtual sensor determines the measured fluid flow rate. The flow sensor feeds the process variable to the S-Single Stage Controller object
S-Single stage controller	Feeds the control variable to the S-Analog Actuator object
S-Analog actuator	Operates the Flow Control Valve of the device

Defining Object Interfaces

OBJECT	INTERFACE
Identity	Message router
Message router	Explicit messaging connection instance
DeviceNet™	Message router
Connection class	Message router
Assembly	I/O connection or message router
S-Device supervisor	Assembly or message router
S-Sensor calibration	Message router
S-Analog sensor	Assembly or message router
S-Single stage controller	Assembly or message router
S-Analog actuator	Assembly or message router

Vendor Specific Section

This section specifies the **Vendor Specific** attributes, service and behaviors supported by this device. It is provided primarily to specify which attributes and services are supported and with what ranges.

NOTE: Specific definitions of attributes and services are included here for reference only. For specification details and latest revisions, see the *DeviceNet™ Specifications*.

NOTE: Attribute Tables that include an "NV" column use the following nomenclature:

V = Volatile: value is lost upon power cycle

NV = Nonvolatile: value is retained through power cycle. A "Reset Type 1" reinitializes these values to their defaults (i.e., Out-of-Box configuration).

NVF = Nonvolatile Factory Set: value is retained through power cycle. Only the factory can change these values with special software access. A "Reset Type 1" has no affect on these values.

NVC = Nonvolatile Constant: value is fixed, determined by software. These values are "hard-coded" and not settable.

Identity Object (01_{hex})

Class

ATTRIBUTES 1.0 – CLASS ATTRIBUTES – IDENTITY OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object Revision	= 01

SERVICES 1.0 – CLASS SERVICES – IDENTITY OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Instance 1

ATTRIBUTES 1.1 – INSTANCE ATTRIBUTES – IDENTITY OBJECT 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Required	Yes	Get	NVC	Vendor ID	UINT	ODVA assigned identification of vendor	864 = NT International
2	Required	Yes	Get	NVC	Device type	UINT	Indication of general type of product	0000
3	Required	Yes	Get	NVF	Product code	UINT	Indication of a particular product of an individual vendor	0001
4	Required	Yes	Get	NVC	Revision	STRUCT of:		
					Major revision	USINT		01
					Minor revision	USINT		01
5	Required	Yes	Get	V	Status	WORD	Summary status of device	b0 = Owned b1 = 0 b2 = Configured b3 = 0 b4 : b7 = 0 b8 = Minor recoverable fault b9 = Minor unrecoverable fault b10 = Major recoverable fault b11 = Major unrecoverable fault b12 : b15 = 0
6	Required	Yes	Get	NVF	Serial number	UDINT	Serial number of device	Must be guaranteed unique for a given Vendor ID
7	Required	Yes	Get	NVF	Product name	SHORT_ STRING	Human readable identification	"FFC"

SERVICES 1.1 – INSTANCES SERVICES – IDENTITY OBJECT 1

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
05_{hex}	Required	Yes	Reset	Type (USINT)	Emulates power cycling the device.	Type 0 = Reset. [default if parameter is omitted] Type 1= Return to the out–of–box configuration, then Reset.

Message Router Object (02_{hex})

Class

ATTRIBUTES 2.0 – CLASS ATTRIBUTES – MESSAGE ROUTER OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object Revision	= 01

SERVICES 2.0 – CLASS SERVICES – MESSAGE ROUTER OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Instance 1

NO INSTANCE ATTRIBUTES

NO INSTANCE SERVICES

DeviceNet™ Object (03_{hex})

Class

ATTRIBUTES 3.0 – CLASS ATTRIBUTES – DEVICENET™ OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object revision	= 02

SERVICES 3.0 – CLASS SERVICES – DEVICENET™ OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Instance 1

