Alicat Scientific™

16 Series

Mass and Volumetric Flow Controllers

Precision Gas Flow Controller

Operating Manual

Note: Although we provide assistance on Alicat Scientific products both personally and through our literature, it is the complete responsibility of the user to determine the suitability of any product to their application.

The manufacturer does not warrant or assume responsibility for the use of its products in life support applications or systems.

Alicat Scientific, Inc.'s Wide-Range Laminar Flow Element Patent:
The wide-range laminar flow element and products using the wide-range laminar flow element are covered by U.S. Patent Number: 5,511,416. Manufacture or use of the wide-range laminar flow element in products other than Alicat Scientific products or other products licensed under said patent will be deemed an infringement.

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Introduction

Thank you for purchasing a VC or MC Series Gas Flow Controller Please take the time to find and read the pertinent information contained in this manual for your specific device. This will help to ensure that you get the best possible service life from your instrument. This manual covers the following Alicat Scientific, Inc. instruments:

VC Series 16 Bit Volumetric Gas Flow Controllers	VC-XXCCM-D
	VC-XXLPM-D
MC Series 16 Bit Mass Gas Flow Controllers	MC-XXSCCM-D
	MC-XXSLPM-D

The 16 Series data presentation format utilizes a full graphic display that allows simultaneous viewing of all operating parameters. The dynamically labeled display allows the user to make field adjustments to the set point, the P (proportional) and D (derivative) loop control terms, and in some cases actually close the control loop on different parameters right on the unit. Selected parameters can be toggled to the large primary display for ease of viewing.

Flow Measurement Operating Principle

All VC or MC Series Gas Flow Controllers are based on the accurate measurement of volumetric flow. The volumetric flow rate is determined by creating a pressure drop across a unique internal restriction, known as a Laminar Flow Element (LFE), and measuring differential pressure across it. The restriction is designed so that the gas molecules are forced to move in parallel paths along the entire length of the passage; hence laminar (streamline) flow is established for the entire range of operation of the device. Unlike other flow measuring devices, in laminar flow controllers the relationship between pressure drop and flow is linear. The underlying principle of operation of the 16 Series Flow Controllers is known as the Poiseuille Equation:

$$Q = (P_1 - P_2)\pi r^4 / 8\eta L \qquad \text{(Equation 1)}$$

Where:
- Q = Volumetric Flow Rate
- $\mathbf{P_1}$ = Static pressure at the inlet
- P_2 = Static pressure at the outlet
- r = Radius of the restriction
- η = (eta) absolute viscosity of the fluid
- L = Length of the restriction

Since π, r and L are constant; Equation 1 can be rewritten as:

$$Q = K\,(\Delta P/\eta) \qquad \text{(Equation 2)}$$

Where K is a constant factor determined by the geometry of the restriction. Equation 2 shows the linear relationship between volumetric flow rate (Q) differential pressure (DP) and absolute viscosity (h) in a simpler form.

Flow Control Operating Principle

For the purposes of this explanation, the term “valve” will refer to the proportional control valve mounted on the controller. The term “controller” will refer to the flow meter and the measurement and control electronics portion of the device. In actuality, the whole device is generally referred to as a controller. The valve may be mounted either upstream or downstream of the controller depending upon the application.

VC and MC Series flow controllers ship with a normally closed proportional control valve. Flow is closed off by a mechanical spring, which holds an elastomer tipped plunger on an appropriately sized flow orifice called a “seat”. No flow will occur until the valve receives a voltage signal from the controller, and the controller will not send a voltage signal to the valve until the user provides a set point to the controller. The user can provide a set point either locally via the display and user interface buttons, or more commonly, by providing an external signal that corresponds to the flow range of the controller. This external signal can be an analog voltage or current signal such as a 0-5 Vdc or 4-20 mA signal, or a digital RS-232 signal via serial communication with a computer.

The controller utilizes what is called PID (Proportional, Integral, Derivative) loop control circuitry and software. The PID loop control works by repeatedly comparing the measured flow rate to the set point and incrementally adjusting the voltage signal to the valve in a continuous attempt to match the measured flow rate to the set point. For example, at any given time the controller looks at the measured flow rate and the set point, if the set point is higher than the measured flow rate, the controller will slightly increase the voltage signal to the valve and thus open it little more. If the set point is lower than the measured flow rate, the controller will slightly decrease the voltage signal to the valve and thus close it off a little more. This look, compare, and adjust “loop” occurs on the order of 1000 times each second.

VC and MC Series flow controllers ship with a general PID tuning that is usually sufficient for most applications. Occasionally an application will require the customer to change this tuning. The Proportional and Derivative terms can be field adjusted in all MC and VC controllers. In very general terms, the P term can be thought of as how fast the controller responds to change and the D term can be thought of as a dampening factor.

Understanding Volumetric and Mass Flow

In order to get an accurate volumetric flow rate reading from your controller, the gas being measured must be selected in the gas select mode. This is important because the device calculates the flow rate based on the viscosity of the gas at the measured temperature. If the gas being measured is not what is selected, an incorrect value for the viscosity of the gas will be used in the calculation of flow, and the resulting output will be inaccurate in direct proportion to the difference in the two gases viscosities.

Gas Viscosity: In order to get an accurate volumetric flow rate, the gas being measured must be selected (see *Gas Select Mode* page 14). This is important because the device calculates the flow rate based on the viscosity of the gas at the measured temperature. If the gas being measured is not what is selected, an incorrect value for the viscosity of the gas will be used in the calculation of flow, and the resulting output will be inaccurate in direct proportion to the difference in the two gases viscosities.

Gas viscosity, and thus gas composition, can be very important to the accuracy of the meter. Anything that has an effect on the gas viscosity (e.g. water vapor, odorant additives, etc.) will have a direct proportional effect on the accuracy. Selecting methane and measuring natural gas for instance, will result in a fairly decent reading, but it is not highly accurate because natural gas contains small and varying amounts of other gases such as butane and propane that result in a viscosity that is somewhat different than pure methane.

Absolute viscosity changes very little with pressure therefore a true volumetric reading does not require a correction for pressure. Changes in gas temperature do affect viscosity. For this reason, the MC Series utilizes the temperature sensor to internally compensate for this change and no outside temperature correction is required for volumetric measurement.

Other Gases: MC Series Flow Controllers can easily be used to measure the flow rate of gases other than those listed as long as “non-corrosive" gas compatibility is observed. For example, a flow meter that has been set for air can be used to measure the flow of argon.

The conversion factor needed for measuring the flow of different gases is linear and is simply determined by the ratio of the absolute viscosity of the gases. This factor can be calculated as follows:

$$Q_{og} = Q_1 [\eta_1 / \eta_{og}]$$

Where:

Q_1 = Flow rate indicated by the flow meter

η_1 = Viscosity of the calibrated gas at the measured temp.

Q_{og} = Flow rate of the alternate gas

η_{og} = Viscosity of the alternate gas at the measured temp.

Say we have a meter set for air and we want to flow argon through it. With argon flowing through the meter, the display reads 110 SLPM. For ease of calculation, let us say the gas temperature is 25°C. What is the actual flow of argon?

Q_{og} = Actual Argon Flow Rate

Q_1 = Flow rate indicated by meter (110 SLPM)

η_1 = Viscosity of gas selected or calibrated for by the meter at the measured temp.

η_{og} = Viscosity of gas flowing through the meter at the measured temp.

At 25°C, the absolute viscosity of Air (η_1) is 184.332 micropoise.

At 25°C, the absolute viscosity of Argon (η_{og}) is 225.987 micropoise.

$$Q_{og} = Q1 (\eta\ 1 / \eta_{og})$$

$$Q_{og} = 110 \text{ SLPM } (184.332 / 225.987)$$

$$Q_{og} = 89.72 \text{ SLPM}$$

So, the actual flow of Argon through the meter is 89.72 SLPM. As you can see, because the Argon gas is more viscous than the Air the meter is set for, the meter indicates a higher flow than the actual flow.

A good rule of thumb is “at a given flow rate, the higher the viscosity, the higher the indicated flow”.

Volume Flow vs. Mass Flow: At room temperature and low pressures the volumetric and mass flow rate will be nearly identical, however, these rates can vary drastically with changes in temperature and/or pressure because the temperature and pressure of the gas directly affects the volume. For example, assume a volumetric flow reading was used to fill balloons with 250 mL of helium, but the incoming line ran near a furnace that cycled on and off, intermittently heating the incoming helium. Because the volumetric meter simply measures the volume of gas flow, all of the balloons would initially be the same size. However, if all the balloons are placed in a room and allowed to come to an equilibrium temperature, they would generally all come out to be different sizes. If, on the other hand, a mass flow reading were used to fill the balloons with 250 standard mL of helium, the resulting balloons would initially be different sizes, but when allowed to come to an equilibrium temperature, they would all turn out to be the same size.

This parameter is called corrected mass flow because the resulting reading has been compensated for temperature and pressure and can therefore be tied to the mass of the gas. Without knowing the temperature and pressure of the gas and thus the density, the mass of the gas cannot be determined.

Once the corrected mass flow rate at standard conditions has been determined and the density at standard conditions is known (see the gas density table on page 31), a true mass flow can be calculated as detailed in the following example:

Mass Flow Meter Reading = 250 SCCM (standard Cubic Centimeters/min)
Gas: Helium
Gas Density at 25C and 14.696 PSIA = .1636 grams/Liter
True Mass Flow = (Mass Flow Meter Reading) X (Gas Density)
True Mass Flow = (250 CC/min) X (1 Liter/ 1000 CC) X (1.8024 grams/Liter)
True Mass Flow = 0.451 grams/min of Helium

Volumetric and Mass Flow Conversion: In order to convert volume to mass, the density of the gas must be known. The relationship between volume and mass is as follows:

$$\text{Mass} = \text{Volume x Density}$$

The density of the gas changes with temperature and pressure and therefore the conversion of volumetric flow rate to mass flow rate requires knowledge of density change. Using ideal gas laws, the effect of temperature on density is:

$$\rho_a / \rho_s = T_s / T_a$$

Where:

ρ_a	=	density @ ambient condition
T_a	=	absolute temp @ ambient condition in °Kelvin
ρ_s	=	density @ standard (reference) condition
T_s	=	absolute temp @ standard (reference) condition in °Kelvin
ºK	=	ºC + 273.15 Note: ºK=ºKelvin

The change in density with pressure can also be described as:

$$\rho_a / \rho_s = \mathbf{P_a} / P_s$$

Where:	ρ_a	=	density @ ambient condition
	$\mathbf{P_a}$	=	ambient absolute pressure
	ρ_s	=	density @ standard (reference) condition
	P_s	=	Absolute pressure @ standard (reference) condition

Therefore, in order to determine mass flow rate, two correction factors must be applied to volumetric rate: temperature effect on density and pressure effect on density.

Although the correct units for mass are expressed in grams, kilograms, etc. it has become standard that mass flow rate is specified in SLPM (standard liters / minute), SCCM (standard cubic centimeters / minute) or SmL/M (standard milliliters / minute).

This means that mass flow rate is calculated by normalizing the volumetric flow rate to some standard temperature and pressure (STP). By knowing the density at that STP, one can determine the mass flow rate in grams per minute, kilograms per hour, etc.

STP is usually specified as the sea level conditions; however, no single standard exists for this convention. Examples of common reference conditions include:

0°C	and	14.696 PSIA
25°C	and	14.696 PSIA
0°C	and	760 torr (mmHG)
70°F	and	14.696 PSIA
68°F	and	29.92 inHG
20°C	and	760 torr (mmHG)

MC Series Flow Controllers reference 25ºC and14.696 PSIA (101.32kPa) - unless ordered otherwise. Refer to the calibration sheet to confirm the reference point.

Installation

Plumbing

All VC or MC Series Gas Flow Controllers are equipped with female inlet and outlet port connections. Because the flow meters set up a laminar flow condition within the flow body, no straight runs of pipe are required upstream or downstream of the meter. The inlet and outlet ports are equal in size and symmetric (in-line). Normally speaking, the port sizes and dimensions for differing flow ranges are as follows:

Flow Range	Height	Length	Depth	Port Size
.5 to 50 (S)CCM	3.867"	2.375"	1.05"	10-32 UNF
50+ (S)CCM to 20 (S)LPM	4.167"	2.375"	1.05"	⅛" NPT(F)
20+ to 100 (S)LPM	4.367"	4.0"	1.6"	¼" NPT(F)
100+ to 250 (S)LPM	5.500"	4.0"	1.6"	½" NPT(F)
250+ to 1000 (S)LPM	5.500"	4.0"	1.6"	¾" NPT(F)

Meters with 10-32 ports have o-ring face seals and require no further sealant or tape. Avoid the use of pipe dopes or sealants on the ports as these compounds can cause permanent damage to the meter should they get into the flow stream. Use of thread sealing Teflon tape is recommended to prevent leakage around the threads. When applying the tape, avoid wrapping the first thread or two to minimize the possibility of getting a piece of shredded tape into the flow stream. When changing fittings, always clean any tape out of the threads that may come loose and enter the flow stream. In addition, it is recommended that a 20 micron filter be installed upstream of meters with full scale ranges of 1 (S)LPM or less and a 50 micron filter be installed upstream of meters with full scale ranges above 1 (S)LPM.

