UNIT

Analog and Digital Mass Flow Controllers and Meters

User's Manual

CELERITY.

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Contents

1. OVERVIEW

Celerity Mass Flow Controllers precisely monitor and control the mass flow of gases in processes such as Plasma Etching, CVD, Diffusion, EPI, and Sputtering where superior accuracy is required. Mass Flow Meters are identical to mass flow controllers, except that they do not have a controlling valve. Therefore they do not control, but only accurately measure and report the gas flow that is passing through them.

1.1 Flow Controller / Flow Meter Model Designations

Unit Mass Flow Controller models have the prefix of "UFC-" (Unit Flow Controller), and Mass Flow Meters have the prefix of "UFM-" (Unit Flow Meter).

Mass Flow Controllers: UFC-XXXX (Unit Flow Controller)

Mass Flow Meters: UFM-XXXX (Unit Flow Meter)

1.2 Flow Controller / Flow Meter Model Designations, by Applications

Table 1 shows the general applicability of each model covered by this manual.

Category / Model Family	Footprint	Full Scale Flow Range (Min - Max)	<Digital> RS485 Analog	<Digital> DeviceNet™ PROFIBUS	<Analog> Analog Protocol
Elastomer Seal Products - 32 µ in Ra Finish					
122 series Control Valves	1.1"	10 sccm - 30 slm		122	
180 series Standard Flow Applications	1"	10 sccm - 30 slm			180HS /180HA
7300 series Standard Flow Applications	1.5"	10 sccm - 30 slm	7301	7304	7300
7320 series Standard Flow w/ Auto Shutoff	1.5"	10 sccm - 30 slm	7321	7324	7320
8100 series Standard Flow Applications	1.5"	10 sccm - 30 slm	8101	8105	8100
8130 series Setpoint Pressure Control	1.5"	10 sccm - 30 slm	8130		
High Purity Metal Seal Products - 10 or 16 µ in Ra Finish					
132 series Control Valves	1.42"	10 sccm - 30 slm		132	
1551 series Standard Flow Applications	1.5"	30 sccm - 6 slm		1551	
1630 series Setpoint Pressure Control	1.5"	10 sccm - 30 slm			1630
1660 series Standard Flow Applications	1.5"	10 sccm - 30 slm	1661	1665	1660
1660 SDS series Safe Delivery Source	1.5"	10 sccm - 30 slm	1663	1664	1662/1662L
3160 series High Flow Applications	1.5"	30 slm - 100 slm	3161	3165	
5360 series High Flow Applications	1.5"	30 slm - 100 slm	5361	5365	
7360 series Standard Flow Applications	1.5"	10 sccm - 30 slm	7361	7364	7360
9660 series High Temperature Applications	1.5"	10 sccm - 30 slm			9660
Ultra High Purity Metal Seal Products - 4 µ in Ra Finish					
8160 series Standard Flow Applications	1.5"	10 sccm - 30 slm	8161	8165	8160
8160 SDS series Safe Delivery Source	1.5"	10 sccm - 30 slm	8163	8164	8162/8162L
8260 series Standard Flow Applications	1.5" mini	10 sccm - 30 slm	8261		8260
8560 series Standard Flow Applications	1.125"	10 sccm - 30 slm	8561	8565	
8560 SDS series Safe Delivery Source	1.125"	10 sccm - 30 slm	8563	8564	
9500 series High Temperature Applications	1.125"	10 sccm - 30 slm	9561	9565	
9860 series High Temperature Applications	1.5"	10 sccm - 30 slm	9861	9865	

Table 1. Model Designations by applications

2. STANDARD FEATURES

2.1 Attitude

- Each MFC is built for a specific attitude either HOS (Horizontal on Side) or HOV (Horizontal or Vertical).
- For further details, refer to Section 7.3 “Mounting Attitude”.

2.2 Calibration Conditions

- MFCs ordered as “Atmosphere” are calibrated with the MFC’s outlet exhausting to Atmosphere.
- MFCs ordered as “Vacuum” are calibrated with the MFC’s outlet exhausting to Vacuum.

2.3 Standard Temperature and Pressure

- 0°C and 760 mm Hg

2.4 Calibration Traceability

- National Institute of Standards and Technology (N.I.S.T.)

2.5 Manufacturing Environment

- Assembled, Calibrated, Tested and Packaged in Class 100 Cleanroom Environment

2.6 Purge Capability

- Full purge capability with 1 slm purge minimum (depends on gas density and pressure).

3. OPTIONAL FEATURES

Options are set at the factory, unless otherwise specified.

3.1 Auto Shut-off Option

- With the Auto Shut-off option a setpoint command of less than 2% (0.1 VDC) closes the MFC control valve.
  - Since an MFC valve is not a positive shutoff valve, a shutoff valve in series with the MFC may be needed.
- Users of digital MFCs can disable or increase the Auto Shutoff option to any value up to a maximum of 10% of the full scale operational range using the MultiFlo Virtual Interface. (Refer to the MultiFlo Virtual Interface User’s Manual.)

3.2 Response Time Options

Fast:	≤1 Sec to a setpoint command of 20%-100% (per SEMI E17-91)
Soft Start:	Ramping gradually (5 second linear ramp)
Soft start options:	4-6, 6-10, 10-15, 20-30, or 40-60 seconds.

- This option is configured in the factory for analog MFCs, and cannot be adjusted by the user.

Users of digital MFCs can select the Response Time to be 0-20 seconds using the MultiFlo Virtual Interface. (Refer to the Details section of the MultiFlo Virtual Interface User’s Manual.)

3.3 Connector Options

The electrical connector configurations are shown in Appendice 16.1, “Electrical Connections”. This includes detailed information and pinouts.

3.4 Special Adapters

Retrofitting of the models of most competitors is accomplished using special electronic and mechanical adapters. Contact Celerity’s Applications Engineering department for help with your particular requirement.

3.5 Valve Options

The valve is configured at the time of manufacture to be Normally Closed or Normally Open, and is not user modifiable.

- Normally-closed (standard): The valve is closed when there is no power applied to the unit.
- Normally-open (optional): The valve is fully open when there is no power applied to the unit.

3.6 Flow Direction Options

There are two configurations of Flow Direction, and this is not user modifiable.

- “Standard”:
  - The sensor is upstream and the valve is downstream.
    - The valve buffers the sensor from downstream (process) pressure fluctuations.
- “Pressure buffered”:
  - The valve is upstream and the sensor is downstream.
    - The valve buffers the sensor from upstream pressure fluctuations.

3.7 Auto-Zero Option

- The Auto-Zero feature detects zero offset during no-flow conditions and electronically re-zeros the output signal.
  - Auto-Zero, on earlier Unit models, was of great benefit in reducing drift and increasing equipment uptime.
  - However, the current sensor models have a drift specification of less than .6% per year.
- The proper application of the Auto-Zero option depends entirely on the ability to ensure absolutely no flow across the MFC sensor during the Auto-Zero cycle.
  - With few exceptions, this means that there must be positive shutoff valves immediately upstream and downstream of the MFC, and that there must be proper valve sequencing.
- All Digital Mass Flow Controllers have Auto-Zero circuitry installed, which can be enabled or disabled using the MultiFlo Virtual Interface. (Refer to the MultiFlo Virtual Interface User’s Manual.)
- For a more complete explanation of the the Auto-Zero Feature see Appendice 16.7.
- If you have any questions regarding the ordering or installing of an MFC with the Auto-Zero feature please consult Applications Engineering first.

3.8 Fittings Options

The fittings available for these units are:

- Swagelok®, VCR®, VCO®
- C-seal and W-seal surface-mount
- Ultraseal, Buttweld and Specials

Not all fittings are available for all gases and ranges. Fitting options will vary according to the MFC model.

4. POWER SUPPLIES

Celerity manufactures a series of analog and digital power supplies. These are capable of monitoring and/or controlling from 1 to 5 mass flow controllers or meters simultaneously. Call Celerity Customer Service for further information.