ATTRIBUTES 3.1 – INSTANCE ATTRIBUTES – DEVICENET™ OBJECT 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get*	NV*	MACID	USINT	Node address	= 0–63
2	Optional	Yes	Get*	NV*	Baud Rate	USINT	Baud rate	0 = 125K 1 = 250K 2 = 500K 3 = undefined
3	Optional	Yes	Get	NV	BOI	BOOL	Bus-off interrupt	0 = Hold bus-off [default] 1 = Auto reset (not supported)
5	Required	Yes	Get	V	Allocation Info	Struct of: BYTE USINT	Allocation Choice Masters MACID	See service parameter
6	Required	Yes	Get	V	MACID Swt Chg	BOOL	Changed since last reset (media access)	0 = No change 1 = Changed
7	Required	Yes	Get	V	BAUD Swt Chg	BOOL	Changed since last reset (media access)	0 = No change 1 = Changed
8	Required	Yes	Get	V	MACID Swt Chg	USINT	Actual switch value	0–99
9	Required	Yes	Get	V	BAUD Swt Chg	USINT	Actual switch value	0–9

*If the corresponding configuration switch is higher than the attribute's limit, the attribute has SET access.

SERVICES 3.1 – INSTANCE SERVICES – DEVICENET™ OBJECT 1

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT); Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific
$4B_{hex}$	Required	Yes	Allocate_Master/ Slave_Connection _Set	Allocation choice; Master	Initializes predefined master/slave connection set	0 × 01 = Explicit 0 × 02 = Poll 0 × 03 = Both
$4C_{hex}$	Required	Yes	Release_Group_2 _Identifier_Set	Allocation choice	Releases predefined master/slave connection set	0 × 01 = Explicit 0 × 02 = Poll 0 × 03 = Both

SERVICES DATA FIELD PARAMETERS

PARAMETER	REQUIRED	DATA TYPE	DESCRIPTION	VALUES
Allocation choice	Yes	BYTE	Specifies the connection types	b0 = Explicit b1 = Polled b2 = Bit strobe b3 = Multicast poll b4 = COS b5 = Cyclic b6 = Ack suppress b7 = Reserved
Master	Yes	USINT	Master's MACID	= 0-63
Allocate success response	Yes	BYTE	Message body format (number of bits for Class/Instance identifiers)	0 = 8/8 [default] 1 = 8/16 2 = 16/16 3 = 16/8

Assembly Object (04_{hex})

Class

ATTRIBUTES 4.0 – CLASS ATTRIBUTES – ASSEMBLY OBJECT

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	NVC	Revision	UINT	Object revision	= 02
100	Vendor specific	Yes	Set	NV	Default I/O consume	USINT	Default output assembly inst ID	= 10, 11 [default] = 10
101	Vendor specific	Yes	Set	NV	Default I/O produce	USINT	Default input assembly inst ID	= 1, 2, 3, 6 [default] = 2

SERVICES 4.0 – CLASS SERVICES – ASSEMBLY OBJECT

CODE	RE-QUIRED	SUP-PORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT); Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific

Instances

Instance Identifiers

4.N ASSEMBLY OBJECT INSTANCES

NUMBER	REQUIRED	TYPE	ELEMENTS
1	Y	Input	Flow
2	Y (default)	Input	Status and flow
3	N	Input	Status, flow and pressure
6	N	Input	Status, flow, pressure and valve
10	Y (default)	Output	Set point
11	Y	Output	Override and set point

Element Mapping

ASSEMBLY OBJECT ELEMENT MAPPING

DATA COMPO-NENT NAME	CLASS		INSTANCE	ATTRIBUTE		
	NAME	NUMBER	NUMBER	NAME	NUMBER	TYPE
Flow	S-Analog sensor	31_{hex}	1	Value	6	INT
Pressure	S-Analog sensor	31_{hex}	2	Value	6	INT
Valve	S-Analog actuator	32_{hex}	1	Value	6	INT
Override	S-Analog actuator	32_{hex}	1	Override	5	USINT
Set point	S-Single stage controller	33_{hex}	1	Set point	6	INT
Status	S-Device supervisor	30_{hex}	1	Exception status	12	BYTE

Instances 1-n

ATTRIBUTES 4.N – INSTANCE ATTRIBUTES – ASSEMBLY OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	ATTRIBUTE DESCRIPTION
3	Required	Yes	Get	Data	The I/O Assembly DATA attribute is formatted as a structure of data elements with the First element (elements are listed in the "Instance Identifiers" table) ordered first. All data components are encoded with the **Low-ordered Byte first**; (i.e., the Least Significant Byte, LSB, is in the Low-ordered Index, Address) also known as Little Endian.