Mounting

All VC or MC Series Gas Flow Controllers have mounting holes in their meters for convenient mounting to flat panels. Some valve/meter combinations may require spacer blocks to mount to flat surfaces. The sizes and dimensions for these holes are shown on pages 33 to 37 of this manual. Please note that there are many different possible controller configurations and that the diagram shows only the footprint and mounting holes in the meter flow body. Position sensitivity is not generally an issue with small valve controllers. Large valve controllers, however, are somewhat position sensitive because of the fairly massive stem assembly and it is generally recommended that they be mounted so that the valve cylinder is vertical and upright. The primary concern in mounting a large valve controller in a position other than the recommended position is the increased risk of leakage when the controller is given a zero set point and is being held closed by the spring force.

Application

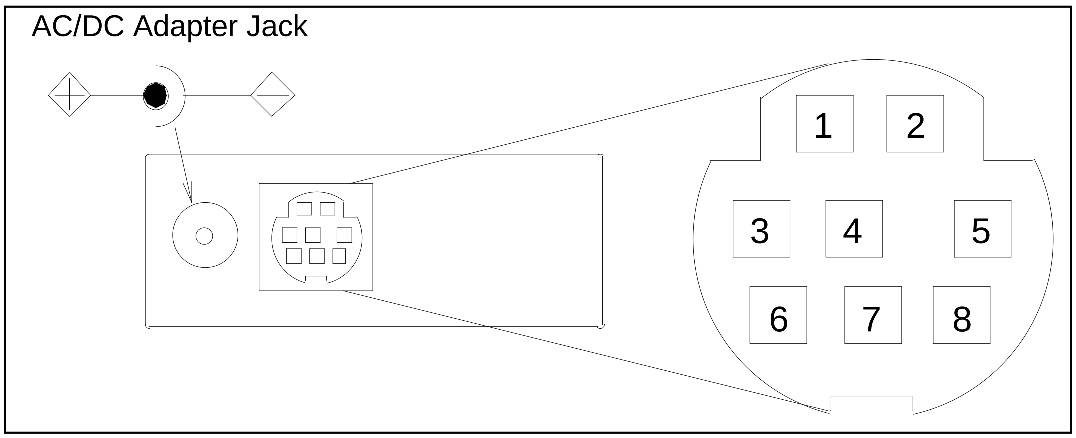
Maximum recommended operating line pressure is 125 PSIG (862 kPa). **Caution: Exceeding 150 PSI line pressure may cause permanent damage to the solid-state differential pressure transducer.** If the line pressure is higher than the 125 PSIG (862 kPa), a pressure regulator should be used upstream from the flow controller to reduce the pressure to 125 PSIG (862 kPa) or less if possible. Many of our controllers are built after extensive consultations with the customer regarding the specific application. The result is that two controllers with the same flow range and part number may look and act quite differently depending upon the application the controller was built for. Care should be taken in moving a controller from one application to another to test for suitability in the new application. *Note that volumetric meters and controllers are not recommended for high pressure or high backpressure applications.*

Power and Signal Connections

Power can be supplied to your VC or MC Series controller through either the power jack or the 8 pin Mini-DIN connector as shown in Figure 1. An AC to DC adapter which converts line AC power to DC voltage and current as specified below. The power jack accepts 2.1 mm female power plugs with positive centers. *Cables and AC/DC adaptors may be purchased from the manufacturer (see Accessories page 30)* and are commonly available at local electronics suppliers. Alternatively, power can be supplied through the Mini-DIN connector as shown below:

Small Valve: If your controller utilizes a small valve (about the size of your thumb), a 12-18 Vdc (standard 68ohm valve coil) or 19-28 Vdc (optional 136ohm valve coil) power supply with a 2.1 mm female positive center plug capable of supplying 300 mA is recommended. Note: 4-20mA output requires at least 15 Vdc.

Large Valve: If your controller utilizes a large valve (about the size of your fist), a 24-30 Vdc power supply with a 2.1 mm female positive center plug capable of supplying at least 750mA is required.



Pin	Function	Mini-DIN Cable Color Code
1	4-20mA Output Signal	Black
2	5.12 Vdc or Auxiliary Output	Brown
3	RS-232 Input Signal	Red
4	Analog Input Signal	Orange
5	RS-232 Output Signal	Yellow
6	0-5 Vdc (or 0-10 Vdc) Output Signal	Green
7	Power In (9-30 Vdc, 100mA)	Blue
8	Ground (common)	Purple

Figure 1. 8 Pin Mini-DIN Connector

Note: The above pin-out is applicable to all the flow meters and controllers available with the mini din connector. The availability of different output signals depends on the Flow Controller options ordered. **CAUTION: Do not connect power to pins 1 through 6 as permanent damage can occur!**

Signal Connections:

Analog Input Signal

Apply analog input to Pin 4 as shown in Figure 1.

Standard 0-5 Vdc: Unless ordered otherwise, 0-5 Vdc is the standard analog input signal. Apply the 0-5 Vdc input signal to pin 4, with common ground on pin 8. The 5.12 Vdc output on pin 2 can be wired through a 50K ohm potentiometer and back to the analog input on pin 4 to create an adjustable 0-5 Vdc input signal source as shown below.

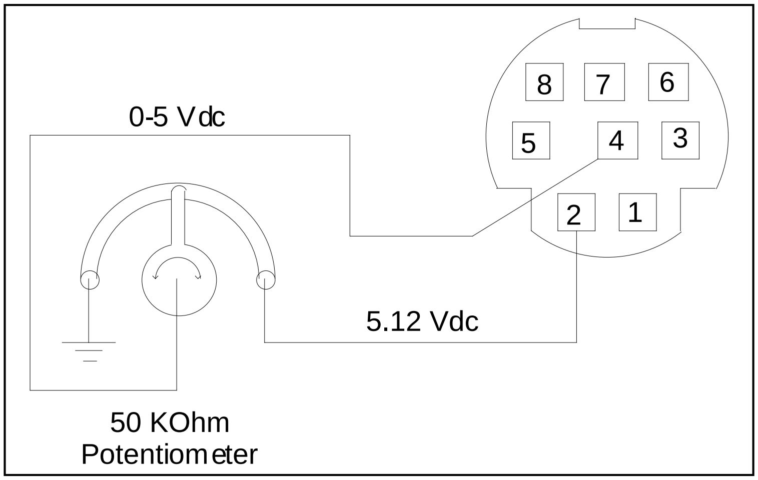


Figure 2. Simple method for providing set point to controllers

Optional 0-10 Vdc: If specified at time of order, a 0-10 Vdc input signal can be applied to pin 4, with common ground on pin 8.

Optional 4-20 mA: If specified at time of order, a 4-20 mA input signal can be applied to pin 4, with common ground on pin 8. Note: 4-20mA output requires at least 15 Vdc.

RS-232 Digital Input Signal

If you will be using the RS-232 output signal, it is necessary to connect the RS-232 Output Signal (Pin 5), the RS-232 Input Signal (Pin 3), and Ground (Pin 8) to your computer serial port as shown in Figure 3. Adapter cables are available from the manufacturer or they can be constructed in the field with parts from a local electronic supply house. In Figure 3, note that the diagrams represent the “port” side of the connections, i.e. the connector on top of the meter and the physical DB-9 serial port on the back of the computer. The cable ends will be mirror images of the diagram shown in Figure 3. (See page 21 for details on accessing RS-232 output and input.)

Analog Output Signals:

****Note**** Upon initial review of the pin out diagram in Figure 1, **it is common to mistake Pin 2 (labeled 5.12 Vdc Output) as the standard 0-5 Vdc analog output signal!** In fact Pin 2 is normally a constant 5.12 Vdc that reflects the system bus voltage and can be used as a source for the input signal. This allows the user in the field to run this output through a 50K ohm potentiometer and back into the analog set point pin to create a 0-5 Vdc set point source.

Standard Voltage (0-5 Vdc) Output Signal

All VC and MC Series Flow Controllers have a 0-5 Vdc (optional 0-10 Vdc) output signal available on Pin 6. This is generally available in addition to other optionally ordered outputs. This voltage is usually in the range of 0.010 Vdc for zero flow and 5.0 Vdc for full-scale flow. The output voltage is linear over the entire range. Ground for this signal is common on Pin 8.

Optional 0-10 Vdc Output Signal

If your meter was ordered with a 0-10 Vdc output signal, it will be available on Pin 6. (See the Calibration Data Sheet that shipped with your meter to determine which output signals were ordered.) This voltage is usually in the range of 0.010 Vdc for zero flow and 10.0 Vdc for full-scale flow. The output voltage is linear over the entire range. Ground for this signal is common on Pin 8.

Optional Current (4-20 mA) Output Signal

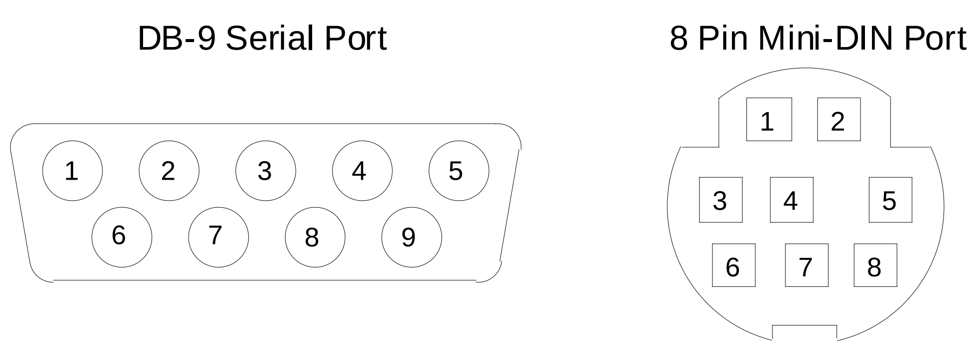
If your meter was ordered with a 4-20 mA current output signal, it will be available on Pin 1. (See the Calibration Data Sheet that shipped with your meter to determine which output signals were ordered.) The current signal is 4 mA at 0 flow and 20 mA at the meter's full scale flow. The output current is linear over the entire range. Ground for this signal is common on Pin 8. This output always tracks the same variable as the standard output. **Note**: 4-20mA output requires at least 15 Vdc. **Note**: *This is a current sourcing device. Do not attempt to connect it to "loop powered " systems.*

Optional 2nd Analog Output Signal

You may specify an optional 2nd analog output on Pin 2 at time of order. (See the Calibration Data Sheet that shipped with your meter to determine which output signals were ordered.) This output may be a 0-5 Vdc, 0-10 Vdc, or 4-20 mA analog signal that can represent any measured parameter. With this optional output, a volumetric flow controller could output the volumetric flow rate with a 0-5 Vdc signal (on pin 6) and a 4-20 mA signal (on pin 2), or a mass flow controller could output the mass flow rate (0-5 Vdc on pin 6) and the absolute pressure (0-5 Vdc on pin 2). This ability makes these devices exceedingly versatile. **Note**: *This is a current sourcing device. Do not attempt to connect it to "loop powered" systems.*

RS-232 Digital Output Signal

If you will be using the RS-232 output signal, it is necessary to connect the RS-232 Output Signal (Pin 5), the RS-232 Input Signal (Pin 3), and Ground (Pin 8) to your computer serial port as shown in Figure 3. *Cables and AC/DC adaptors may be purchased from the manufacturer (see Accessories page 30)* and are commonly available at local electronics suppliers. In Figure 3, note that the diagrams represent the "port" side of the connections, i.e. the connector on top of the controller and the physical DB-9 serial port on the back of the computer. The cable ends will be mirror images of the diagram shown in Figure 3.