5. PRODUCT DRAWINGS

You can access and download a product drawing for any specific model of mass flow controller (MFC) via www.celerity.net (http://www.celerity.net/html/products/technical_data/drawings).

6. PRODUCT SPECIFICATIONS

You can access and download the exact product specifications for any specific model, via www.celerity.net (http://www.celerity.net/html/products/literature/literature.html)

6.1 MFC side can label

MFC side can labels carry a detailed listing of all information about a specific MFCs statistics as built at the factory.

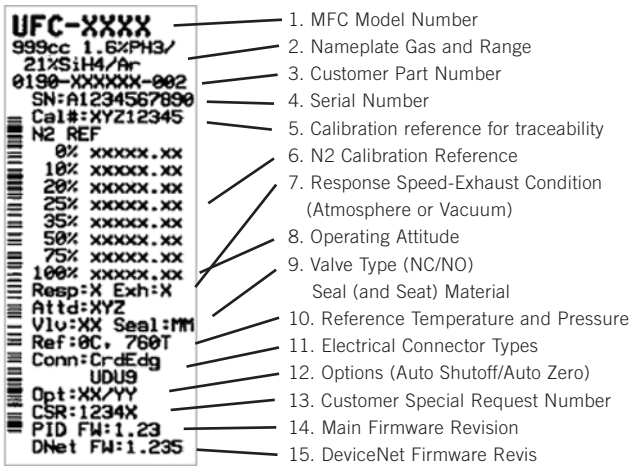


Figure 1. MFC Side Can Label with Explanations

6.2 Traceability

If you wish to replace an MFC, call Celerity with the serial number of the MFC you wish to replace. Celerity will determine the part number for the equivalent MFC with the same options.

7. INSTALLATION

7.1 Unpacking

Verify that the controller was not damaged in shipment. Notify the shipper immediately if you find a problem. All products returned must have a Return Material Authorization number (RMA #; see section 12.8) issued prior to return shipment to the factory.

NOTE: Do not remove the shipping caps covering the inlet and outlet fittings until immediately prior to the actual MFC installation in the tool.

7.2 Purging before Installing the MFC

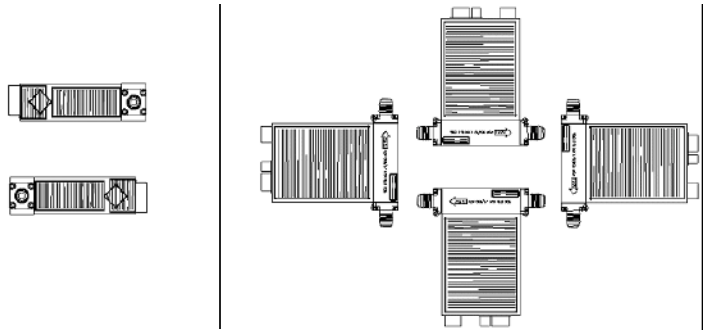
Before installing the MFC completely purge the gas lines with nitrogen or argon. The purge gas must be moisture and oxygen free, to less than 100 ppb. The preferable method is to cycle purge the line for a period of two to four hours, depending on the cleanliness required by the process and the reactiveness of the process gas.

Cycle purging consists of evacuating to a low pressure, adequate to induce outgassing, and then purging to remove adhered moisture and oxygen. The cycle is repeated several times to complete the cleaning. Alternatively, eight to twenty-four hours of purging alone may be used if vacuum is not available.

7.3 Positioning the Controller

The controller must be positioned so that the gas flow is in the direction of the arrow stamped on the controller base. It is designed to be mounted only in the position for which it was calibrated (See the side label of the MFC. Refer to Section 6.1). High Temperature models (9000-series) are designed to be mounted in the horizontal position only.

Mounting Attitude



HOS
Horizontal-On-Side

HOV
Horizontal-Or-Vertical

Figure 1. Mounting Attitudes. Two Configurations: HOS and HOV

In order to provide optimum performance, Celerity calibrates all Mass Flow Controllers and Mass Flow Meters to the position specified at the time of the order.

7.4 Mounting the Controller

Use two #8-32 screws to mount the controller. This will ensure the flow controller's resistance to vibration from external sources.

7.5 Connecting to gas supply line

Once the unit is correctly mounted, connect the inlet and outlet fittings of the controller to the gas supply line. Depending on the type of fittings used, connect and tighten per fitting manufacturers specifications.

NOTE: You MUST use two wrenches to tighten each fitting of the unit, one for the nut and the other to keep the fitting from receiving any rotational stress. If you do not do this you could cause a leak, due to stress applied to the MFC's internal seals.

8. ELECTRICAL CONNECTIONS

8.1 Voltage and Pinouts

- Check that the pin connections of the mating cable have the same pinout (See Appendice 16.1).
  - Most analog and digital MFCs use ±15 VDC power.
  - DeviceNet MFCs use +11-25 VDC power.
- A Flow meter has the same pinout as a controller, except that the following pinouts do not apply on a meter:
  - Setpoint, Valve Test Point, Valve Off
  - Auto-Zero Disable, Auto-Zero Alarm.

NOTE: Do not make any connections to any unlabeled connector pins.

8.2 Connections to a Power Supply

If you are using a power supply other than one from Celerity, check the pin assignments, making sure they match those in Appendice 16.1, depending on connector type.

Celerity power supplies use a cable that has a 20 pin female header type connector at one end and a 20 pin card edge (MFC) type at the other.

- The connectors are keyed at both ends.
- When making the connection, be sure to apply pressure directly down on the edge connector.

NOTE: Do not rock the connector back and forth; this could cause damage to the electronic circuits.

8.3 Warm Up

Once the power supply is securely connected to the MFC/MFM, please allow at least 60 minutes for the unit to stabilize.

9. MULTIFLO VIRTUAL INTERFACE

9.1 Features

To fully take advantage of all the outstanding operational features of Celerity's digital mass flow controllers, a Multiflo Virtual Interface User Kit is required. This will allow access to the mass flow controllers through a conventional personal computer.

With it you can issue commands to, and access information from, up to 32 MFCs.

(See the MultiFlo Virtual Interface Operational Manual for details)

- Refer to Multiflo Virtual Interface User Manual to perform the following.
- Monitor Setpoint, Flow, and Valve Voltage
- Turn the Flow Off and On
- Archive and analyze collected data from these units.
- Make comparisons among units.
- Change the gas that the unit is configured for.
- Troubleshoot quickly.
- Correct for a calibration inaccuracy.

NOTE: The Digital MultiFlo MFC doesn't need to be warmed up to be programmed for gas and range.

9.2 Configure the DMFC for Networking

1. Power the MFC (see Section 8).
2. Starting from left to right configure each DMFC for a MacID address.
   - The MacID address must be between 32 and 96, inclusive.
3. Using RJ-11 connectors, daisy chain up to 32 DMFC's.

4. Install the appropriate length RJ-11 connector to the final DMFC in the daisy chain and connect to the “25 Pin” to “RJ-11” adapter on the RS-232/RS-485 converter supplied with your MultiFlo Virtual Interface User Kit.
5. Connect the “25 Pin” to “9 Pin” adapter to the serial port of your personal computer or Laptop.
6. Install MultiFlo Virtual Interface Software supplied in the Multiflo Virtual Interface User Kit.

10. OPERATION AND PERFORMANCE CHECKS

Perform the following checks after the mass flow controller has been installed into the system.

10.1 Automatic Zero Initialization

See Appendices 16.3 and Appendices 16.7.

10.2 Proper Sequencing

Systems using a microprocessor or computer for operating the MFC should sequence the valve off between processes.

This is accomplished in the following way:

- MFC’s with Automatic Shut-off
  - Simply provide a zero setpoint.
  - Gas will automatically be shut off.
- MFC’s without Automatic Shut-off
  - Switch Pin J off (if applicable).