SERVICES 4.N – INSTANCE SERVICES – ASSEMBLY OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Connection Object (05_{hex})

Class

ATTRIBUTES 5.0 – CLASS ATTRIBUTES – CONNECTION OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object revision	= 01

SERVICES 5.0 – CLASS SERVICES – CONNECTION OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Instance 1 - Explicit

ATTRIBUTES 5.1 – INSTANCE ATTRIBUTES – CONNECTION OBJECT 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Required	Yes	Get	State	USINT	Object state	00 = Non-existent 01 = Configuring 02 = Waiting for conn ID 03 = Established 04 = Timed out 05 = Deferred delete
2	Required	Yes	Get	Instance type	USINT	= Explicit	= 00
3	Required	Yes	Get	Trans Class/Trig	USINT	= Server Class 3	= 0x83
4	Required	Yes	Get	P Conn ID	UINT	Exp Resp. CAN ID	= 10xxxxxx011; x = MACID
5	Required	Yes	Get	C Conn ID	UINT	Exp Req. CAN ID	= 10xxxxxx100; x = MACID
6	Required	Yes	Get	Initial Comm characteristics	BYTE	Group IDs	= 0x21
7	Required	Yes	Get	P Conn size	UINT	Maximum data production size	= 40
8	Required	Yes	Get	C Conn size	UINT	Maximum data consumption size	= 40
9	Required	Yes	Set	EPR	UINT	Expected packet rate in milliseconds	2500 = Default
12	Required	Yes	Set	WTO action	USINT	Watch dog timeout Action	00 = Time out (not supported) 01 = Auto delete [default] 02 = AutoReset (not supported) 03 = Deferred delete
13	Required	Yes	Get	P Conn Path Length	UINT	Path length	= 00
14	Required	Yes	Get	P Conn Path	EPATH	Path from which connection produces	= Empty
15	Required	Yes	Get	C Conn Path length	UINT	Path length	= 00
16	Required	Yes	Get	C Conn Path	EPATH	Path to which connection consumes	= Empty

SERVICES 5.1 – INSTANCE SERVICES – CONNECTION OBJECT 1

CODE	RE-QUIRED	SUP-PORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT); Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific

Instance 2 - Polled

ATTRIBUTES 5.2 – INSTANCE ATTRIBUTES – CONNECTION OBJECT 2

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Required	Yes	Get	State	USINT	Object state	See Instance 1
2	Required	Yes	Get	Instance type	USINT	= Poll	= 01
3	Required	Yes	Get	Trans Class/ Trig	USINT	= Server Class 2	= 0x82
4	Required	Yes	Get	P Conn ID	UINT	Poll Resp. CAN ID	= 01111xxxxxx; x = MACID
5	Required	Yes	Get	C Conn ID	UINT	Poll Req. CAN ID	= 10xxxxxx101; x = MACID
6	Required	Yes	Get	Initial Comm characteristics	BYTE	Group IDs	= 0x01
7	Required	Yes	Get	P Conn size	UINT	Produced data size	= Size of selected input assembly data
8	Required	Yes	Get	C Conn size	UINT	Consumed data size	= Size of selected output assembly data
9	Required	Yes	Set	EPR	UINT	Expected packet rate in milliseconds	0 = Default
12	Required	Yes	Set	WTO action	USINT	Watch dog timeout action	00 = Time out [default] 01 = Auto delete
13	Required	Yes	Get	P Conn Path length	UINT	Path length	= 06
14	Required	Yes	Set	P Conn Path	EPATH	Path from which connection produces	= 20 04 24 NN 30 03 (hex) where NN = assembly inst id
15	Required	Yes	Get	C Conn Path length	UINT	Path length	= 06
16	Required	Yes	Set	C Conn Path	EPATH	Path to which connection consumes	= 20 04 24 NN 30 03 (hex) where NN = assembly inst id

SERVICES 5.2 – INSTANCE SERVICES – CONNECTION OBJECT 2

CODE	RE-QUIRED	SUP-PORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT); Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific

S-Device Supervisor Object (30_{hex})

Class

ATTRIBUTES 30.0 – CLASS ATTRIBUTES – S-DEVICE SUPERVISOR OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object revision	= 01

SERVICES 30.0 – CLASS SERVICES – S-DEVICE SUPERVISOR OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Instance 1