5----------Ground-------------------------------------Ground----------8
3----------Transmit----------------------------------Receive---------3
2----------Receive------------------------------------Transmit--------5

Figure 3. Mini-DIN to DB-9 Connection for RS-232 Signals

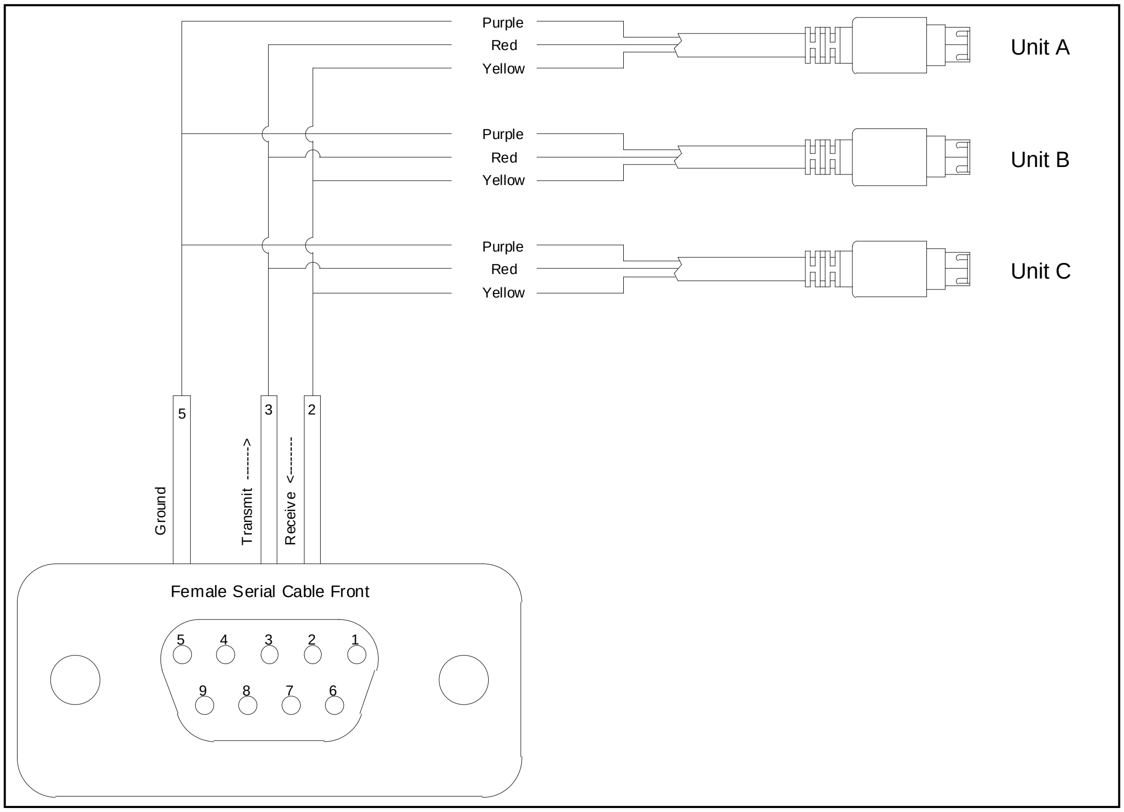


Figure 4. Typical Multiple Device (Addressable) Wiring Configuration

An optional industrial connector is also available:

Pin	Function	Cable Color Code
1	Power In	Red
2	RS-232 Output	Blue
3	RS-232 Input Signal	White
4	Analog Input Signal	Green
5	Ground	Black
6	Signal Out (Voltage or Current as ordered)	Brown

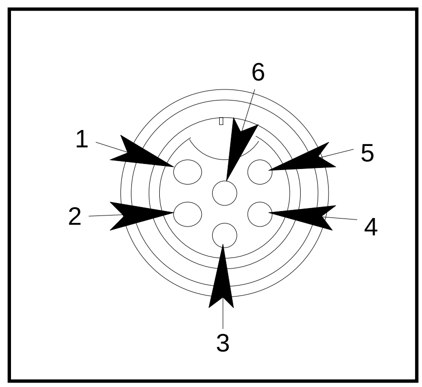


Figure 5. Optional Industrial Connector

Note: The above pin-out is applicable to all flow meters and controllers ordered with the industrial connector. The availability of different output signals depends on the options ordered.

VC Series Volumetric Flow Controller Operation

The VC Series Volumetric Flow Controller is a simple, rugged device. The membrane switch user interface and dynamically labeled graphic display combine to provide exceedingly flexible and user-friendly operation. The VC Series has several screen “modes”. All VC Series Controllers with a display have a default Main Mode, a Control Setup Mode, a Gas Select Mode, and an Identity Mode. Each mode is described below. The device defaults to Main Mode as soon as power is applied to the controller.

Main Mode

The main mode screen shows the volumetric flow in the units specified at time of order. In the main mode, only two buttons are active as shown in Figure 5. The process gas that is selected is shown directly under the flow units.

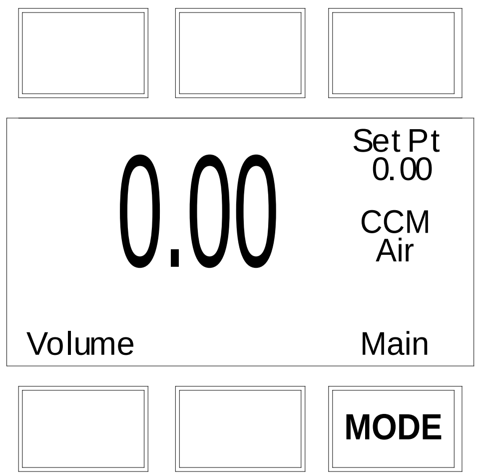


Figure 6. Main Mode Display, VC Series Flow Controller

MODE - The “MODE” button in the lower right hand corner toggles the display between modes.

Volume – The volume flow rate is defaulted on the primary display. If the set point has been toggled to the primary screen as described below, the volume flow rate can be toggled back to the primary display by pushing the button (lower left corner) directly beneath the dynamic label “Volume”.

Set Pt – The set point is shown in the upper right corner of the display. The set point cannot be adjusted from the main mode screen. For information on changing the set point, see the Control Set Up Mode below.

Control Setup Mode

The Control Setup Mode is accessed by pressing the button labeled “MODE” until the dynamic label over the button reads “Control Setup” as shown in Figure 6 below. This mode allows the user to set up most parameters commonly associated with PID control. VC Series flow controllers allow the user to select how the set point is to be conveyed to the controller, what that set point is if control is local, and what the Proportional and Differential terms of the PID control loop will be. The UP and DOWN buttons for adjusting variables can be held down for higher speed adjustment or pressed repeatedly for fine adjustment.

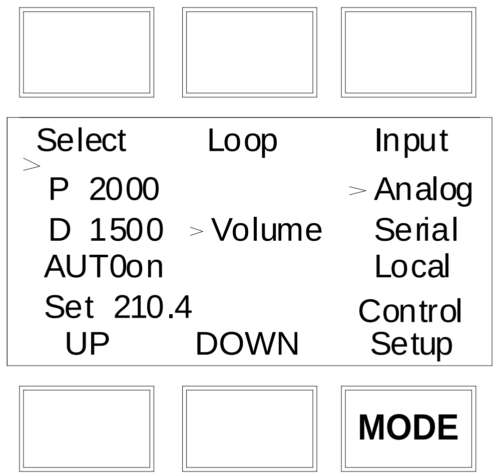


Figure 7. VC Series Control Setup Mode Screen

Input – VC Series Flow Controllers normally ship defaulted to analog control as indicated in Figure 7 above. To change how the set point will be conveyed to the controller push the button in the upper right hand corner just above the dynamic label “Input” until the arrow is directly in front of the desired option. The controller will ignore any set point except that of the selected input and it will remember which input is selected even if the power is disconnected.

Analog refers to a remote analog set point applied to Pin 4 of the Mini-DIN connector as described in the installation section of this manual. To determine what type of analog set point your controller was ordered with, refer to the Calibration Data Sheet that was included with your controller. 0-5 Vdc is standard unless ordered otherwise. Note that if nothing is connected to Pin 4, and the controller is set for analog control, the set point will float. **CAUTION!** ***Never leave a Controller with any non-zero set point if no pressure is available to make flow. The controller will apply full power to the valve in an attempt to reach the set point. When there is no flow, this can make the valve very HOT!***

Serial refers to a remote digital RS-232 set point applied via a serial connection to a computer or PLC as described in the Installation and RS-232 sections of this manual. **CAUTION!** ***NEVER LEAVE A CONTROLLER WITH ANY NON-ZERO SET POINT IF NO PRESSURE IS AVAILABLE TO MAKE FLOW. THE CONTROLLER WILL APPLY FULL POWER TO THE VALVE IN AN ATTEMPT TO REACH THE SET POINT. WHEN THERE IS NO FLOW, THIS CAN MAKE THE VALVE VERY HOT!***

Local refers to a set point applied directly at the controller. For more information on changing the set point locally refer to the heading "Select" below. Local input must be selected prior to attempting to change the set point locally. **CAUTION!** ***NEVER LEAVE A CONTROLLER WITH ANY NON-ZERO SET POINT IF NO PRESSURE IS AVAILABLE TO MAKE FLOW. THE CONTROLLER WILL APPLY FULL POWER TO THE VALVE IN AN ATTEMPT TO REACH THE SET POINT. WHEN THERE IS NO FLOW, THIS CAN MAKE THE VALVE VERY HOT!***

Select – To avoid accidental changing of the PID loop parameters or the set point, the Control Setup mode defaults with the selector on a null position. To change the set point or the P and D PID loop parameters, push the button in the upper left corner just above the dynamic label "Select" until the selection arrow is pointing to the parameter you wish to change. When the parameter you wish to change is selected, it may be adjusted up or down with the buttons under the display below the dynamic labels "UP" and "DOWN". Press the buttons repeatedly to make slow adjustments or hold them down to make fast adjustments.

P refers to the Proportional term of the PID loop. Before changing this parameter, it is good practice to write down the initial value so that it can be returned to the factory settings if necessary.

D refers to the Differential term of the PID loop. Before changing this parameter, it is good practice to write down the initial value so that it can be returned to the factory settings if necessary.

AUT0on / AUT0off refers to the standard auto-tare or "auto-zero" feature. It is recommended that the controller be left in the default auto-tare ON mode unless your specific application requires that it be turned off. The auto-tare feature automatically tares (takes the detected signal as zero) the unit when it receives a zero set point for more than two seconds. A zero set point results in the closing of the valve and a known "no flow" condition. This feature helps to make the device more accurate by periodically removing any cumulative errors associated with drift.

Set refers to the Set Point. This parameter may only be changed if "Local" is selected as the Input. See above for information on selecting the input. Using the UP and DOWN buttons, the set point may be adjusted between zero and the full-scale range of the controller. **CAUTION!** ***NEVER LEAVE A CONTROLLER WITH ANY NON-ZERO SET POINT IF NO PRESSURE IS AVAILABLE TO MAKE FLOW. THE CONTROLLER WILL APPLY FULL POWER TO THE VALVE IN AN ATTEMPT TO REACH THE SET POINT. WHEN THERE IS NO FLOW, THIS CAN MAKE THE VALVE VERY HOT!***

Gas Select Mode

The gas select mode is accessed by pressing the button labeled “MODE” until the dynamic label over the button reads “Gas” as shown in Figure 8 below. The selected gas is displayed on the default main mode screen as shown in Figure 5, and is indicated by the arrow in the gas select mode screen in Figure 8. To change the selected gas, use the buttons under the dynamic labels “UP” and “DOWN” to position the arrow in front of the desired gas. When the mode is cycled back to the main mode, the selected gas will be displayed on the main screen. In order to get an accurate volumetric flow rate, the gas being measured must be selected. This is important because the device calculates the flow rate based on the viscosity of the gas at the measured temperature. If the gas being measured is not what is selected, an incorrect value for the viscosity of the gas will be used in the calculation of flow, and the resulting output will be inaccurate in direct proportion to the difference in the two gases viscosities. (See page 2 Understanding Volumetric and Mass Flow.)

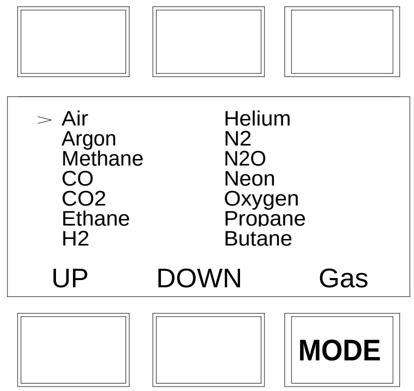


Figure 8. Gas Select Mode

The selected gas is displayed on the default main mode screen as shown in Figure 5, and is indicated by the arrow in the gas select mode screen in Figure 8. To change the selected gas, use the buttons under the dynamic labels “UP” and “DOWN” to position the arrow in front of the desired gas. When the mode is cycled back to the main mode, the selected gas will be displayed on the main screen.