Valves, whether upstream or downstream from the mass flow controller, should be programmed to:

- turn on prior to turning on the MFC, and
- turn off after the MFC is turned off.

For units with Auto Zero, it is recommended that the upstream valve and downstream valve be turned off for a minimum of three minutes prior to the start of a process. This is because the Auto Zero function employs a 2 minute time delay before it begins to act upon any zero offset.

10.3 Leak Test

It is important to test the mass flow controller connections for leak integrity, after it has been installed into your system, with a helium leak detector.

10.4 Purge

There are two recommended purging processes, one for non-reactive gases and one for reactive gases.

10.4.1 Non-Reactive Gases:

From process tool control system fully open the MFC by setting the setpoint to 100% of the full scale range. Purge the mass flow controller with clean, dry nitrogen or argon for a minimum of two hours.

10.4.2 Reactive Gases:

Use one of the following three methods:

(See “Connecting to Gas Supply Line” Section 7.5)

- Cycle purge:
  - Alternately evacuate and purge the mass flow controller for 2 to 4 hours with clean, dry nitrogen or argon.
    -For toxic and corrosive gases it is recommended to use 100 - 120 cycles.
- Continuous purge:
  - Purge the mass flow controller with clean, dry nitrogen or argon for 8 to 24 hours.
- Evacuation purge:
  - Evacuate the mass flow controller for 8 to 24 hours.

10.5 Zero Check

Reference Appendice 16.2

Note: For remote readouts, including analog-to-digital converters, ensure that the readouts match the inputs to the controller. Adjust their zero and full-scale to match.

For more information on setting the MFC/MFM Zero, please refer to Appendice 16.2.

10.6 Full Flow Check

1.Apply the gas at the appropriate inlet pressure.
2.Apply a Setpoint of 100%. This is accomplished by applying a 5.00 VDC setpoint (to pin A relative to pin B or C on the cardedge connector.
3.Verify that the indicated flow output reads a steady 5 volts ±10 mV (pin 3 relative to pin B (or C) on the cardedge connector. This is equivalent to a flow of 100% ±0.2%.

10.7 Flow Control Response Check

1.Close the valve by
(a) applying a 0% setpoint (where auto shut-off is enabled) or
(b) apply a Valve Off command (apply 0 volts to pin J of the cardedge connector).
2.Remove the Valve Off command.
- This accomplished by disconnecting pin J from pin 10.
3.Verify that the response time is correct.
- For “fast start” units refer to the response specifications for each model and range.
- For “slow start” (linear response) units the response time that is best for your application was chosen at the time of your order
- 4-6 seconds, 6-10 seconds, 10-15 seconds, 20-30 seconds or 40-60 seconds
4.If the unit does not meet the response specifications contact Celerity for assistance.

10.8 Calibration Check

Calibration is checked by flowing gas through a calibration reference upstream from the mass flow controller or meter.

- If the gas used for this calibration check is other than the specific surrogate gas or the actual process gas (such as N2) MFC errors of up to ±10% can be expected. This is due to the different characteristics among the different gases.

11. TROUBLESHOOTING

Many problems that appear to be MFC-related may actually be caused by another part of the system. Go through the step-by-step Troubleshooting Guide (Appendice 16.3) before removing the MFC from service.

Environmental factors may affect MFC performance (see Table 1) but these are easily resolved using a simple troubleshooting checklist (see Table 2).

11.1 Environmental Factors

SYMPTOMS	CAUSES
Inaccurate flow (span shifts)	• Temperature (steady state and transient)
	• Inlet pressure (steady state and transient)
	• Power supply problems, electrical interference
Control problems (cannot reach setpoint, oscillation)	• Differential pressure not within operating range
	• Inlet pressure not stable
	• Cable losses (too much ground current
Zero problems (indicated zero not stable)	• Temperature (steady state and transient)
	• Inlet pressure (steady state and transient)
	• Power supply problems, electrical interference
	• Attitude sensitivity

Table 1. Environmental factors

11.2 MFC Troubleshooting Checklist

Check For These Factors:

- Verify that the supply voltage is correct.
- Verify that the grounding is consistent.
- Verify that the setpoint signal at the MFC connector is the same as the setpoint signal coming from the tool.
- Verify that the Output (Indicated Flow) of the flow controller is the same at the input of the tool.
- Verify the valve voltage response.
- Move the setpoint upward and downward, looking for the valve voltage to change accordingly.
- Compare recent valve voltage to past valve voltage. If it has changed and the other parameters have not then a failure is likely.

12. REMOVAL

The following procedures are designed to minimize or eliminate the contamination normally associated with the most highly reactive gases. Celerity has also designated these procedures to reduce the overall exposure of wafers to foreign particles.

12.1 Purging before removing the MFC

Before removing the MFC purge the gas lines with nitrogen or argon. The purge gas must be moisture and oxygen free, to less than one hundred parts per billion. The preferable method is to cycle purge the line for a period of two to four hours, depending on the cleanliness required by the process and the reactiveness of the process gas.

Cycle purging consists of evacuating to a low pressure adequate to induce outgassing and then purging to remove adhered moisture and oxygen. The cycle is repeated several times to complete the cleaning. Alternatively, eight to twenty-four hours of purging alone may be used if vacuum is not available.

12.2 Removing the MFC

Once the line has been purged, the MFC can be removed. Inspect the upstream and downstream lines, as well as the MFC inlet and outlet, for signs of contamination. Immediately hardcap the inlet and outlet fittings of the MFC and cap the line fittings as well. The unit should be sealed in a cleanroom plastic bag before leaving the cleanroom area.

12.3 Packaging the MFC

The unit can now be transported to the service or calibration location. If the MFC is to be transported outside of the facility, it should be packaged in its original carton or 1 inch of foam cushion on all sides, adequate for shipping an instrument.

Be sure to include documentation of any contamination found, failure symptoms, and the location of its installation. This documentation can facilitate future contamination analysis. If a product is being returned to Celerity it must include your company name, contact, Contaminination Disclosure Form, and RMA #. Call Unit for an RMA # prior to shipping.

12.4 Un-Packaging

When the MFC is received at a service or calibration facility, the bag should be opened only within a cleanroom area (Class 1000 or better).

12.5 Cleaning

Cleaning of the MFCs should be done with semiconductor grade chemicals. Assembly, calibration, response timing, and performance testing is to be accomplished in a Class 100 or better environment.

12.6 Shipping

Once the unit has been cleaned, serviced and/or recalibrated, it must be hardcapped and bagged for return. Include with the removal documentation any documentation relevant to the calibration and service that was performed.

12.7 Shipping Costs

Celerity prepays outgoing freight charges when any part of the service is performed under warranty. All domestic shipments are sent via UPS ground transport. However, if the unit has been returned collect to Celerity, the costs are added to the repair invoice. Import/export charges, foreign shipping charges, or special customer specified handling will be paid for by the customer.

12.8 Returned Material Authorizations (RMA)

All product returns must accompany a RMA number for proper material handling within Celerity. Contact customer service at (714) 921-2640, for a Returned Material Authorization number.

12.9 Documentation

The documentation of the service and calibration should be maintained, based on the location, in order to determine the contamination of each gas line. These procedures should provide maximum cleanliness. This is required for many of the new, more critical semiconductor processes.

13. MAINTENANCE

13.1 Emergency Service

In addition to a fast turnaround time for regular service and repairs, Celerity can, in most cases, provide an advance replacement unit for EMERGENCY PRODUCTION DOWN situations. In this way, your production can get back on-line while your original unit is repaired.

13.2 Routine Maintenance

Any precision instrument such as a mass flow controller requires occasional servicing. It is especially important to perform this service if the flow controller has been operating for an extended period of time or has been subjected to gases which leave excessive residue. If non-reactive gases are used, the flow controller should be serviced annually. If reactive gases are used, the flow controller should be serviced every six months.

Occasionally the Zero Offset should be checked. See the section, “Operation and Performance Checks”, for adjustment instructions.