ATTRIBUTES 30.1 – INSTANCE ATTRIBUTES – S-DEVICE SUPERVISOR OBJECT 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
3	Required	Yes	Get	NVC	Device Type	SHORT STRING	ASCII Text, Max. 8 Characters, see "Semantics" section	"FFC"
4	Required	Yes	Get	NVC	SEMI Standard Revision Level	SHORT STRING	Specifies the revision level of the SEMI S/A Network Standard to which the device complies.	"E54-0997"
5	Required	Yes	Get	NVC	Manu-facturer's Name	SHORT STRING	ASCII text, max. 20 characters	"NT International"
6	Required	Yes	Get	NVF	Manu-facturer's Model Number	SHORT STRING	ASCII text, max. 20 characters	"6500"
7	Required	Yes	Get	NVC	Software Revision Level	SHORT STRING	ASCII text, max. 6 characters	"x.xx" current *Application Code* SW revision
8	Required	Yes	Get	NVF	Hardware Revision Level	SHORT STRING	ASCII text, max. 6 characters	"x.xx" current *Controller Circuit Board* HW revision
9	Optional	Yes	Get	NVF	Manu-facturer's Serial Number	SHORT STRING	ASCII text, max. 30 characters	Device specific
10	Optional	Yes	Get	NVF	Device Configur-ation	SHORT STRING	ASCII text, max. 50 characters	Device specific
11	Required	Yes	Get	V	Device Status	USINT	State of the device's application objects	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 100-255 = Vendor specific
12	Required	Yes	Get	V	Exception Status	BYTE	Bitmapped summary of the exception detail bits	b0 = Common alarm b1 = Device specific alarm b2 = Vendor specific alarm b3 = Reserved b4 = Common warning b5 = Device specific warning b6 = Vendor specific warning b7 = 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
13	Based on Exception Status b7	Yes	Get	V	**Exception Detail Alarm**	STRUCT of:	A Structure of three Structures containing bitmapped representations of the alarm detail	
					Common Exception Detail	STRUCT of:		
					Size	USINT	Number of common detail bytes	= 02
					Detail [0]	BYTE		b0 = Internal diagnostics b1 = 0 b2 = EPROM b3 = EEPROM b4 = RAM b5 = 0 b6 = Internal real-time b7 = 0
					Detail [1]	BYTE		b0 : b7 = Not supported
					Device Exception Detail	STRUCT of:		
					Size	USINT	Number of common detail bytes	= 03
					Detail [0]	BYTE		b0 = 0 b1 = Flow low b2 = Flow high b3 = 0 b4 = 0 b5 = 0 b6 = Pressure low b7 = Pressure high
					Detail [1]	BYTE		b0 : b7 = 0
					Detail [2]	BYTE		b0 : b7 = 0
					Manu-facturer Exception Detail	STRUCT of:		
					Size	USINT	Number of manufacturer detail bytes	= 01
					Detail [0]	BYTE	Manufacturer specified	b0 : b7 = 0

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
14	Based on Exception Status b7	Yes	Get	V	**Exception Detail Warning**	STRUCT of:	A Structure of three Structures containing bitmapped representations of the warning detail	
					Common Exception Detail	STRUCT of:		
					Size	USINT	Number of common detail bytes	= 02
					Detail [0]	BYTE		b0 = Internal diagnostics b1 = 0 b2 = EPROM b3 = EEPROM b4 = RAM b5 = 0 b6 = Internal real-time b7 = 0
					Detail [1]	BYTE		b0 : b7 = Not supported
					Device Exception Detail	STRUCT of:		
					Size	USINT	Number of device detail bytes	= 03
					Detail [0]	BYTE		b0 = Reading valid b1 = Flow low b2 = Flow high b3 = 0 b4 = 0 b5 = 0 b6 = Pressure Low b7 = Pressure High
					Detail [1]	BYTE		b0 : b7 = 0
					Detail [2]	BYTE		b0 : b7 = 0
					Manu-facturer Exception Detail	STRUCT of:		
					Size	USINT	Number of manufacturer detail bytes	= 01
					Detail [0]	BYTE	Manufacturer specified	b0 : b7 = 0
15	Required	Yes	Set	NV	Alarm Enable	BOOL	Enables the setting of alarm bits	00 = Disabled 01 = Enabled [default]
16	Required	Yes	Set	NV	Warning Enable	BOOL	Enables the setting of warning bits	00 = Disabled 01 = Enabled [default]