Identity Mode

The Identity Mode is accessed by pressing the “MODE” button until the dynamic label over the “MODE” button reads “I.D.” as shown in Figure 9. The identity mode displays important information about your Flow Controller including the model number, serial number, and date of manufacture.

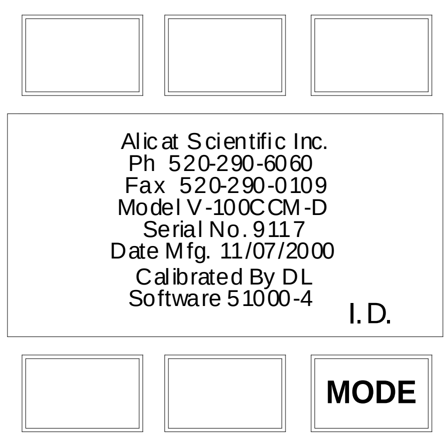


Figure 9. Identity Mode

Volumetric Flow Meters Under Pressure

V and VC Series Volumetric Flow Meters and Controllers are intended for use in low pressure applications. This is because an accurate measurement of the volumetric flow rate by means of differential pressure requires the flow at the differential pressure sensor to be in a laminar state. The state of the flow is quantified by what is known as the Reynolds Number. If the Reynolds Number gets above a certain point, generally accepted as approximately 2000, the flow will become non-laminar. The Reynolds Number for a given Newtonian fluid flow is defined as:

$$Re = \rho VL/\mu$$

Where:
- ρ = density
- V = average velocity
- L = Constant determined by length and geometry of passage
- μ = viscosity

From this relationship we see that increasing the gas density or velocity increases the Reynolds Number, and increasing the gas viscosity decreases the Reynolds number. For a given gas in a given meter at a given temperature, L and μ are roughly fixed constants.

For the purpose of illustration, let us put two 100 (S)LPM flow meters, identical in every way except that one is a volumetric flow meter and one is a mass flow meter, in series with one another in a pipeline. Now let us pass a small constant air flow through the meters, thus fixing the velocity V though both meters. With the flow fixed, let us begin increasing the pressure, and thus the density ρ. The mass flow meter, which is measuring the absolute pressure and compensating for the density change registers this pressure increase as an increase in mass flow rate because the number of molecules of gas keeps going up in the fixed volume of flow. In addition, the Reynolds number has increased proportionately with the pressure increase because the density goes up with the pressure. If you increase the pressure high enough, the mass flow meter will max out at 100 SLPM, the Reynolds number has increased fairly dramatically, and the volumetric meter still registers your small fixed flow rate.

Now if we maintain the higher pressure and try to take the volumetric meter up to its published full scale flow of 100 LPM, our density ρ AND our velocity V will be high, which often results in a high Reynolds number and non-laminar flow. When the flow is non-laminar, the Poiseuille Equation upon which we base our volumetric flow measurement is no longer valid and the meter reading is therefore no longer valid.

Gas properties also need to be taken into account in deciding whether you can use a volumetric flow meter at a particular line pressure. Helium, which has a relatively low density and a relatively high viscosity at standard conditions, can generally get away with higher pressures in a volumetric flow meter. Propane, on the other hand, has a relatively high density and relatively low viscosity making it a considerably more difficult gas to measure at higher pressures in a volumetric flow meter. In air, most volumetric meters make valid full scale measurements up to 10-15 PSIG line pressure.

MC Series Mass Flow Controller Operation

The MC Series Mass Flow Controller is designed to provide a multitude of useful flow data in one simple, rugged device. The membrane switch user interface and dynamically labeled graphic display combine to provide exceedingly flexible and user-friendly operation. The MC Series has several screen “modes”. It is designed to provide maximum versatility in a compact, user-friendly mass flow controller.

Main Mode

The main mode screen defaults on power up with the mass flow on the primary display. The following parameters are displayed in the main mode as shown in Figure 10.

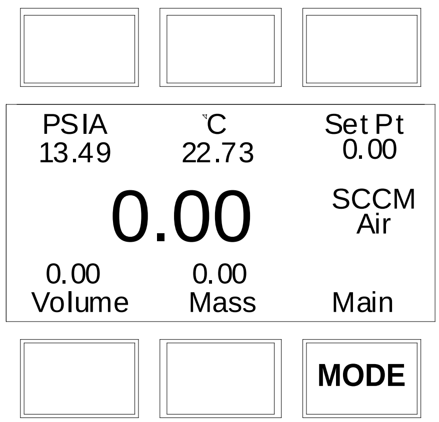


Figure 10. Main Mode Display, MC Series Flow Controller

MODE - The “MODE” button in the lower right hand corner toggles the display between modes.

Set Pt – The set point is shown in the upper right corner of the display. The set point cannot be adjusted from the main mode screen. For information on changing the set point, see the Control Set Up Mode below.

Gas Absolute Pressure: The MC Series Flow Controllers utilize an absolute pressure sensor to measure the line pressure of the gas flow being monitored. This sensor references hard vacuum and accurately reads line pressure both above and below local atmospheric pressure. This parameter is located in the upper left corner of the display under the dynamic label “PSIA”. This parameter can be moved to the primary display by pushing the button just above the dynamic label (top left). The engineering unit associated with absolute pressure is pounds per square inch absolute (PSIA). This can be converted to gage pressure (psig = the reading obtained by a pressure gauge that reads zero at atmospheric pressure) by simply subtracting local atmospheric pressure from the absolute pressure reading:

PSIG = PSIA – (Local Atmospheric Pressure)

The flow controllers use the absolute pressure of the gas in the calculation of the mass flow rate. For working in metric units, note that 1 PSI = 6.89 kPa.

Gas Temperature: The MC Series Flow Controllers also utilize a temperature sensor to measure the line temperature of the gas flow being monitored. The temperature is displayed in engineering units of degrees Celsius (°C). The flow controllers use the temperature of the gas in the calculation of the mass flow rate. This parameter is located in the upper middle portion of the display under the dynamic label "°C". This parameter can be moved to the primary display by pushing the button above the dynamic label (top center).

Volumetric Flow Rate: The volumetric flow rate is determined using the Flow Measurement Operating Principle described elsewhere in this manual. This parameter is located in the lower left corner of the display over the dynamic label "Volume". This parameter can be moved to the primary display by pushing the button below the dynamic label (lower left). In order to get an accurate volumetric flow rate, the gas being measured must be selected (see *Gas Select Mode* page 15). This is important because the device calculates the flow rate based on the viscosity of the gas at the measured temperature. If the gas being measured is not what is selected, an incorrect value for the viscosity of the gas will be used in the calculation of flow, and the resulting output will be inaccurate in direct proportion to the difference in the two gases viscosities.

Mass Flow Rate: The mass flow rate is the volumetric flow rate corrected to a standard temperature and pressure (14.696 psia and 25°C). This parameter is located in the lower middle portion of the display over the dynamic label "Mass". This parameter can be moved to the primary display by pushing the button located below the dynamic label (bottom center). The meter uses the measured temperature and the measured absolute pressure to calculate what the flow rate would be if the gas pressure was at 1 atmosphere and the gas temperature was 25°C. This allows a solid reference point for comparing one flow to another.

Control Setup Mode

The Control Setup Mode is accessed by pressing the button labeled "MODE" until the dynamic label over the button reads "Control Setup" as shown in Figure 10 below. This mode allows the user to set up most parameters commonly associated with PID control. Alicat Scientific flow controllers allow the user to select how the set point is to be conveyed to the controller, what that set point is if control is local, and what the Proportional and Differential terms of the PID control loop will be. The UP and DOWN buttons for adjusting variables can be held down for higher speed adjustment or pressed repeatedly for fine adjustment.

Input – Alicat Scientific Flow Controllers normally ship defaulted to analog control as indicated in Figure 11. To change how the set point will be conveyed to the controller push the button in the upper right hand corner just above the dynamic label "Input" until the arrow is directly in front of the desired option. The controller will ignore any set point except that of the selected input and it will remember which input is selected even if the power is disconnected.

Analog refers to a remote analog set point applied to Pin 4 of the Mini-DIN connector as described in the installation section of this manual. To determine what type of analog set point your controller was ordered with, refer to the Calibration Data Sheet that was included with your controller. 0-5 Vdc is standard unless ordered otherwise. Note that if nothing is connected to Pin 4, and the controller is set for analog control, the set point will float. **CAUTION!** ***NEVER LEAVE A CONTROLLER WITH ANY NON-ZERO SET POINT IF NO PRESSURE IS AVAILABLE TO MAKE FLOW. THE CONTROLLER WILL APPLY FULL POWER TO THE VALVE IN AN ATTEMPT TO REACH THE SET POINT. WHEN THERE IS NO FLOW, THIS CAN MAKE THE VALVE VERY HOT!***

Serial refers to a remote digital RS-232 set point applied via a serial connection to a computer or PLC as described in the Installation and RS-232 sections of this manual. **CAUTION!** ***NEVER LEAVE A CONTROLLER WITH ANY NON-ZERO SET POINT IF NO PRESSURE IS AVAILABLE TO MAKE FLOW. THE CONTROLLER WILL APPLY FULL POWER TO THE VALVE IN AN ATTEMPT TO REACH THE SET POINT. WHEN THERE IS NO FLOW, THIS CAN MAKE THE VALVE VERY HOT!***

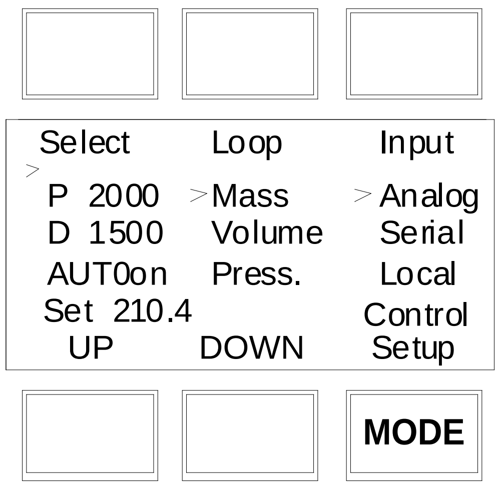


Figure 11. MC Series Control Setup Mode Screen

<u>Loop</u>—The selection of what variable to close the loop on is a feature unique to these mass flow controllers. When the mass flow controller is supplied with the control valve upstream of the electronics portion of the system, the unit can be set to control on outlet pressure (absolute pressures only) or volumetric flow rate, in stead of mass flow rate. Repeatedly pressing the button adjacent to the word “Loop” on the control setup screen will change what variable is controlled. The change from mass to volume can usually be accomplished without much, if any, change in the P and D settings. When you change from controlling flow to controlling pressure, sometimes fairly radical changes must be made to these variables. Consult the factory if you are having difficulties with this procedure.

<u>Select</u> – To avoid accidental changing of the PID loop parameters or the set point, the Control Setup mode defaults with the selector on a null position. To change the set point or the P and D PID loop parameters, push the button in the upper left corner just above the dynamic label “Select” until the selection arrow is pointing to the parameter you wish to change. When the parameter you wish to change is selected, it may be adjusted up or down with the buttons under the display below the dynamic labels “UP” and “DOWN”. Press the buttons repeatedly to make slow adjustments or hold them down to make fast adjustments.

P refers to the Proportional term of the PID loop. Before changing this parameter, it is good practice to write down the initial value so that it can be returned to the factory settings if necessary.

D refers to the Differential term of the PID loop. Before changing this parameter, it is good practice to write down the initial value so that it can be returned to the factory settings if necessary.

AUT0on / AUT0off refers to the standard auto-tare or “auto-zero” feature. It is recommended that the controller be left in the default auto-tare ON mode unless your specific application requires that it be turned off. The auto-tare feature automatically tares (takes the detected signal as zero) the unit when it receives a zero set point for more than two seconds. A zero set point results in the closing of the valve and a known “no flow” condition. This feature helps to make the device more accurate by periodically removing any cumulative errors associated with drift.