13.3 Factory Calibration and Service

Celerity provides a 5 day turnaround time for factory calibration and repair, and an even shorter turnaround time for a nominal additional cost.

13.4 Field Service

Celerity Mass Flow Controllers are field serviceable by the factory. They should be maintained, cleaned, and repaired by an authorized Celerity/Unit repair center.

13.5 Technical Support

A factory technician is available to answer your questions by phone any time, 24 hours a day, 7 days a week 1-888-UNIT-INC.

14. WARRANTY

Celerity products are warranted against defects in materials and workmanship for a period of two or three years, depending on the model, from the date of shipment, when used in accordance with specifications and not subjected to physical damage, abuse, or contamination.

MODEL TYPES	ULTRA HIGH PURITY METAL SEAL MFCs	HIGH PURITY METAL SEAL MFCs	ELASTOMERIC MFCs
MODEL NUMBERS	8160 8161 8162 8163 8165 8260 8262 8561 8564 8565	1551 1660 1661 1662 1663 1665 3161 3165	8100 8101 8105 3101
WARRANTY LENGTH	Three years	Three years	Two years

MODEL TYPES	HIGH PURITY METAL SEAL MFCs	HIGH PURITY METAL SEAL MFCs	ELASTOMERIC MFCs
MODEL NUMBERS	7360 7361 7364	5361 5365	180 7300 7301 7304 5301
WARRANTY LENGTH	Three years	Two years	Two years

Table 3. Warranties

If units are judged to be out of warranty, Celerity will notify the owner of replacement or repair costs before proceeding. Factory service and repairs include a ninety-day warranty on all parts and labor. Normal turnaround time is five working days, or less, on any standard range item returned for warranty service.

MFCs that are repaired by anyone other than Celerity service centers during the warranty period void their warranty.

Check our website at www.celerity.net to find your local service center.

15. WEB SITE TECHNICAL RESOURCES

Celerity provides several technical information resources on our website, including “The Basics of Thermal Mass Flow Control”.

16. APPENDICES

16.1 Connector Pinouts

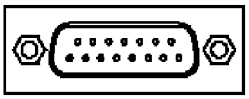
MFC CARDEDGE CONNECTOR

1	Case Ground
2	Power Common
3	Output (0-5 VDC)
4	+15 VDC
5	
6	Sensor Out
8	
9	
10	Common
A	Setpoint (0-5 VDC)
B	Signal Common
C	Signal Common
D	Valve Test Point
E	
F	-15 VDC
H	
I	Zero Alarm
J	Valve Off

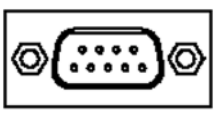
MFM CARDEDGE CONNECTOR

1	Case Ground
2	Power Common
3	Output (0-5 VDC)
4	+15 VDC
5	
6	Sensor Out
8	
9	
10	
A	
B	Signal Common
C	Signal Common
D	
E	
F	-15 VDC
H	
I	
J	

15 PIN D CONNECTOR



9 PIN D CONNECTOR



15 PIN "D" CONNECTOR (UDU15)

1	Common
2	
3	
4	+15 VDC
5	
6	Output (0-5 VDC)
7	Power Common
8	Case Ground
9	Valve Off
10	
11	-15 VDC
12	Valve Test Point
13	Signal Common
14	Signal Common
15	Setpoint (0-5 VDC)

REMOTE "D" CONNECTOR OPTION (UDU15)

1	Common
2	
3	
4	+15 VDC
5	
6	Output (0-5 VDC)
7	Power Common
8	Case Ground
9	Valve Off
10	
11	-15 VDC
12	Valve Test Point
13	Signal Common
14	Signal Common
15	Setpoint (0-5 VDC)

15 PIN "D" BROOKS CONNECTOR (UDB15/ UDN15)

1	Signal Common
2	Flow Out
3	Power Common
4	Valve Off
5	+15 VDC
6	-15 VDC
7	Valve Test Point
8	Setpoint (0-5 VDC)
9	Power Common
10	Signal Common
11	
12	
13	
14	Case Ground
15	

15 PIN "D" BROOKS SMART CONNECTOR

1	Setpoint Return
2	0-5VDC Flow Out
3	
4	Output (4-20mA)
5	+24 VDC MFC Power
6	
7	Setpoint (4-20mA)
8	
9	Power Common
10	Flow Output Common
11	
12	Valve Override
13	VTP
14	RS485 A+
15	RS485 A-

15 PIN "D" CONNECTOR (UDK15)

1	MKS Test Point
2	Flow Out
3	Valve Close
4	Valve Open
5	Power Common
6	-15 VDC
7	+15 VDC
8	Setpoint (0-5 VDC)
9	
10	Optional Input
11	Signal Common
12	Signal Common
13	
14	
15	Chassis Ground

15 PIN "D" 4-20mA CONNECTOR (UDI15)

1	Common
2	Zero Alarm
3	
4	+15 VDC
5	
6	Output (4-20mA)
7	Power Common
8	Case Ground
9	Valve Off
10	+15 to +35 VDC Ext Drv. (Option)
11	-15 VDC
12	Valve Test Point
13	Signal Common
14	Signal Common
15	Setpoint (4-20mA)

20 PIN HONDA CONNECTOR (UDH20)

1	
2	Power Common
3	Output (0-5 VDC)
4	+15 VDC
5	
6	VTP -15 – 0 VDC
7	
8	
9	
10	
11	Setpoint (0-5 VDC)
12	Signal Common
13	Signal Common
14	Purge/Close
15	
16	-15 VDC
17	
18	
19	
20	

9 PIN "D" CONNECTOR (UDU9/UDT9)

1	Valve Off
2	Output (0-5 VDC)
3	+15 VDC
4	Power Common
5	-15 VDC
6	Setpoint (0-5 VDC)
7	Signal Common
8	Signal Common
9	Valve Test Point

9 PIN "D" STEC CONNECTOR (UDS9/UDF9/UDJ9)

1	Purge/Close-
2	Output (0-5 VDC)
3	+15 VDC
4	Power Common
5	-15 VDC
6	Setpoint (0-5 VDC)
7	Signal Common
8	Signal Common
9	VTP -15 – 0 VDC

9 PIN "D" STEC CONNECTOR (UDV9)

1	Purge/Close-
2	Output (0-5 VDC)
3	+15 VDC
4	Power Common
5	-15 VDC
6	Setpoint (0-5 VDC)
7	Signal Common
8	Signal Common
9	VTP -10 VDC

9 PIN "D" STEC 7350 COMPATIBLE PINOUT (UDM9/UDY9/UDZ9)

1	Purge/Close-
2	Output (0-5 VDC)
3	+15 VDC
4	Signal Common
5	-15 VDC
6	Setpoint (0-5 VDC)
7	AZ Alarm
8	VTP
9	AZ Disable

9 PIN "D" PORTER CONNECTOR (UDR9)

1	Open
2	Output
3	Setpoint
4	Power Common
5	Valve Test Point
6	-15 VDC
7	+15 VDC
8	Signal Common
9	Shield

9 PIN "D" STEC UDS CONNECTOR (UDQ9/UDW9/UDO9) W/INTERCONNECTED GROUNDS

1	Purge/Close-
2	Output (0-5 VDC)
3	+15 VDC
4	Power/Signal Common
5	-15 VDC
6	Setpoint (0-5 VDC)
7	Power/Signal Common
8	Power/Signal Common
9	VTP -15 – 0 VDC

9 PIN "D" PROFIBUS CONNECTOR (UDP9)

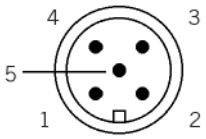
1	Protective Ground
2	Reserved for Power
3	Recv/Transmit-Data-P
4	Control-P
5	Data Gnd.
6	Voltage Plus
7	Reserved for Power
8	Recv/Transmit-Data-N
9	Control-N

9 PIN "D" CONNECTOR (UDG9)

1	Valve Control
2	Output (0-5 VDC)
3	+15 VDC
4	Power Common
5	-15 VDC
6	Setpoint (0-5 VDC)
7	Signal Common
8	RS485 DX+
9	RS485 DX-

DEVICENET CONNECTOR

1	Drain
2	V+ 11-25 VDC
3	V-
4	CAN-H
5	CAN-L



16.2 Setting the MFC/MFM Zero

MFC zero must be set correctly and consistently to avoid any flow inaccuracies that might be present in a mass flow controller or meter.