SERVICES 3.01 – INSTANCE SERVICES – S-DEVICE SUPERVISOR OBJECT

CODE	RE-QUIRED	SUP-PORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT); Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific
05_{hex}	Required	Yes	Reset	None	Resets the device to the self-testing state	
06_{hex}	Required	Yes	Start	None	Moves the device to the executing state	
07_{hex}	Optional	Yes	Stop	None	Moves the device to the idle state	
$4B_{hex}$	Required	Yes	Abort	None	Moves the device to the abort state	
$4C_{hex}$	Required	Yes	Recover	None	Moves the device out of the abort state	
$4E_{hex}$	Required	Yes	Perform_ Diags	Test ID (USINT)	Causes the device to perform a set of diagnostic routines	0 = Standard 1-63 = Reserved 64-127 = Device profile 128-255 = Vendor specific

S-Analog Sensor Object (31_{hex})

Class

ATTRIBUTES 31.0 – CLASS ATTRIBUTES – S-ANALOG SENSOR OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object revision	= 01

SERVICES 31.0 – CLASS SERVICES – S-ANALOG SENSOR OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Instance 1 - Flow

ATTRIBUTES 31.1 – INSTANCE ATTRIBUTES – S-ANALOG SENSOR OBJECT 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
3	Optional	Yes	Get	NVC	Data Type	USINT	Determines the Data Type of value and all related attributes as specified in this table.	[default] = INT
4	Optional	Yes	Get	NVC	Data Units	ENGUNITS	Determines the Units context of value and all related attributes.	[default] = Counts*
5	Required	Yes	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	Yes	Get	V	Value	INT or specified by Data Type if supported	Analog input value	The corrected, converted, calibrated final value of the sensor
7	Required	Yes	Get	V	Status	BYTE	Alarm and Warning state of this object instance	b0 = High alarm b1 = Low alarm b2 = High warning b3 = Low warning b4-b7 = Reserved
8	Optional	Yes	Set	NV	Alarm Enable	BOOL	Enables the setting of the Alarm status bits	0 = Disable [default] 1 = Enable

* Counts are interpreted as a "Percent of Full Scale" where a Count Value of 24576 (6000 hexadecimal) corresponds to 100%. This allows a maximum reading of 133.33%.

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
9	Optional	Yes	Set	NV	Warning Enable	BOOL	Enables the setting of the Warning status bits	0 = Disable [default] 1 = Enable
10	Optional	Yes	Get	NVC	Full Scale	Same as *Value*	The value of Full Scale for the sensor	= 6000_{hex}
17	Optional	Yes	Set	NV	Alarm Trip Point High	Same as *Value*	Determines the value above which an Alarm Condition will occur	[default] = Maximum value for its data type.
18	Optional	Yes	Set	NV	Alarm Trip Point Low	Same as *Value*	Determines the value below which an Alarm Condition will occur	[default] = Minimum value for its data type.
21	Optional	Yes	Set	NV	Warning Trip Point High	Same as *Value*	Determines the value above which a Warning Condition will occur	[default] = Maximum value for its data type.
22	Optional	Yes	Set	NV	Warning Trip Point Low	Same as *Value*	Determines the value below which a Warning Condition will occur	[default] = Minimum value for its data type.
25	Optional	Yes	Set	NV	Safe State	USINT	Specifies the behavior for the value for states other than Execute	0 = Zero [default] 1 = Full Scale 2 = Hold last value 3 = Use safe value 4 = Continue sensing 5-50 = Reserved 51-99 = Device specific 100-255 = Vendor specific
26	Optional	Yes	Set	NV	Safe Value	Same as *Value*	The value to be used for Safe State = Safe Value	[default] = 0
27	Optional	Yes	Set	NV	Autozero Enable	BOOL	Enables the Autozero**	0 = Disable 1 = Enable [default] **NOTE: This default is a DeviceNet™ compliance variance.**
28	Optional	Yes	Get	V	Autozero Status	BOOL	Indicates the status of the automatic nulling**	0 = Inactive 1 = Active

** With Autozero enabled, upon Set point = 0, the device will close the valve then wait a delay period before beginning the sensor nulling process. The Autozero status can be monitored to detect when the nulling process actually begins.