Set refers to the Set Point. This parameter may only be changed if “Local” is selected as the Input. See above for information on selecting the input. Using the UP and DOWN buttons, the set point may be adjusted between zero and the full-scale range of the controller. **CAUTION!** ***NEVER LEAVE A CONTROLLER WITH ANY NON-ZERO SET POINT IF NO PRESSURE IS AVAILABLE TO MAKE FLOW. THE CONTROLLER WILL APPLY FULL POWER TO THE VALVE IN AN ATTEMPT TO REACH THE SET POINT. WHEN THERE IS NO FLOW, THIS CAN MAKE THE VALVE VERY HOT!***

Gas Select Mode

The gas select mode is accessed by pressing the button labeled “MODE” until the dynamic label over the button reads “Gas” as shown in Figure 8. The selected gas is displayed on the default main mode screen as shown in Figure 10, and is indicated by the arrow in the gas select mode screen in Figure 8. To change the selected gas, use the buttons under the dynamic labels “UP” and “DOWN” to position the arrow in front of the desired gas. When the mode is cycled back to the main mode, the selected gas will be displayed on the main screen. In order to get an accurate volumetric flow rate, the gas being measured must be selected. This is important because the device calculates the flow rate based on the viscosity of the gas at the measured temperature. If the gas being measured is not what is selected, an incorrect value for the viscosity of the gas will be used in the calculation of flow, and the resulting output will be inaccurate in direct proportion to the difference in the two gases viscosities. (See the Volumetric and Mass Gas Flow Information section for more information.)

Identity Mode

The Identity Mode is accessed by pressing the “MODE” button until the dynamic label over the “MODE” button reads “I.D.” as shown in Figure 9. The identity mode displays important information about your Flow Controller including the model number, serial number, and date of manufacture.

RS-232 Input and Output

Configuring HyperTerminal®:

1. Open your HyperTerminal® RS-232 terminal program (installed under the "Accessories" menu on all Microsoft Windows operating systems).
2. Select "Properties" from the file menu.
3. Click on the "Configure" button under the "Connect To" tab. Be sure the program is set for: 19,200 baud and an 8-N-1-None (8 Data Bits, No Parity, 1 Stop Bit, and no Flow Control) protocol.
4. Under the "Settings" tab, make sure the Terminal Emulation is set to ANSI.
5. Click on the "ASCII Setup" button and be sure the "Send Line Ends with Line Feeds" box is not checked and the "Echo Typed Characters Locally" box and the "Append Line Feeds to Incoming Lines" boxes are checked. Those settings not mentioned here are normally okay in the default position.
6. Save the settings, close Hyperterminal® and reopen it.

In Polling Mode, the screen should be blank except the blinking cursor. In order to get the data streaming to the screen, hit the "Enter" key several times to clear any extraneous information. Type "*@=@" followed by "Enter". If data still does not appear, check all the connections and com port assignments.

Changing From Streaming to Polling Mode: When the meter is in the Streaming Mode, the screen is updated approximately 10-60 times per second (depending on the amount of data on each line) so that the user sees the data essentially in real time. It is sometimes desirable, and necessary when using more than one unit on a single RS-232 line, to be able to poll the unit.

In Polling Mode the unit measures the flow normally, but only sends a line of data when it is "polled". Each unit can be given its own unique identifier or address. Unless otherwise specified each unit is shipped with a default address of capital A. Other valid addresses are B thru Z.

Once you have established communication with the unit and have a stream of information filling your screen:

1. Type *@=A followed by "Enter" to stop the streaming mode of information. Note that the flow of information will not stop while you are typing and you will not be able to read what you have typed. Also, the unit does not accept a backspace or delete in the line so it must be typed correctly. If in doubt, simply hit enter and start again. If the unit does not get exactly what it is expecting, it will ignore it. If the line has been typed correctly, the data will stop.
2. You may now poll the unit by typing A followed by "Enter". This does an instantaneous poll of unit A and returns the values once. You may type A "Enter" as many times as you like. Alternately you could resume streaming mode by typing *@=@ followed by "Enter". Repeat step 1 to remove the unit from the streaming mode.
3. To assign the unit a new address, type *@=New Address, e.g. *@=B **Care should be taken not to assign an address to a unit if more than one unit is on the RS232 line as all of the addresses will be reassigned.** Instead, each should be individually attached to the RS-232 line, given an address, and taken off. After each unit has been given a unique address, they can all be put back on the same line and polled individually.

Sending a Set Point via RS-232: To send a set point via RS-232, “Serial” must be selected under the “Input” list in the control set up mode. To give controllers a set point, or change an existing point, simply type in a number between 0 and 65535 (2% over range), where 64000 denotes full-scale flow rate, and hit “Enter”. The set point column and flow rates should change accordingly. If they do not, try hitting “Enter” a couple of times and repeating your command. The formula for performing a linear interpolation is as follows:

Value = (Desired Set Point X 64000) / Full Scale Flow Range

For example, if your device is a 100 SLPM full-scale unit and you wish to apply a set point of 35 SLPM you would enter the following value:

22400 = (35 SLPM X 64000) / 100 SLPM

If the controller is in polling mode as described in *Changing from Streaming Mode to Polling Mode*, the set point must be preceded by the address of the controller. For example, if your controller has been given an address of D, the set point above would be sent by typing:

D22400 followed by “Enter”

To adjust the Proportional and Differential (P&D) terms via RS-232:

Type *@=A followed by “Enter” to stop the streaming mode of information.

To adjust the “P” or proportional term of the PID controller, type *R21 followed by “Enter”.

The computer will respond by reading the current value for register 21 between 0-65535. It is good practice to write this value down so you can return to the factory settings if necessary. Enter the value you wish to try by writing the new value to register 21. For example, if you wished to try a “P” term of 220, you would type *W21=**220** followed by “Enter” where the bold number denotes the new value.

The computer will respond to the new value by confirming that 21=220. To see the effect of the change you may now poll the unit by typing A followed by “Enter”. This does an instantaneous poll and returns the values once. You may type A “Enter” as many times as you like. Alternately you could resume streaming mode by typing *@=@ followed by “Enter”. Repeat step 3 to remove the unit from the streaming mode.

To adjust the “D” or proportional term of the PID controller, type *R22 followed by “Enter”.

The computer will respond by reading the current value for register 22 between 0-65535. It is good practice to write this value down so you can return to the factory settings if necessary. Enter the value you wish to try by writing the new value to register 22. For example, if you wished to try a “D” term of 25, you would type *W22=**25** followed by “Enter” where the bold number denotes the new value.

The computer will respond to the new value by confirming that 22=25. To see the effect of the change you may now poll the unit by typing A followed by “Enter”. This does an instantaneous poll and returns the values once. You may type A “Enter” as many times as you like. Alternately you could resume streaming mode by typing *@=@ followed by “Enter”. Repeat.

You may test your settings for a step change by changing the set point. To do this type A32000 (A is the default single unit address, if you have multiple addressed units on your RS-232 line the letter preceding the value would change accordingly.) followed by “Enter” to give the unit a ½ full scale setpoint. Monitor the unit's response to the step change to ensure it is satisfactory for your needs. Recall that the "P" term controls how quickly the unit goes from one setpoint to the next, and the "D" term controls how quickly the signal begins to "decelerate" as it approaches the new set point (controls the overshoot).

Selecting a Gas: The selected gas can be changed via RS-232 input. To change the selected gas, enter the following commands:

In Streaming Mode: $$#<Enter>
In Polling Mode: Address$$#<Enter> (e.g. A$$#<Enter>)

Where # is the number of the gas selected from the table below. Note that this also corresponds to the gas select menu on the flow controller screen:

Number (#)	Gas
0	Air
1	Argon
2	Methane
3	Carbon Monoxide
4	Carbon Dioxide
5	Ethane
6	Hydrogen
7	Helium
8	Nitrogen
9	Nitrous Oxide
10	Neon
11	Oxygen
12	Propane
13	Butane

For example, to select Propane enter: $$12<Enter>

Collecting Data: The RS-232 output updates to the screen many times per second. Very short-term events can be captured simply by disconnecting (there are two telephone symbol icons at the top of the HyperTerminal® screen for disconnecting and connecting) immediately after the event in question. The scroll bar can be driven up to the event and all of the data associated with the event can be selected, copied, and pasted into Microsoft® Excel® or other spreadsheet program as described below.

For longer term data, it is useful to capture the data in a text file. With the desired data streaming to the screen, select "Capture Text" from the Transfer Menu. Type in the path and file name you wish to use. Push the start button. When the data collection period is complete, simply select "Capture Text" from the Transfer Menu and select "Stop" from the sub-menu that appears.

Data that is selected and copied, either directly from HyperTerminal® or from a text file can be pasted directly into Excel®. When the data is pasted it will all be in the selected column. Select "Text to Columns…" under the Data menu in Excel® and a Text to Columns Wizard (dialog box) will appear. Make sure that "Fixed Width" is selected under Original Data Type in the first dialog box and click "Next". In the second dialog box, set the column widths as desired, but the default is usually acceptable. Click on “Next” again. In the third dialog box, make sure the column data format is set to “General”, and click “Finish”. This separates the data into columns for manipulation and removes symbols such as the plus signs from the numbers. Once the data is in this format, it can be graphed or manipulated as desired.

For long term data capture see “Sending a Simple Script to Hyperterminal” on page 18 or consider purchasing our FlowVision Software.

Data Format: The data stream on the screen represents the flow parameters of the main mode in the units shown on the display. For volumetric flow controllers, there are three columns of data representing volumetric flow rate in the units specified at time of order, set point and the selected gas.

```
+4.123 4.125 Air
+4.123 4.125 Air
+4.123 4.125 Air
+4.123 4.125 Air
+4.124 4.125 Air
+4.125 4.125 Air
```

VC Series Volumetric Flow Controller Data Format

For mass flow controllers, there are 6 columns of data representing pressure, temperature, volumetric flow, mass flow and the selected gas. The first column is absolute pressure (normally in PSIA), the second column is temperature (normally in °C), the third column is volumetric flow rate (in the units specified at time of order and shown on the display), and the fourth column is mass flow (also in the units specified at time of order and shown on the display). For instance, if the meter was ordered in units of SCFM, the display on the meter would read 2.004 SCFM and the last two columns of the output below would represent volumetric flow and mass flow in CFM and SCFM respectively.

```
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
```

MC Series Mass Flow Controller Data Format

Sending a Simple Script File to HyperTerminal®

It is sometimes desirable to capture data from a device for an extended period of time. Standard streaming mode information is useful for short term events, however, when capturing data for an extended period of time, the amount of data and thus the file size can become too large very quickly. Without any special programming skills, the user can use HyperTerminal® and a text editing program such as Microsoft Word® to capture text at user defined intervals.

1. Open your text editing program, MS Word for example.
2. Set the cap lock on so that you are typing in capital letters.
3. Beginning at the top of the page, type A<Enter> repeatedly. If you're using MS Word, you can tell how many lines you have by the line count at the bottom of the screen. The number of lines will correspond to the total number of times the flow device will be polled, and thus the total number of lines of data it will produce.

For example: A
A
A
A
A
A

will get a total of six lines of data from the flow meter, but you can enter as many as you like.
The time between each line will be set in HyperTerminal.

4. When you have as many lines as you wish, go to the File menu and select save. In the save dialog box, enter a path and file name as desired and in the "Save as Type" box, select the plain text (.txt) option. It is important that it be saved as a generic text file for HyperTerminal to work with it.
5. Click Save.
6. A file conversion box will appear. In the "End Lines With" drop down box, select CR Only. Everything else can be left as default.
7. Click O.K.
8. You have now created a "script" file to send to HyperTerminal. Close the file and exit the text editing program.
9. Open HyperTerminal and establish communication with your flow device as outlined in the manual.
10. Set the flow device to Polling Mode as described in the manual. Each time you type A<Enter>, the meter should return one line of data to the screen.
11. Go to the File menu in HyperTerminal and select "Properties".
12. Select the "Settings" tab.
13. Click on the "ASCII Setup" button.
14. The "Line Delay" box is defaulted to 0 milliseconds. This is where you'll tell the program how often to read a line from the script file you've created. 1000 milliseconds is one second, so if you want a line of data every 30 seconds, you'd enter 30000 into the box. If you want a line every 5 minutes, you'd enter 300000 into the box.
15. When you've entered the value you want, click on OK and OK in the Properties dialog box.
16. Go the Transfer menu and select "Send **Text** File…" (NOT Send File…).
17. Browse and select the text "script" file you created.
18. Click Open.
19. The program will begin "executing" your script file, reading one line at a time with the line delay you specified and the flow device will respond by sending one line of data for each poll it receives, when it receives it.

You can also capture the data to another file as described in the manual under "Collecting Data". You will be simultaneously sending it a script file and capturing the output to a separate file for analysis.

TROUBLESHOOTING

Display does not come on or is weak.
Check power and ground connections.

Flow reading is approximately fixed either near zero or near full scale regardless of actual line flow.
Differential pressure sensor may be damaged. Avoid installations that can subject sensor to pressure drops in excess of 10 PSID. A common cause of this problem is instantaneous application of high-pressure gas as from a snap acting solenoid valve upstream of the meter. **Damage due to excessive pressure differential is not covered by warranty.**

After installation, there is no flow.
Alicat Scientific VC and MC controllers incorporate normally closed valves and require a set point to operate. Check that your set point signal is present and supplied to the correct pin and that the correct input is selected under the Input list in the control set up mode screen. Also check that the unit is properly grounded.