16.2.1 Background

It is normal to experience zero drift in the flow meter output during the life of an mass flow controller (MFC). MFC users should understand what MFC zero offset is and how to adjust for its drift. When an MFC is first installed, it is normal to re-zero the device to ensure the best results. "MFC Zero" is the signal produced by the mass flow sensor when gas is not flowing. This signal is measured at the output terminal of the MFC with respect to the signal common terminal. The MFC zero must be set such that the output reads 0.0% when the MFC is not flowing any gas. Zero offset is a major contributor to flow inaccuracies particularly at lower control setpoints, where the zero offset error becomes a large percentage of the total flow signal. Because of this problem, it is imperative that the MFC zero be set correctly and consistently. There are two common errors that can result in errant zeroing.

16.2.2 Gas Inlet Pressure

The inlet pressure is an often overlooked source of potential zero error on MFCS. Many high density, low viscosity gasses exhibit slight changes in zero output as a function of MFC inlet pressure. MFCs flowing gasses such as tungsten hexafluoride and many fluoro carbons are especially sensitive to this problem. A simple way of minimizing this problem is to keep the inlet pressure as low as possible.

Note: This does not apply to pressure buffered "reverse flow" controllers as the pressure sensitive portion of the MFC is on the downstream side of the MFC.

16.2.3 MFC control valve leakage

Because the MFC is not intended to be used as a positive shut-off device, the MFC valve is not guaranteed to be leak tight when the valve is closed. What this means is that setting the MFC zero while there is a pressure differential across the MFC can be a problem because the MFC will be measuring the valve leakage. Setting the zero under these conditions will result in a calibration error. In order to minimize flow errors, it is suggested that the user follow the zeroing procedure below.

16.2.4 Factory Suggested Zeroing Procedure

1. Mount the MFC in the intended physical orientation. The gas delivery system should be at the intended operating temperature.

2. Insure the MFC flow path is filled with process gas. If the MFC was recently purged or newly connected to the system, run process gas for 5 to 10 minutes. Alternatively, evacuate the MFC using a vacuum pump then run process gas long enough to full the MFC and gas line.

3. While running process gas at the normal operating pressure, close the down stream isolation valve.

4. Place the MFC in purge mode or give it a command to flow 100% setpoint. Monitor the indicated flow until it stabilizes near zero.

5. Close the upstream isolation valve.

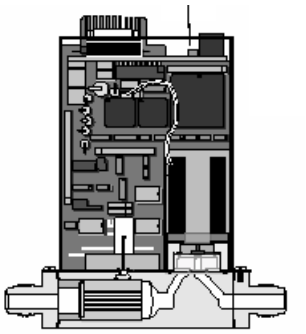
6. Give the MFC a zero percent flow command to close the control valve.

7. Let the MFC warm up and stabilize for 60 minutes.

8. Monitor the zero output to insure it has stabilized.

9. ANALOG MFC's - Adjust R13, Zero Potentiometer until desired zero value is established.

10. DIGITAL MFC's - Activate the zero adjust routine by one of two methods:



10.1 Depress the zero momentary contact switch on the top of the MFC.

10.2 Through the RS 485 digital interface: Class0x68, Instance 1, Attribute 0xBA. Send a write command with an 8 bit integer value of 1.

11. Wait 30 seconds while the MFC runs the zero routine. Do not send any commands to the MFC or disturb the inlet pressure.

Note: The status of the zero service routine can be monitored through the RS485 digital interface. Read the Class 0x68, Instance 1, Attribute 0xBA. The MFC will return an eight bit integer value of 1 while it is in process of running the zero service routine and return an eight bit integer value of 0 when the zero service routine has been completed.

12. Read the zero output. If it is not 0% FS +/- .05%, then repeat from step 9.

16.2.5 Conclusion

Improperly zeroed MFCs can cause significant calibration errors and result in process inconsistencies. Following the above zeroing procedure should eliminate the most often overlooked sources of zero adjustment error. If you have any questions regarding the adjustment of MFC zero or any technical questions, please call the Celerity Applications Engineering Department at (714) 921-2640 or visit our website at www.celerity.net.

16.3 9000 Series Supplement

Metal Seal High Temperature Liquid & Solid Source Vapor Mass Flow Controllers
Models 9660, 9661, 9860, 9861, and 9865

16.3.1 Installation Instructions

16.3.1.1 Unpacking

- Verify that the controller was not damaged in transit.
- The following items are part of the 9000 Series controller:
  - 9000 Series controller
  - 9000 Series remote electronics
  - High temperature cable assembly, length 3 ft. P/N 955-000-0003
  - Remote clamp bracket P/N 860-004-1015
  - Optional 15 pin “D” to 20 pin card edge adapter. P/N 200-104-1000 (Model 9660, 9860, 9861 only)

16.3.2 Site Preparation

Thoroughly clean, dry, and purge all piping associated with the entire flow control system prior to installing the controller.

16.3.3 Positioning and Mounting the Controller

The controller must be positioned so that the gas flow is in the direction of the arrow stamped on the controller base. The High Temperature controller is designed and calibrated to be mounted in the Horizontal position only. Match the mounting holes on the bottom of the flow controller with those on the mounting surface.

Using two #8-32 screws, mount the flow controller. See drawings 990-111-9660U or 990-111-9865U for mounting hole positions.

The Remote electronics must be mounted outside of the high temperature area. The controller and Remote electronics are connected through the high temperature cable assembly. Using the remote clamp bracket, mount the Remote electronics in any position that is convenient, within reach of the high temperature cable. Longer length cable can be specially ordered. The temperature limit of the electronics is 0-50°C (32°F-122°F).

16.3.4 Connect to Gas Supply Line

Once the controller is correctly mounted, connect the inlet and outlet VCR fittings to the gas supply line.

1. Install new gaskets compatible with the gas to be used.
2. Tighten nut finger tight.
3. Tighten in accordance with the fitting manufacturers specifications.

16.3.5 Connect to Power Supply

- The 9000 Series uses a Cardedge plus either 15 pin or 9 pin “D” connector for power, flow, and control signal lines, unless it is a DeviceNet model.
- If you are using a power supply other than one from Unit Instruments, check the pin assignments, making sure they match those in Figure 1.
- Once the power supply is securely plugged in, the flow controller should be warmed up for 60 minutes before any other operation.

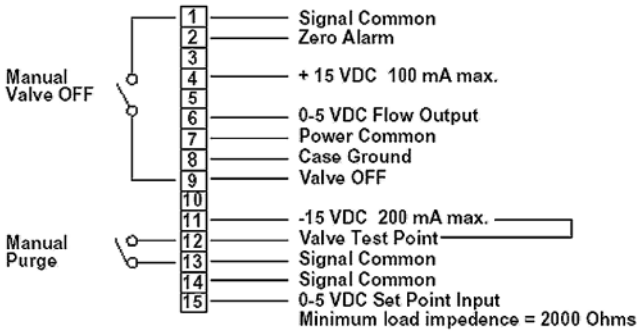


Figure 1. 9000 Series 15 pin D Connector Pinout

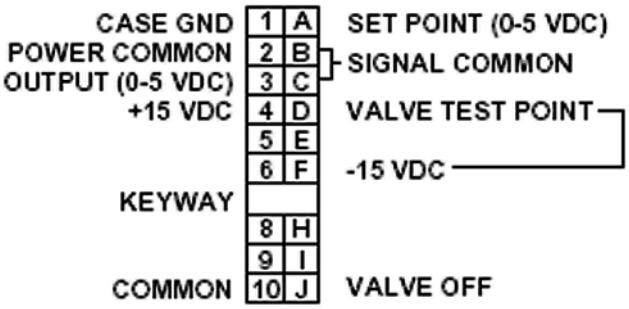


Figure 2. 9000 Series Cardedge Connector Pinout

NOTE: The Model 9865 DeviceNet versions use a mini 5 pin connector that is compliant with DeviceNet specifications (see Pinouts below).