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
35	Optional	Yes	Set	NV	Gas Cali-bration Object Instance	UINT	Indicates which Gas Calibration object instance is active for this object.	00 = Disabled 01 = Enable [default] **NOTE: This default is a DeviceNet™ compliance variance.**
99	Cond.	Yes	Get	NVC	Subclass	UINT	Identifies Instance Subclass	01 = Flow diagnostics
100	Vendor specific	Yes	Set	NV	Damping Coefficient	USINT	Low-pass filter coefficient $\tau \approx 62.5ms^* 2^n$	0 = disabled 1–6 = n [default] = 2 ($\tau \approx 0.25$ sec) 7-255 = reserved

SERVICES 31.1 – INSTANCE SERVICES – S-ANALOG SENSOR OBJECT 1

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT): Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific
$4B_{hex}$	Optional	Yes	Zero_Adjust	None	Causes the device to begin a re-zero process.	
32_{hex}	Vendor Specific	Yes	Stop_Zero _Adjust	None	Terminates the re-zero process.*	

***NOTE:** Upon termination of Zero Adjust, if the Actuator Override is set to Hold, the Actuator will resume to hold at the value just prior to the initiation of the Zero Adjust.

Hence, the FFC device can be made to jump-start the position of the valve at the outset of the control algorithm by the following sequence:

1. Leave set point at a desired value
2. Actuator Override = Hold (the valve freezes in its current position)
3. Sensor Zero_Adjust (closes the valve and, after a settling period, begins the zeroing)
4. Sensor Stop_Zero_Adjust (valve returns to previously held position)
5. Actuator Override = Normal (the device begins normal control)

Instance 2 - Inlet Pressure

ATTRIBUTES 31.2 – INSTANCE ATTRIBUTES – S-ANALOG SENSOR OBJECT 2

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
3	Optional	Yes	Get	NVC	Data Type	USINT	Determines the Data Type of value and all related attributes as specified in this table.	[default] = INT
4	Optional	Yes	Get	NVC	Data Units	ENGUNITS	Determines the Units context of value and all related attributes.	[default] = Counts*
5	Required	Yes	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	Yes	Get	V	Value	INT or specified by Data Type if supported	Analog input value	The corrected, converted, calibrated final value of the sensor
7	Required	Yes	Get	V	Status	BYTE	Alarm and Warning state of this object instance	b0 = High alarm b1 = Low alarm b2 = High warning b3 = Low warning b4-b7 = Reserved
8	Optional	Yes	Set	NV	Alarm Enable	BOOL	Enables the setting of the Alarm status bits	0 = Disable [default] 1 = Enable
9	Optional	Yes	Set	NV	Warning Enable	BOOL	Enables the setting of the Warning status bits	0 = Disable [default] 1 = Enable
10	Optional	Yes	Get	NVC	Full Scale	Same as *Value*	The value of Full Scale for the sensor.	= 6000_{hex}
17	Optional	Yes	Set	NV	Alarm Trip Point High	Same as *Value*	Determines the value above which an Alarm Condition will occur.	[default] = Maximum value for its data type.
18	Optional	Yes	Set	NV	Alarm Trip Point Low	Same as *Value*	Determines the value below which an Alarm Condition will occur.	[default] = Minimum value for its data type.
21	Optional	Yes	Set	NV	Warning Trip Point High	Same as *Value*	Determines the value above which a Warning Condition will occur.	[default] = Maximum value for its data type.

* Counts are interpreted as a "Percent of Full Scale" where a Count Value of 24576 (6000 hexadecimal) corresponds to 100%. This allows a maximum reading of 133.33%.

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
22	Optional	Yes	Set	NV	Warning Trip Point Low	Same as *Value*	Determines the value below which a Warning Condition will occur.	[default] = Minimum value for its data type.
25	Optional	Yes	Set	NV	Safe State	USINT	Specifies the behavior for the value for states other than Execute.	0 = Zero [default] 1 = Full scale 2 = Hold last value 3 = Use safe value 4 = Continue sensing 5-50 = Reserved 51-99 = Device specific 100-255 = Vendor specific
26	Optional	Yes	Set	NV	Safe Value	Same as *Value*	The value to be used for Safe State = Safe Value	[default] = 0
100	Vendor Specific	Yes	Set	NV	Damping Coefficient	USINT	Low-pass Filter coefficient $\tau \approx 62.5ms * 2^n$	0 = Disabled 1–6 = n [default] = 2 ($\tau \approx 0.25$ sec) 7-255 = reserved