The flow lags below the set point.
Be sure there is enough pressure available to make the desired flow rate. If either the set point signal line and/or the output signal line is relatively long, it may be necessary to provide heavier wires (especially ground wiring) to negate voltage drops due to line wire length. An inappropriate PID tuning can also cause this symptom if the D term is too large relative to the P term.

Meter does not agree with another meter I have in line.
Volumetric meters will often not agree with one another when put in series because they are affected by pressure drops. Volumetric Flow Controllers should not be compared to Mass Flow Controllers. Mass Flow Controllers can be compared against one another provided there are no leaks between the two meters and they are set to the same standard temperature and pressure. Both meters must also be calibrated (or set) for the gas being measured. MC Series Mass Flow Controllers are normally set to Standard Temperature and Pressure conditions of 25° C and 14.696 PSIA. *Note:* it is possible to special order meters with a customer specified set of standard conditions. The calibration sheet provided with each meter lists its standard conditions.

Controller is slow to react to a set point change or imparts an oscillation to the flow.
An inappropriate PID tuning can cause these symptoms. Use at conditions considerably different than those at which the device was originally set up can necessitate a re-tuning of the PID loop.

Flow flutters or is jumpy.
The meters are very fast and will pick up any actual flow fluctuations such as from a diaphragm pump, etc. Consult factory for adjusting the screen averaging rate. Also, inspect the inside of the upstream connection for debris such a Teflon tape shreds. *Note:* MC & VC Series meters feature a programmable geometric running average (GRA) that can aid in allowing a rapidly fluctuating flow to be read.

(Troubleshooting continued)

The output signal is lower than the reading at the display.
This can occur if the output signal is measured some distance from the meter as voltage drops in the wires increase with distance. Using heavier gauge wires, especially in the ground wire, can reduce this effect.

My volumetric meter reading is strange, inconsistent, or incorrect.
Make sure you use a Volumetric Flow Controller only under low pressure (close to atmospheric) and with little to no back pressure for accurate readings. Mass meters should be used for higher pressure applications. Please see page 16.

RS-232 Serial Communications is not responding.
Check that your meter is powered and connected properly. Be sure that the port on the computer to which the meter is connected is active. Confirm that the port settings are correct per the RS-232 instructions in this manual. Reboot the computer if necessary.

Slower response than specified.
VC and MC Series meters feature an RS-232 programmable Geometric Running Average (GRA). Depending on the full scale range of the meter, it may have the GRA set to enhance the stability/readability of the display, which would result in slower perceived response time. If you require the fastest possible response time, please consult the factory for written instructions on adjusting the GRA.

Jumps to zero at low flow.
VC and MC Series meters feature an RS-232 programmable zero deadband. The factory setting is usually 0.5% of full scale. This can be adjusted via RS-232 programming between NONE and 6.375% of full scale. Contact the factory for more information.

Maintenance and Recalibration

General: VC and MC Series Flow Controllers require minimal maintenance. They have no moving parts. The single most important thing that affects the life and accuracy of these devices is the quality of the gas being measured. The meter is designed to measure CLEAN, DRY, NON-CORROSIVE gases. A 20 micron filter (50 micron for 50 LPM and up) mounted upstream of the meter is highly recommended. Moisture, oil, and other contaminants can affect the laminar flow elements and/or reduce the area that is used to calculate the flow rate. This directly affects the accuracy.

Recalibration: The recommended period for recalibration is once every year. Providing that the CLEAN, DRY, and NON-CORROSIVE mantra is observed, this periodic recalibration is quite sufficient. A label located on the back of the meter lists the recalibration due date. The meter should be returned to the factory for recalibration near the listed due date. Before calling to schedule a recalibration, please note the serial number on the back of the meter. The Serial Number, Model Number, and Date of Manufacture are also available on the Identity Mode screen.

Cleaning: V and M Series Flow Controllers require no periodic cleaning. If necessary, the outside of the meter can be cleaned with a soft dry rag. Avoid excess moisture or solvents.

For repairs, re-calibrations, or recycling of this product, contact:

Alicat Scientific, Inc.
2045 N Forbes Blvd. Suite 103
Tucson, Arizona 85745
USA
Ph. 520-290-6060
Fax 520-290 0109
email: info@alicatscientific.com

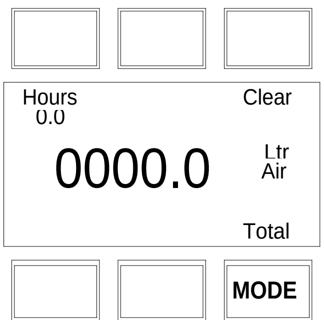
Warranty

This product is warranted to the original purchaser for a period of one year from the date of purchase to be free of defects in material or workmanship. Under this warranty the product will be repaired or replaced at manufacturer’s option, without charge for parts or labor when the product is carried or shipped prepaid to the factory together with proof of purchase. This warranty does not apply to cosmetic items, nor to products that are damaged, defaced or otherwise misused or subjected to abnormal use. See “Application” under the Installation section. Where consistent with state law, the manufacturer shall not be liable for consequential economic, property, or personal injury damages. The manufacturer does not warrant or assume responsibility for the use of its products in life support applications or systems.

Options

Totalizing Mode Screen: VC and MC Series Flow Meters and Controllers can be purchased from the factory with the Totalizing Mode option. This option adds an additional mode screen that displays the total flow (normally in the units of the main flow screen) that has passed through the meter or controller since the last time the totalizer was cleared. The Totalizing Mode screen shown below is accessed by pushing the "MODE" button until the dynamic label over it reads "Total".

Counter – The counter can have as many as six digits. At the time of order, the customer must specify the resolution of the count. This directly affects the maximum count. For instance, if a resolution of 1/100ths of a liter is specified on a meter which is totalizing in liters, the maximum count would be 9999.99 liters. If the same unit were specified with a 1 liter resolution, the maximum count would be 999999.



Hours.--. The display will show elapsed time since the last reset in 0.1 hour increments. The maximum measurable elapsed time is 6553.5 hours (about nine months). The hours count resets when the "clear" button is pushed, an RS-232 clear is executed or on loss of power

Rollover – The customer can also specify at the time of order what the totalizer is to do when the maximum count is reached. The following options may be specified:

1. No Rollover – When the counter reaches the maximum count it stops counting until the counter is cleared.
2. Rollover – When the counter reaches the maximum count it automatically rolls over to zero and continues counting until the counter is cleared.
3. Rollover with Notification – When the counter reaches the maximum count it automatically rolls over to zero, displays an overflow error, and continues counting until the counter is cleared.

Clear – The counter can be reset to zero at any time by pushing the dynamically labeled "Clear" button located above the upper right side of the display. To clear the counter via RS-232, establish serial communication with the meter or controller as described in the RS-232 section of the manual. To reset the counter, enter the following commands:

In Streaming Mode: $$T <Enter>

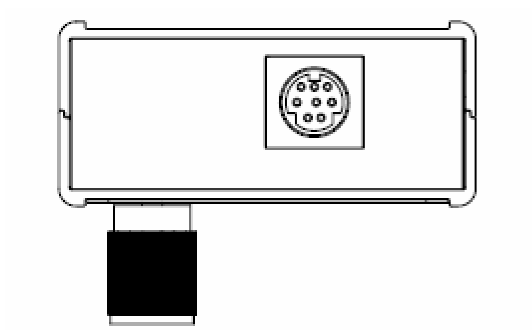
In Polling (addressable) Mode: Address$$T <Enter> (e.g. B$$T <Enter>)

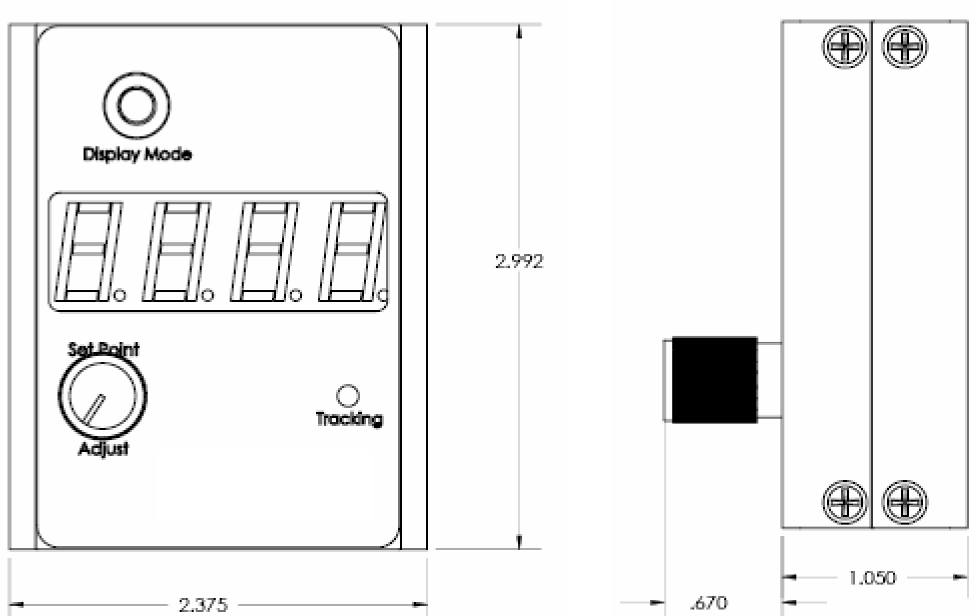
Local Set Point Module

The optional Local Set Point Module (**LSPM**) is designed to provide the user with a simple “turn of the dial” method of changing the controller set point. The LSPM features a set point control dial, a digital LED display which can be set to show either the set point or the actual process measurement, and a tracking alarm LED which glows red whenever the actual process measurement deviates from the set point by more than 2% of full scale. This device is handy as a remote control/display device where the controller is out of convenient reach or view. It is supplied with a 6’ double ended cable to run between the controller and the LSPM. There is an additional 8 pin Mini-DIN port on the LSPM that allows access to normal signal/power functions of the controller’s Mini-DIN port.

- 8 Pin Mini-DIN connector connects to controller or to external device for power or output signal recording
- LCD Display can display either the set point or the process measurement.
- Set Point Adjustment Knob provides simple "dial it in" process changes.
- Display button switches display between actual set point and measured flow parameter.
- LED indicator switches from green to red when the measured parameter deviates from the set point by more than 2% of full scale.

Operation Notes: The LSPM requires a double ended DC-62 8 Pin Mini-DIN cable connected between either the top or bottom connector socket of the LSPM to the connector socket on top of the controller. The two connector sockets on the LSPM are "pass through" connected so that the unused socket can be connected to a DC-61 single ended cable for connection of output signals and/or power. Appropriate power can be connected to either the LSPM or the controller, whichever is more convenient. Unless specially ordered otherwise, the LSPM utilizes the 5.12 Vdc output pin on the controller (pin 2) as a source. The 5.12 volts is connected through the potentiometer and returned to the controller on the set point pin (pin 4) as a 0 though 5.12 Vdc input signal depending on the position of the adjustment knob.