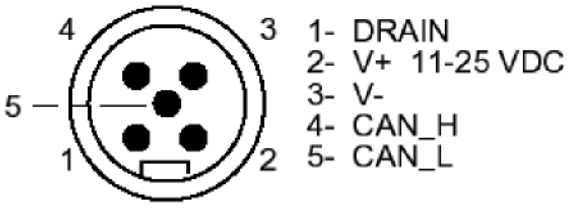


Figure 3. 9000 Series DeviceNet Connector Pinout (Male)

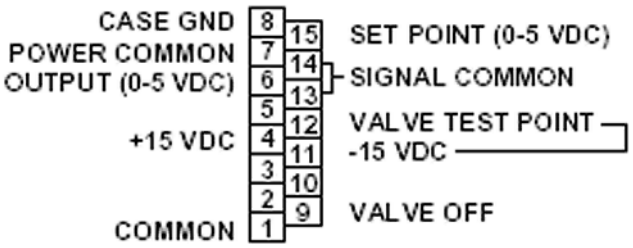


Figure 4. 9000 Series Remote "D" Connector Option Pinout (UDU15)

16.3.6 Purge

Prior to introducing process gas, insure that the MFC and gas lines have been thoroughly purged with clean, dry N2.

16.3.7 Zero Check (For High Temp Controllers)

The electrical zero should be regularly monitored and adjusted accordingly, using the zero adjustment.

16.3.7.1 Ensure that the flow controller has been ON for more than 60 minutes and the flow controller is at its operational temperature.

- The High Temperature controllers have a calibration temperature window that is ±15°C from the nominal operating temperature.

16.3.7.2 Shut OFF the inlet and outlet gas supply lines to the flow controller, making sure that no gas is flowing through the controller.

16.3.7.3 The flow signal output should read a steady 0. If the output is not within ±0.5%(±25 mV) of 0.0 V, then remove the small inspection label on the Remote electronics and press the Zero button.

- For best performance the Zero should be within ±0.2% (±10 mV). See drawing 990-111-9660U for zero adjustment access.

Note: For remote readouts, including analog to digital converters, ensure that the readouts match the 9000 Series signals. Adjust the remote readout zero and full-scale to match the 9000 Series signals.

16.3.8 Calibration Check (For High Temp Controllers)

Calibration must be checked by flowing gas through a calibration reference and then through the mass flow controller to verify correct readout.

Celerity recommends that all High Temperature metal seal controllers be returned to Celerity for re-calibration.

16.3.9 Maintenance

16.3.9.1 Service

Any precision instrument such as a mass flow controller requires occasional servicing. It is especially important to perform this service if the flow controller has been operating for an extended period of time or has been subjected to corrosive gases or other gases which leave excessive residue. If non-reactive gases are used, service your flow controller annually. If reactive gases are used, the flow controller should be serviced every six months. Due to the high service temperature, low particle count, and high leak integrity all High Temperature metal seal flow controllers must be returned to Celerity for service.

16.4 Troubleshooting Guide

16.4.1 Determining Whether or Not to Remove the MFC, Always contact Celerity Technical Support before removing the MFC.

- Prior to replacing an MFC thoroughly purge the system or replace/re-clean contaminated components.

NO GAS FLOW	WHAT TO DO?
Is the gas supply turned on?	Check the shut-off valve and the pressure readout.
Is the regulator on and at the correct operating pressure?	Typically 25 psia.
Are any upstream or downstream isolation valves closed, either by the system or because of failure?	Verify that the pneumatic valves are operating.
Is the MOD LED on the MFC lit solid green?	Look at the top of the unit.
Is the NET LED on the MFC lit solid green?	Look at the top of the unit. If not, cycle power to the unit or re-boot.
Is the commanded setpoint from the system "0%"?	Use the tool software. Verify interlocks.
Has the MFC been commanded off by an active "valve close" input?	Use the tool software. Verify interlocks.

FLOW OUT-OF-RANGE WHAT TO DO?	
Is the gas inlet/outlet pressure differential either too high or too low? • If the differential is too high, MFC valve voltage or drive will be zero or abnormally low for the setpoint.	Verify that the pressure is correct for this gas and range, typically 25 psia.
Is the MOD LED on the MFC lit solid green?	Look at the top of the unit.
Is the setpoint correct for the required flow?	Use the tool software to verify this.
Is the MFC calibrated for the particular gas?	Check the MFC label. Run Flow Verify.
Is the MFC zero correct? (If not refer to the Zeroing Procedure.)	Verify Leak Check Rates are OK.

NO GAS CONTROL; FLOW IS AT OR ABOVE MAXIMUM	WHAT TO DO?
Is there too much gas pressure across the MFC?	Verify that the pressure is correct for this gas and range, typically 25 psia.
Is a system "valve open" or "purge" input activated?	Use the tool software to verify this.
Is the setpoint correct for the required flow?	Use the tool software to verify this.

FLOW UNABLE TO REACH A SETPOINT (When the setpoint is raised beyond this point, the MFC remains at some value lower than the setpoint.)	WHAT TO DO?
Is the gas inlet/outlet pressure-differential sufficient? • If the differential is too low, the MFC valve voltage or drive will be at its maximum value when the setpoint is raised above the point where the flow will increase. • Adjust regulator to the proper operating pressure. Verify that the pressure is correct for this gas and range, typically 25 psia.	Verify that the pressure is correct for this gas and range, typically 25 psia.
Is the MFC calibrated for the gas flowing? • If not, replace the MFC with properly calibrated unit.	Check the MFC label. Run Flow Verify.

NO GAS FLOW CONTROL BELOW SOME SETPOINT (When the setpoint is lowered below this point, the MFC signal remains at some value higher than the setpoint.)	**WHAT TO DO?**
Is the gas inlet/outlet pressure differential too high? • If the differential is too high, MFC valve voltage or drive will be at its minimum value when the setpoint is lowered below the point where the flow will decrease. • Adjust the regulator to the proper operating pressure.	Verify that the pressure is correct for this gas and range, typically 25 psia.
Is the MFC valve leaking? • Possibly caused by contamination • Test the valve for leak integrity and replace if leaking.	Run the Leak By procedure.

GAS FLOW OR MFC READING OSCILLATES	**WHAT TO DO?**
Is the MFC calibrated for the gas flowing? • If not, replace MFC with properly calibrated unit. • Most nitrogen calibrated MFCs will oscillate on hydrogen or helium.	Check the MFC label. Run Flow Verify.
Is there too much gas pressure across the MFC? • Adjust regulator to proper operating pressure if necessary. Are the inlet and outlet pressures steady? • Check inlet pressure.	Verify that the pressure is correct for this gas and range, typically 25 psia.
• If erratic, a faulty pressure regulator can make an MFC appear to oscillate.	Verify that the pressure is correct for this gas and range, typically 25 psia.

MFC DOES NOT READ ZERO WHEN GAS IS SHUT OFF	**WHAT TO DO?**
Is the differential pressure across the MFC really zero? • Equalize the pressure across the MFC by opening the control valve briefly. • Perform a zero adjustment, using tool software. (If not refer to the Zeroing Procedure.)	Verify that the pressure is correct for this gas and range, typically 25 psia. (If the unit has been contaminated the valve may not be able to close, and therefore it will not zero.)
Is the MFC configured properly in the tool software?	Use the tool software to verify this.
Is the MFC mounted in the proper attitude? • Also, for best results, calibrate the MFC in the same attitude in which it will be operating.	See the MFC side can label; look for HOV (Vertical) or HOS (Horizontal). Check the part number or “MFC Description”.