SERVICES 31.2 – INSTANCE SERVICES – S-ANALOG SENSOR OBJECT 2

CODE	RE-QUIRED	SUP-PORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT); Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific

S-Analog Actuator Object (32_{hex})

Class

ATTRIBUTES 32.0 – CLASS ATTRIBUTES – S-ANALOG ACTUATOR OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object revision	= 01

SERVICES 32.0 – CLASS SERVICES – S-ANALOG ACTUATOR OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Instance 1

ATTRIBUTES 32.1 – INSTANCE ATTRIBUTES – S-ANALOG ACTUATOR OBJECT 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
3	Optional	Yes	Get	NVC	Data Type	USINT	Determines the data type of *Value*	[default] = INT
4	Optional	Yes	Get	NVC	Data Units	UINT	Determines the context of *Value*	[default] = Counts*
5	Required	Yes	Set	NV	Override	USINT	Specifies an override for the physical actuator. For values other than zero (normal control), the *Value* attribute is ignored.	0 = Normal 1 = Off 2 = On 3 = Hold 4-127 = Reserved 128-255 = Vendor specific
6	Required	Yes	Get	V	Value	INT	Analog output value	
7	Required	Yes	Get	V	Status	BYTE	Alarm and Warning state of this object instance	b0 : b3 = 0 b4 = Low warning exception b5 = High warning exception b6 = Low alarm exception b7 = High alarm exception
21	Optional	Yes	Set	NV	Safe State	USINT	Specifies the behavior of the physical actuator for states other than Execute	0 = Close 1 = Open 2 = Hold 3-255 = Invalid

*Counts are interpreted as a "Percent of Full Scale" where a Count Value of 24576 (6000 hexadecimal) corresponds to 100%. This allows a maximum reading of 133.33%.

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
100	Vendor Specific	Yes	Get	NVF	Actuator Serial Number	UINT	Configuration**	Values are stored in the Stepper Motor controller
101	Vendor Specific	Yes	Get	NVF	Stepper FW Rev	SHORT STRING	Configuration**	Values are stored in the Stepper Motor controller
102	Vendor Specific	Yes	Get	NVF	Home Offset	USINT	Configuration**	Values are stored in the Stepper Motor controller
103	Vendor Specific	Yes	Get	NVF	Upper Limit	USINT	Configuration**	Values are stored in the Stepper Motor controller

**A description of these vendor-specific configuration parameters is beyond the scope of this document.

SERVICES 32.1 – INSTANCE SERVICES – S-ANALOG ACTUATOR OBJECT 1

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT): Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific
32_{hex}	Vendor Specific	Yes	Load_Stepper _Defaults	None	Causes the Stepper Driver to revert to default parameters	
33_{hex}	Vendor Specific	Yes	Update_Stepper Parameter_ Attributes	None	Updates the DeviceNet™ visible Stepper Attributes from the Stepper Driver.	

S-Single Stage Controller Object (33_{hex})

Class

ATTRIBUTES 33.0 – CLASS ATTRIBUTES – S-SINGLE STAGE CONTROLLER OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object revision	= 01

SERVICES 33.0 – CLASS SERVICES – S-SINGLE STAGE CONTROLLER OBJECT

CODE	REQUIRED	SUPPORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255

Instance 1

ATTRIBUTES 33.1 – INSTANCE ATTRIBUTES – S-SINGLE STAGE CONTROLLER OBJECT 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
5	Optional	Yes	Set	NV	Control Mode	USINT	Specifies the operational mode of the controller	0 = Normal 1 = Off 2 = On 3 = Hold 4-127 = Reserved 128-255 = Vendor specific
6	Required	Yes	Set	V	Set point	*	The set point to which the process variable will be controlled	[default] = 0
10	Required	Yes	Get	V	Status	BYTE	Alarm and Warning state of this object instance	b0 : b5 = 0 b6 = Warning exception b7 = Alarm exception
100	Vendor Specific	Yes	Get	NVF	Track Band Limit	INT	Tuning Parameter**	
101	Vendor Specific	Yes	Get	NVF	Acquire Band Gain	INT	Tuning Parameter**	
102	Vendor Specific	Yes	Get	NVF	Damping Factor	INT	Tuning Parameter**	

*Specified by the value of S-Analog sensor object Instance 1, Attribute 3.