Additional Information

Accessories:

Part Number	Description
LSPM	Local Set Point Module
RDD	Remote Digital Display
DC-61	8 Pin Male Mini-DIN connector cable, single ended, 6 foot length
DC-62	8 Pin Male Mini-DIN connector cable, double ended, 6 foot length
DC-251	8 Pin Male Mini-DIN connector cable, single ended, 25 foot length
DC-6RT	8 Pin Male Right Angle Mini-Din Cable, single ended, 6 foot length
MD8DB9	8 Pin Male Mini-DIN to DB9 Female Adaptor 6 foot length
PVPS	AC to DC 12 Volt Power Supply Adapter
PVPS24	AC to DC 24 Volt Power Supply Adapter
PVPSE	AC to DC 12 Volt European Power SupplyAdapter
PVPSE24	AC to DC 24 Volt European Power Supply Adapter
IC-10	Industrial cable, 6 Pin, single ended, 10 foot length
FVISION	FlowVision software for Interface with all Alicat instruments

Gas Viscosity Table:

Absolute viscosities of common gases at 25°C in micro poise
(1 Poise = gram / (cm)(sec))

Butane	75.68
Propane	81.340
Hydrogen	89.230
Ethane	92.462
Methane	111.296
Nitrous Oxide	147.880
Carbon Dioxide	148.711
Carbon Monoxide	177.761
Nitrogen	177.820
Air	184.332
Helium	197.616
Oxygen	205.353
Argon	225.987
Neon	314.743

Flow Conversion Table:

	CCM	CCH	LPM	LPH	CFM	CFH
CFH	0.0021	0.00003	2.1189	0.035	60.0	1.0
CFM	0.000035	0.0000005	0.035	0.00059	1.0	0.0166
LPH	0.06	0.001	60.0	1.0	1699.0	28.316
LPM	0.001	0.000017	1.0	0.0166	28.316	0.4719
CCH	60.0	1.0	60000.0	1000.0	1699011.0	28317.0
CCM	1.0	0.0167	1000.0	16.667	28317.0	471.947

Gas Density Table:

Gas	Molecular Weight Grams/Mole	Density Grams/Liter at 0°C, 14.696 PSIA	Density Grams/Liter at 25°C, 14.696PSIA
Butane	58.124	2.5932	2.3758
Propane	44.097	1.9674	1.8024
H2	2.016	0.0899	0.0824
Ethane	30.070	1.3416	1.2291
Acetylene	26.038	1.1617	1.0643
Methane	16.043	0.7158	0.6557
Nitrous Oxide	44.013	1.9637	1.7990
CO2	44.011	1.9636	1.7989
CO	28.010	1.2497	1.1449
N2	28.013	1.2498	1.1450
Air	28.964	1.2922	1.1839
He	4.003	0.1786	0.1636
O2	31.999	1.4276	1.3079
Ar	39.948	1.7823	1.6328
Neon	20.183	0.9005	0.8250

Performance Specifications for VC and MC Series Mass and Volumetric Flow Controllers

SPECIFICATION	MASS MC Series	VOLUMETRIC VC Series	ENGINEERING UNITS
Accuracy [1]	+/-1% (0.5%opt)	+/-1% (0.5%opt)	Full Scale
Repeatability	+/-0.5%	+/-0.5%	Full Scale
Excess Measurable Flow Rate	28%	28%	Full Scale
Response Time [2]	100	100	Milliseconds
Operating Temperature	-10 to +50	-10 to +50	°C
Zero Shift	0.02%	0.02%	Full Scale / °C / ATM
Span Shift	0.02%	0.02%	Full Scale / °C / ATM
Humidity Range	0-100%	0-100%	Non-Condensing
Common Mode Pressure (max)	125	125 [3]	PSIG
Supply Current: small valve large valve	250 750	250 750	Milliamp
Supply Voltage: small valve large valve	12—18 [4] 24—30	12—18 [4] 24 –30	Volts DC
Electrical Connections:Standard	8 pin	8 pin	Circ. Mini DIN/Multi Pin
Electrical Connections: Optional	6 pin	6 pin	Industrial
Mechanical Connections	10-32 for .5 to 50 (S)CCM	10-32 for .5 to 50 (S)CCM	UNF
	1/8” for 50+ (S)CCM to 20 (S)LPM	1/8” for 50+ (S)CCM to 20 (S)LPM	NPT (female)
	1/4” for 20+ to 100 (S)LPM	1/4” for 20+ to 100 (S)LPM	
	1/2" for 100+ to 250 (S)LPM	1/2" for 100+ to 250 (S)LPM	
	3/4" for 250+ to 1500 (S)LPM	3/4" for 250+ to 1500 (S)LPM	

1. The 0.5% Option is not available on 0.5 (S)CCM or 100+ (S)LPM flow ranges

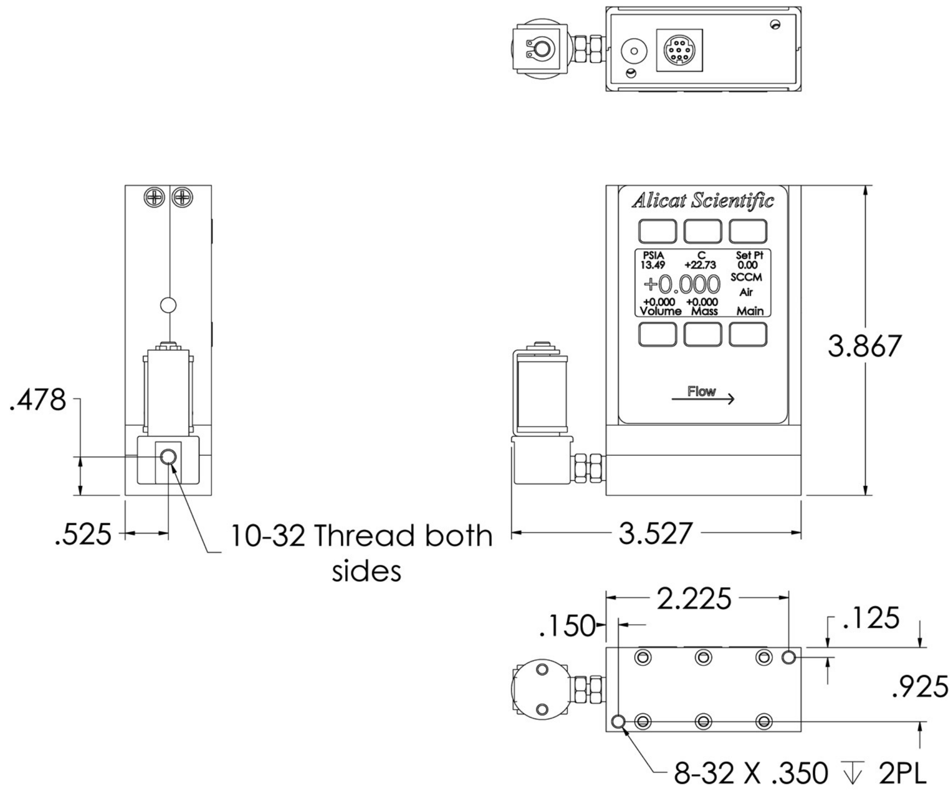
2. 100 ms represents a typical default response time for 63.2% of a step change.

3. Volumetric controllers are intended for operation near atmospheric pressure conditions. They can withstand 125 PSIG common mode pressures without damage, but they will not operate properly at this pressure. 15 PSIG is the recommended max operating pressure for any gas, although the physical properties of some gases will allow accurate control at higher pressures. See page 15 of the manual for details.

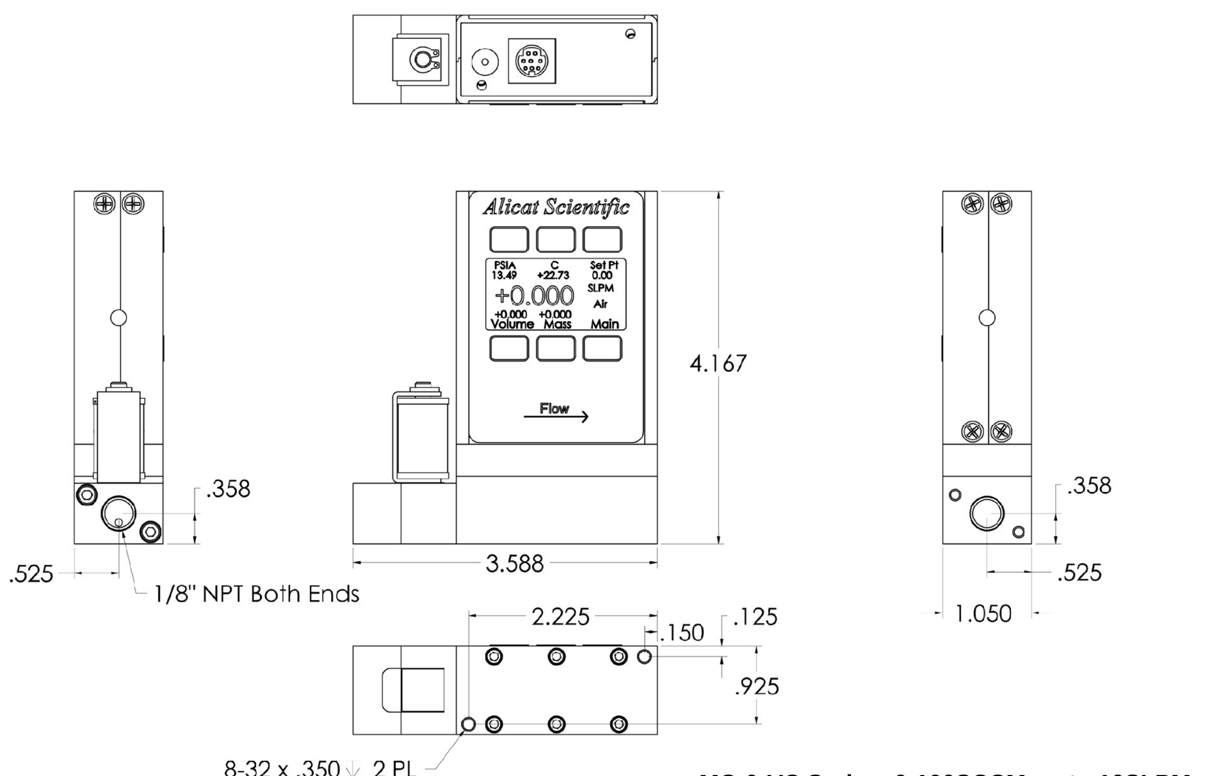
4. 19-28 Vdc may be used but require a 136ohm valve coil. 15 Vdc minimum required for 4-20mA output.

Conformity / Supplemental Information:

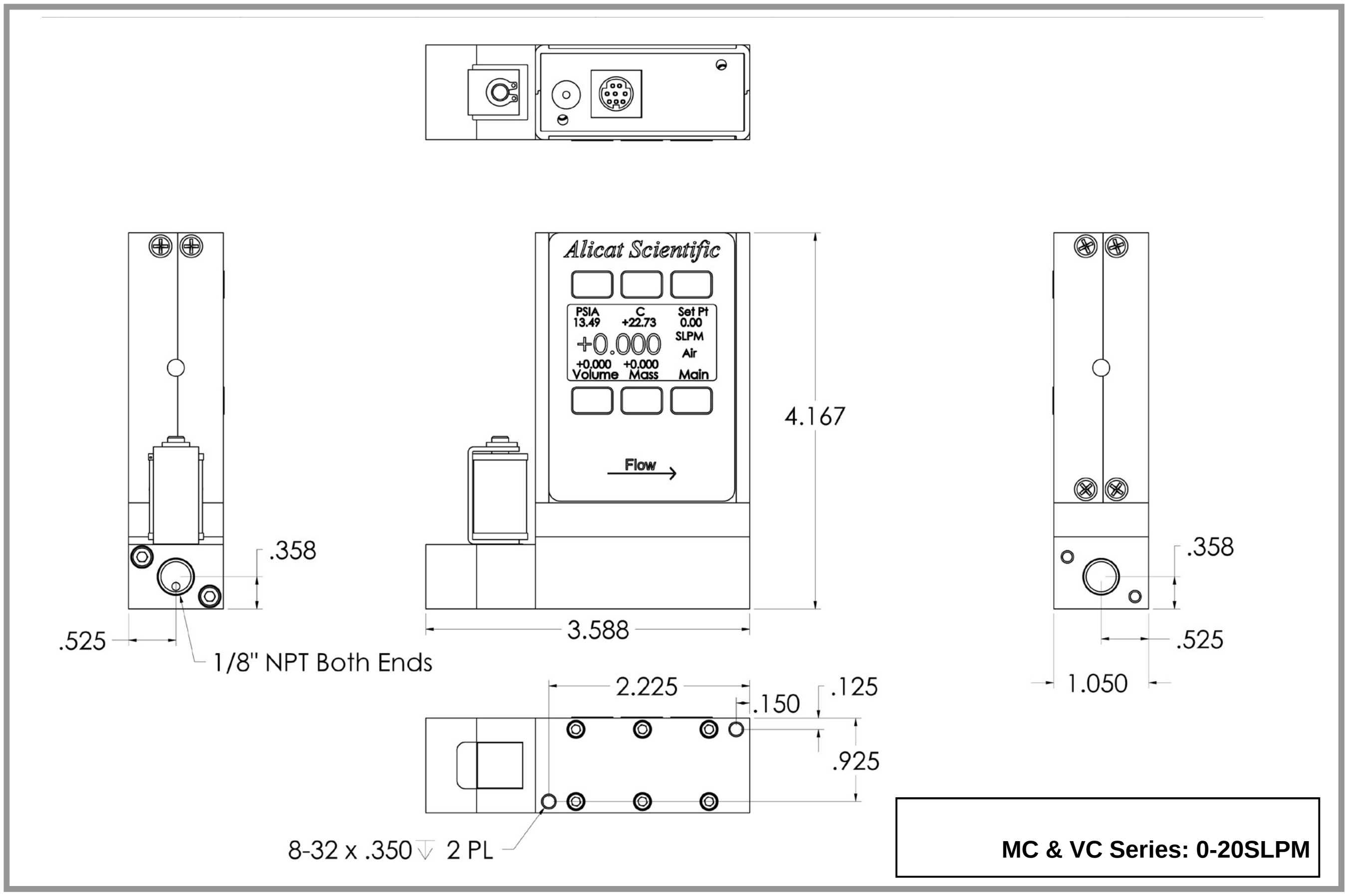
The product complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly. Contact the manufacturer for more information.