16.5 Maintenance

MOD (Module) Status LED

LED	INDICATES	WHAT TO DO
Not lit	No power to the MFC.	Check the voltage at the cable connector across pins 2 and 3. Verify that the voltage is 11-25 Vdc.
Not lit	Damaged/Defective LED	Contact Kinetics Technical Support.
Not lit	MFC Power Supply problem.	Contact Celerity Technical Support.
Flashing Green/Red	The device is in Self-test mode.	The Device is operating normally if this flashing green/red lasts for no more than five seconds.
Steady Red	The microprocessor has failed.	Contact Celerity Technical Support.
Steady Green	The device is powered up.	This is normal operating mode.

NET (Network) Status LED

LED	INDICATES	WHAT TO DO
Not lit	No power to the MFC.	If both the Mod and Net LEDs are out, check the voltage at the cable connector across pins 2 and 3. Verify that the voltage is 11-25 VDC.
Not lit	Damaged/Defective LED	Unplug and plug the MFC cable (performing a hard reset), or send the tool command to soft reset the MFC. Verify that the LED is flashing red/green. If not, contact Celerity Technical Support.
Not lit	A single MFC is the only connection to the bus.	Having the NET Status LED not lit is normal operating mode for a single device on the system controller.
Not lit	There is a tool connection issue.	Verify the physical condition of the system controller connections.
Flashing Green/Red	The device is in Self-test mode.	This is normal operation for the Self test mode.
Flashing Green	The device is in Standby mode.	This is normal operation. It is waiting for the MFC to be connected to the tool.
Flashing Green	The MFC and tool are not communicating.	Verify that the MFC has been set up with the MAC ID that the tool is expecting.
Flashing Green	The System Controller is not functioning (it is off the bus).	Reconnect the system controller bus.
Steady Green	The device is operating normally and communicating properly.	This is normal operation.
Steady Red	There are duplicate MAC Ids.	Correct the MAC Ids. Unplug, and plug the MFC cable (to create a hard reset), or send a tool command to soft-reset the MFC.
Steady Red	The baud rate of the MFC is different from the rest of the bus.	Switch setting: 2 (for 500K). Reset the baud rate to be consistent with the rest of the devices on the bus.
Steady Red	There is a failure in the communication link.	Verify the integrity of the physical connection to the bus. Recycle the power to reinitialize the MFCs.
Flashing Red	The Poll I/O connection timed out.	The System Controller may attempt to reestablish communication (tool software). Verify that the software timing is correct for the number of devices being polled.
Flashing Red	The software does not have enough time to poll the number of devices on the bus.	Revise the timing in the System Controller.

16.6 Manufacturing, Sales, and Service Locations

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16.7 AUTO-ZERO FEATURE (FOR ANALOG MASS FLOW CONTROLLERS)

16.7.1 Introduction

Celerity MFCs guarantee a zero drift of less than .6% per year, essentially eliminating the need for the Auto Zero feature. However it is still offered as an option. The Auto-Zero feature eliminates zero drift as a contributor to long-term process non-repeatability. It automatically and continuously re-zeros the MFC between process runs. This reduces the need for frequent calibration, a procedure which can be both costly and time-consuming.

This feature can identify an MFC which is in need of recalibration or repair, and can be used as a trigger for a system alarm to the operator prior to a process run. (See Figure #2)

The Auto-Zero feature eliminates zero drift thus maximizing process repeatability. The significance of this enhanced repeatability is very dramatic at the low end of the MFC ranges, as shown in Figure 1, where a ±1% zero variance can result in a ±10% error at 10% of full scale.

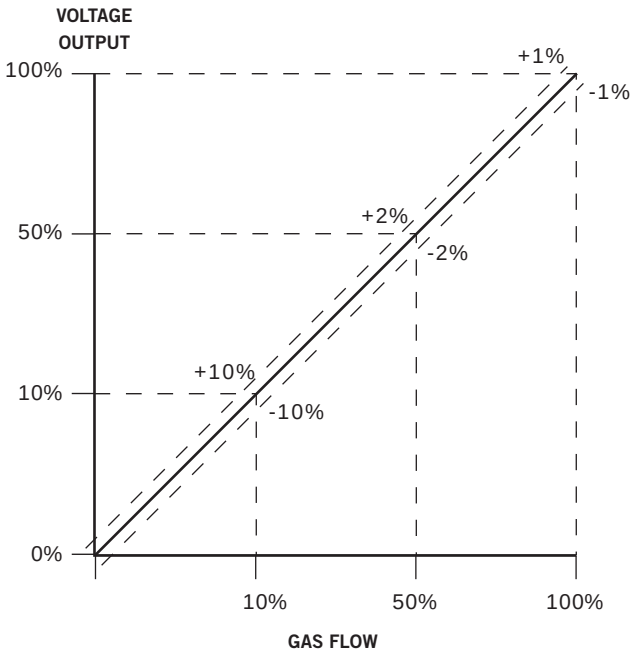

Figure 1. Zero Variance of +/- 1% the effects

*An alarm may be triggered to indicate that the calibration of this MFC should be evaluated.

16.7.2 Operation

Start of Auto-Zero Sequence

The Auto-Zero function is activated by a Valve Off signal from pin J on the MFC. This signal can be triggered by either manual shutoff or the Auto-Shutoff.

Start Delay

When the off signal is received, the Auto-Zero initiates a 90 second flow stabilization delay.

Operating Limits

Following the 90 second delay, the Auto-Zero continuously compares the output of the MFC meter with DC Common and makes any necessary alignment of the MFC meter by adjusting a digital potentiometer. This comparison/adjustment process typically requires 30-60 seconds for completion.

Operating Limits

If the variation between the MFC meter output and DC Common is greater than 4 to 5%, the Auto-Zero will not zero but will display the differential between the true zero and the 4 to 5% limit. This difference and the Auto-Zero alarm indicates the need to check calibration or service of the MFC.

Auto-Zero Hold

When the valve is turned on to resume flow, the Auto-Zero reference is stored in memory and maintained through subsequent operations until the MFC is turned off again. (Any time the MFC is unplugged the Auto-Zero procedure should be re-initiated before use in process control.)

System Standby

Most systems are programmed to shutoff the MFC during Standby conditions. This activates the auto zero continuously until the process is turned on. In addition, most systems return to standby if there is a loss of power and the system is powered back up. This standby condition automatically activates the auto zero to zero the MFC for process running.

Automatic Zero Frequency Requirements

It is recommended that the MFC with Auto-Zero be turned off and taken through above Steps #2-3 at a typical frequency of daily to weekly to ensure its best performance.

Automatic Zero Alarm

The alarm indicates that zero has drifted beyond the operating limits of the Auto-Zero. The Auto-Zero alarm will indicate to the system that there is a need to check the calibration.