**A description of these vendor-specific tuning parameters is beyond the scope of this document.

SERVICES 33.1 – INSTANCE SERVICES – S-SINGLE STAGE CONTROLLER OBJECT 1

CODE	RE-QUIRED	SUP-PORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT); Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific

S-Sensor Calibration Object (64_{hex})

Class

ATTRIBUTES 64.0 – CLASS ATTRIBUTES – S-SENSOR CALIBRATION OBJECT

ATT. ID	REQUIRED	SUPPORTED	ACCESS RULE	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
1	Optional	Yes	Get	Revision	UINT	Object revision	= 01

SERVICES 64.0 – CLASS SERVICES – S-ANALOG SENSOR OBJECT

CODE	RE-QUIRED	SUP-PORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
$4B_{hex}$	Required	Yes	Get_All_ Instances	None	Retrieves a list of all supported instances	See response below

SERVICE DATE FIELD PARAMETERS – GET_ALL_INSTANCES – SUCCESS RESPONSE

PARAMETER	REQUIRED	DATA TYPE	DESCRIPTION	VALUES
Size of list	Required	UINT	Specifies the number of elements in the array	Number of calibrations in the list
List of calibrations	Required if Size > 0	ARRAY of:	Supported list	
		STRUCT of:	Supported calibration	
		UINT	S-Sensor calibration object instance ID	= 01
		UINT	Calibration ID number	= 0-65535
		UINT	Valid sensor instance	= 01

Instance 1

ATTRIBUTES 64.1 – INSTANCE ATTRIBUTES – S-SENSOR CALIBRATION OBJECT 1

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
3	Required	Yes	Get	NVF	Calibration ID Number	UINT	Identifies the calibration (e.g., fluid type)	[default] = 0
4	Required	Yes	Get	NVC	Valid Sensor Instance	UINT	S-Analog sensor object instance ID for which this object instance is valid	= 01

ATT. ID	RE-QUIRED	SUP-PORTED	ACCESS RULE	NV	NAME	DATA TYPE	ATTRIBUTE DESCRIPTION	VALUES
5	Optional	Yes	Set	NV	Calibration Name	SHORT STRING	ASCII text, max 50 characters, User accessible string representation used to identify the calibration or application.	[default] = Null
6	Optional	Yes	Get	NVF	Full Scale	STRUCT of:	Full scale of the device using this object instance	[default] = 0, 0
						REAL	Amount	
						ENGUNITS	Units	

SERVICES 64.1 - INSTANCE SERVICES - S-SENSOR CALIBRATION OBJECT 1

CODE	RE-QUIRED	SUP-PORTED	NAME	PARAMETERS	DESCRIPTION	PARAMETER VALUES
$0E_{hex}$	Required	Yes	Get_Attribute_ Single	Attribute ID (USINT)	Retrieves an attribute value	1–255
10_{hex}	Required	Yes	Set_Attribute_ Single	Attribute ID (USINT); Value	Sets an attribute value	Attribute ID = 1–255 Value = attribute specific

Repair and Warranty Service

Entegris, Inc. warrants each new product against defects in materials and workmanship for 18 months of time from shipment. Entegris makes no warranty, express or implied, with respect to any components, products, information or services provided by any third party. With respect to products specifically manufactured to Buyer's specifications, Entegris warrants only that such products have been manufactured, without testing, to Buyer's specifications but makes no other warranty, express or implied. Upon Entegris' confirmation of defects, Entegris agrees, as its **EXCLUSIVE REMEDY** to repair or, in its discretion, replace defective product without charge. Entegris is not responsible for product damage resulting from accident, misuse or lack of reasonable care. **IMPORTANT: NO OTHER WARRANTY, WRITTEN OR VERBAL, IS AUTHORIZED BY ENTEGRIS. ENTEGRIS IS NOT LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES. IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE SPECIFICALLY DISCLAIMED.**

Repair and warranty service is available at the Entegris factory. To expedite the return and repair of the product, contact Entegris at 877-503-0200. A Return Materials Authorization (RMA) number and a product packaging and return procedure will be provided at that time.

WARNING!
All products returned to Entegris must be accompanied by a list of all chemicals that have been in contact with the unit and the corresponding Material Safety Data Sheet (MSDS) for each chemical. Returned products will not be accepted without an MSDS.

Notes

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