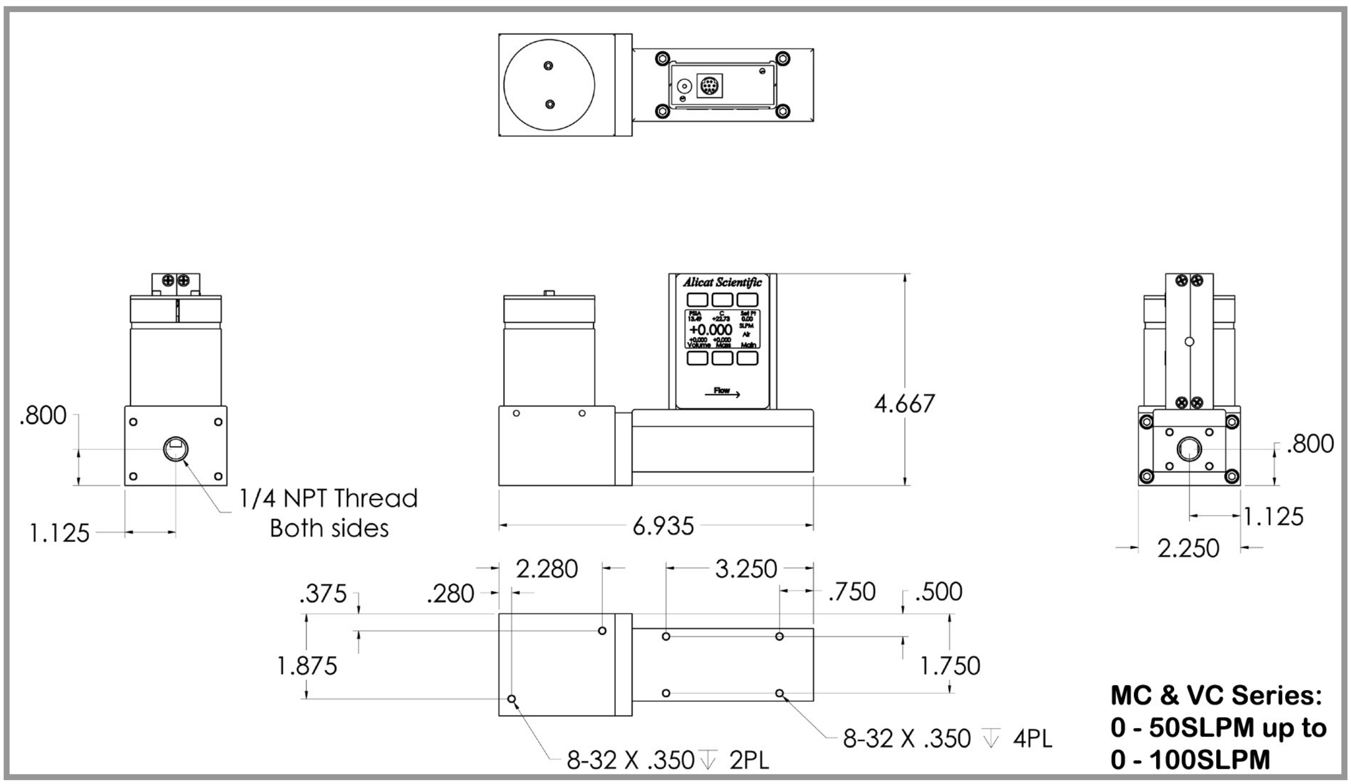


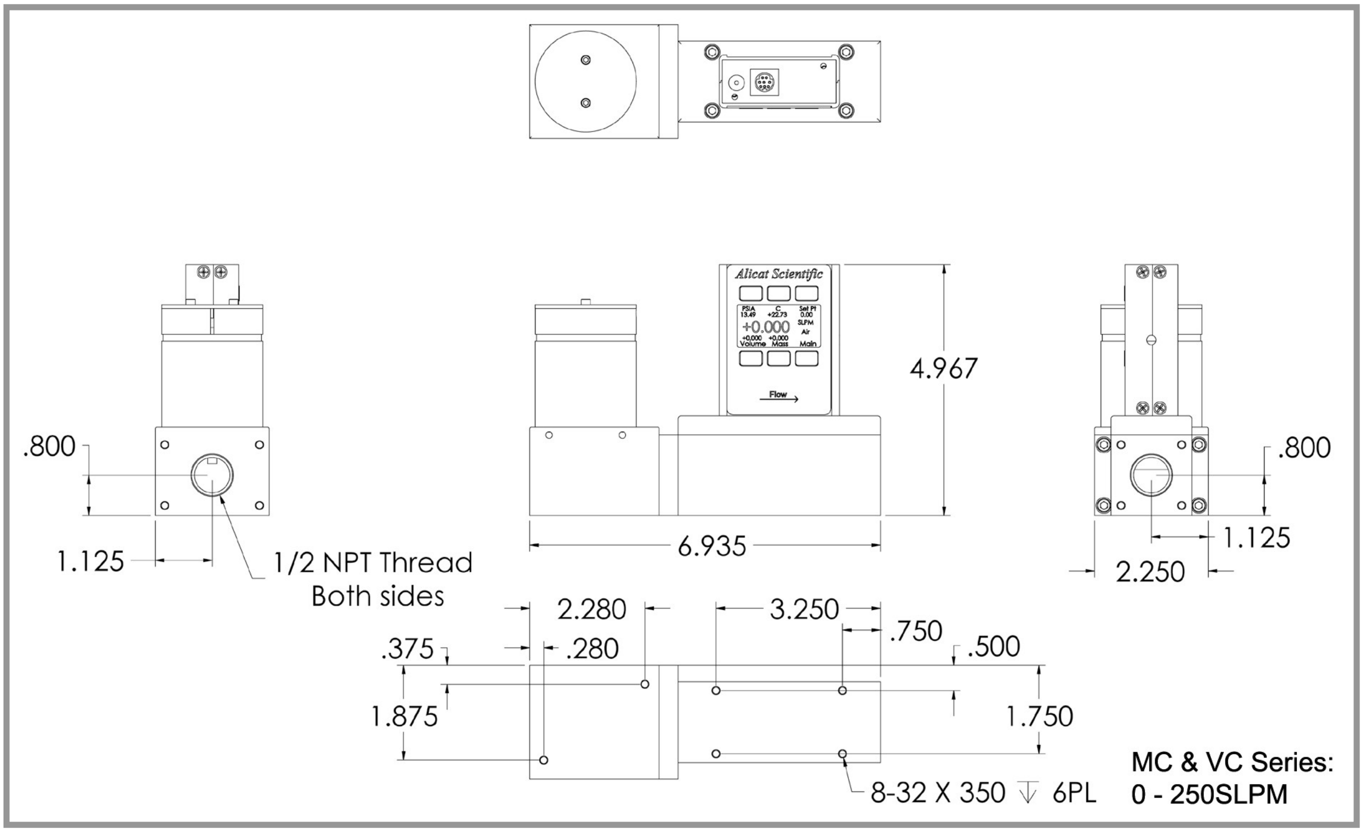
MC & VC Series:
0-0.5SCCM up to 0-50SCCM



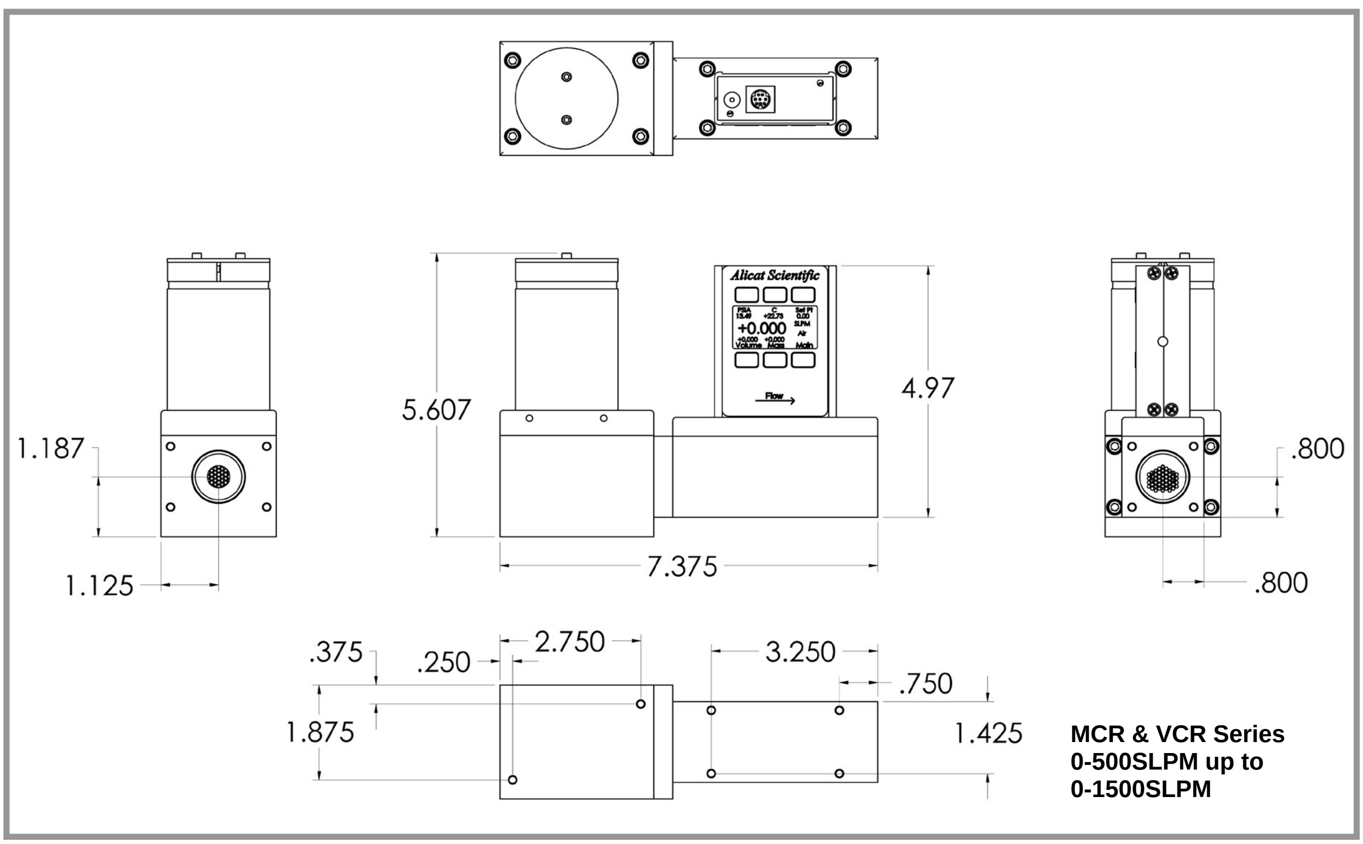
MC & VC Series: 0-100SCCM up to 10SLPM


Alicat Scientific
PSIA 13.49
C +22.73
Set Pt 0.00
+0.000
SLPM
Air
+0.000 Volume
+0.000 Mass
Main
Flow
4.167
.358
.525
1/8" NPT Both Ends
3.588
2.225
.150
.125
.925
1.050
8-32 x .350 2 PL
MC & VC Series: 0-20SLPM


Alicat Scientific
+0.000
Flow
4.667
.800
1/4 NPT Thread
Both sides
1.125
6.935
2.250
2.280
3.250
.375
.280
.750
.500
1.875
1.750
8-32 X .350 4PL
8-32 X .350 2PL
MC & VC Series:
0 - 50SLPM up to
0 - 100SLPM



Alicat Scientific
4.967
.800
1.125
1/2 NPT Thread
Both sides
6.935
.800
1.125
2.250
2.280
3.250
.750
.375
.280
.500
1.875
1.750
8-32 X 350 ↓ 6PL
MC & VC Series:
0 - 250SLPM



Alicat Scientific
5.607
4.97
1.187
1.125
7.375
.800
.800
.375
.250
2.750
3.250
.750
1.875
1.425
MCR & VCR Series
0-500SLPM up to
0-1500SLPM