16.7.3 Theory of Auto-Zero Operation

The Auto-Zero feature in CELERITY Mass Flow Controllers overcomes zero drift by automatically adjusting the MFC meter to electrical zero during off-cycles between process runs. A stable zero enables operators to achieve repeatability of ±1% even in very low flow operations (±0.2% of full scale). The following tabulation and graph demonstrate the critical effect of zero drift on repeatability:

Setpoint	Error if ±1% Zero Offset	Error if ±2% Zero Offset	Maximum with Auto-Zero
100% FS	±1%	±2%	±0.2%
50% FS	±2%	±4%	±0.4%
20% FS	±5%	±10%	±1.0%
10% FS	±10%	±20%	±2.0%
1% FS	±100%	±200%	±20.0%

*Such drift may vary from MFC to MFC

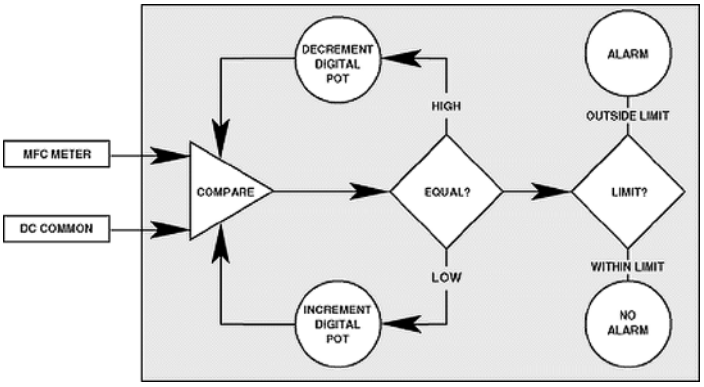

Figure 3. Simplified Logic of the Auto-Zero Circuitry. Flow Diagram

The Auto-Zero circuitry is triggered by a signal from Valve-Off command (pin J) or zero setpoint for automatic shutoff (A) feature models of the MFC which initiates a 2 minute delay. After the delay the Auto-Zero compares the output of the MFC meter to DC Common, determining the direction and degree of variance. The Auto-Zero then executes an incremental or decremental step of its digital potentiometer (as determined) and compares the new reading to zero. This continuous incremental step-and-compare cycle continues indefinitely.

The operator may observe the progress of this cycle by monitoring the readout of the MFC meter. A stable zero readout is typically achieved in 30-60 seconds, at which point the MFC is ready for operation. After a stable zero (±0.2%) is achieved, the operator may turn on the MFC. This action disconnects pin J, disabling the Auto-Zero circuitry, and maintaining the new zero setting.

If the meter output never achieves zero, the MFC zero variance may have exceeded the correction limit of the Auto-Zero circuitry (±4-5% of full scale). The Automatic Zero alarm will then indicate the need for service or re-calibration of the MFC.

16.7.4 Operational Test

1. Plug in the MFC with the gas off and the MFC turned on.
2. Allow the MFC to warm-up for 60 minutes.
3. Note what zero reading is displayed.
4. Turn off the MFC, using either manual (pin J, Input=0 VDC) or automatic shutoff (zero setpoint of models with Auto Shutoff feature). Verify that no gas is flowing when the MFC is off. This is critical to the accurate and repeatable operation of the automatic zero feature.

Celerity suggests that positive isolation valves be installed upstream and downstream of the MFC to ensure no gas flow during Auto-Zero operation cycle. If the MFC is being used in a vacuum process we recommend that zeroing take place under vacuum conditions to better ensure that there is no flow.

If the MFC is installed in the vertical position, the gas should either be evacuated or the pressure reduced to atmosphere. Celerity recommends this because, some high density gases exhibit a thermal siphon effect within the MFC during standby. Thermal siphon produces internal recirculating flow within mass flow controllers due to heating of the gas. This effect will cause the Auto-Zero to offset in error. Current Celerity MFCs with the new sensor will not exhibit this offset

5. Wait 3 minutes to allow the Auto-Zero to complete the zeroing process.
6. Confirm that the reading is zero (±0.2% of full scale).

16.7.5 Auto-Zero Specifications

Performance

Accuracy.....±0.2% of full scale

Time Requirement

Warm-Up.....60 minutes

Auto-Zero stabilization.....2 min delay between turn on and Auto-Zero function

Auto-Zero operation.....continuous comparative cycle for 30-60 seconds minimum after valve off or until the MFC is turned on

Operating Period.....after MFC cutoff and 90 sec. delay continuous operation until the MFC is turned on

Minimum Operating Time..2 to 3 minutes depending on offset of true zero

Operating Limits.....±4-5% of full scale

Auto-Zero Alarm.....Indicates Auto-Zero at operating limits.
Transistor close: Pin I B/C

Ambient Temp. Range.....0°-50°C (32°-122°F)

Dimensions.....1.6" x 1.1" x 0.1"

16.7.6 Troubleshooting

Auto-Zero boards should be either replaced or repaired at the factory. The following is a list of potential sources of operator difficulty when improperly utilizing the Auto-Zero feature. Each item on the checklist should be investigated during troubleshooting:

16.7.7 Checklist

1. Was the MFC warmed up for 60 minutes prior to zeroing?
2. Is the MFC being operated in the position for which it was calibrated?
3. Was the Auto-Zero allowed the 90 second delay for stabilization?
4. Is the setpoint above 1% of full scale (for units with Auto Shut-off(A))?
5. Was the Auto-Zero board installed correctly?
6. Is there gas flowing when the MFC is off?
7. Is the MFC meter zero beyond the ±4-5% range of automatic zero and in need of repair or recalibration?
8. Has the Auto-Zero MFC been off-cycled regularly to ensure best performance?
9. Is the Auto-Zero allowed to operate for a minimum of 3 minutes to re-establish zero?

16.7.8 Disabling Auto-Zero to Establish True Zero

1. Apply a setpoint of 2% or more.
2. Turn on the MFC (pin J open circuited or 5VDC applied)
3. Isolate gas flow or evacuate the MFC.
4. Unplug the MFC
5. Replug the MFC and allow 10 min. warm-up (assuming previous 60 min. warm-up)
6. Establish the normal operating temperature and attitude of the MFC.

The true zero should now appear on the flow readout. If the true zero is beyond the operating limits (±4-5%), then the following re-zero procedure can be used. (Re-zeroing is advised if true zero is more than ±1% out.)

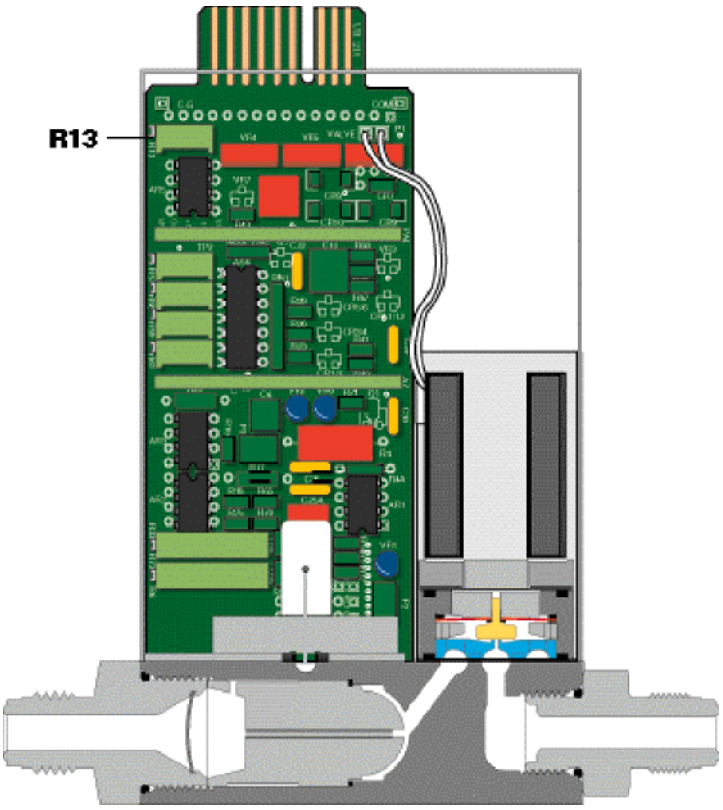

Figure 6. Zero Pot Location Adjusted with no pressure applied to the unit

16.7.10 AUTO-ZERO FUNCTIONAL TEST

The Auto-Zero control may be tested by intentionally adjusting true zero to -1% or +1%, turning off the MFC (zero setpoint or 0 VDC applied to pin J) and observing the Auto-Zero compensation after the two minute delay.

After the test is complete reset the true zero to zero output utilizing the same procedure described in the section Auto-Zero Out of Range Adjustment, re-zeroing true zero.

16.7.11 AUTO-ZERO ALARM FUNCTIONAL TEST

When the true zero is outside of the range of the Auto-Zero (±4-5% F.S.) the Auto-Zero alarm should be activated. The true zero may be adjusted outside of this range to test the alarm on/off.