BASIS Mass Flow Controller Operating Bulletin

Thank you for purchasing an Alicat BASIS Mass Flow Controller.
Please take the time to read the information contained in this bulletin. This will help to ensure that you get the best possible service from your device
Please contact Alicat at 1-888-290-6060 or info@alicat.com if you have any questions regarding the use or operation of this device.

MOUNTING
BASIS (BC-Series) Mass Flow Controllers have holes on the bottom for mounting to flat panels. The thread size is M3.
No straight runs of pipe are required upstream or downstream of the controller.

PLUMBING
Make sure that the gas will flow in the direction indicated by the flow arrow.
The inlet and outlet port sizes (process connections) are 7/16 - 20 SAE thread, J1926 port.
These fittings have an o-ring and do not require the use of Teflon tape.
Do not use pipe dopes or sealants on the process connections as these compounds can cause permanent damage to the controller should they get into the flow stream.
When changing fittings, carefully clean any debris from the ports.

PRESSURE
Maximum operating line pressure is 145 psig (1 MPa).
If the line pressure is higher than 145 psig (1 MPa), use a pressure regulator upstream of the flow controller to reduce the pressure to 145 psig (1 MPa) or less.

POWER AND SIGNAL CONNECTIONS
Power must be supplied to your controller through the 9-pin D-Sub connector.
BC-Series controllers require a 10-30 Vdc power supply capable of supplying 200 mA.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Alicat DB9 cable color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not Connected</td>
<td>Black</td>
</tr>
<tr>
<td>2</td>
<td>Not Connected</td>
<td>Brown</td>
</tr>
<tr>
<td>3</td>
<td>Serial RS-232 RX or RS-485B (-) Signal</td>
<td>Red</td>
</tr>
<tr>
<td>4</td>
<td>0-5 Vdc Analog Setpoint Input</td>
<td>White</td>
</tr>
<tr>
<td>5</td>
<td>Serial RS232 TX or RS-485A (+) Signal</td>
<td>Yellow</td>
</tr>
<tr>
<td>6</td>
<td>0-5 Vdc Analog Output Signal</td>
<td>Green</td>
</tr>
<tr>
<td>7</td>
<td>Power In (as described above)</td>
<td>Blue</td>
</tr>
<tr>
<td>8</td>
<td>Ground (common for power, communications, and analog signals)</td>
<td>Orange</td>
</tr>
<tr>
<td>9</td>
<td>Ground (common for power, communications, and analog signals)</td>
<td>Orange</td>
</tr>
</tbody>
</table>

Do not connect power to pins 3 through 6 as permanent damage can occur!
INPUT SIGNALS

Standard Voltage (0-5 Vdc) Input Signal
The standard analog input signal is 0-5 Vdc. Apply the 0-5 Vdc input signal to pin 4, with common ground on pin 8.

RS-232 Digital Input Signal
To use the RS-232 signals, connect the RS-232 RX Signal (Pin 3) to your computer serial port TX pin, and Ground (Pin 8 or 9) to your computer serial port.

RS-485 Digital Input Signal
To use the RS-485 signals, connect the RS-485A (+) Signal (Pin 5), the RS-485B (-) Signal (Pin 3), and Ground (Pin 8 or 9) to your computer serial port.

OUTPUT SIGNALS

Standard Voltage (0-5 Vdc) Output Signal
The standard analog output signal is 0-5 Vdc, available on Pin 6. 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.

RS-232 Digital Output Signal
To use the RS-232 signals, connect the RS-232 TX Signal (Pin 5) to your computer serial port RX pin, and Ground (Pin 8 or 9) to your computer serial port.

RS-485 Digital Output Signals
To use the RS-485 signals, connect the RS-485A (+) Signal (Pin 5), the RS-485B (-) Signal (Pin 3), and Ground (Pin 8 or 9) to your computer serial port.

Serial Communication

Do not connect this device to “loop powered” systems, as this will destroy portions of the circuitry. If you must interface with existing loop powered systems, always use a signal isolator and a separate power supply.

Configuring HyperTerminal®:
1. Open HyperTerminal® RS-485 terminal program (installed under the “Accessories” menu on all Microsoft Windows® operating systems prior to Windows Vista®).
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: 38,400 baud (or matches the baud rate of the device; 38,400 is default) 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 or Auto Detect.
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. Other settings not mentioned here are normally okay in the default position.
6. Save the settings, close HyperTerminal® and reopen it.

Unit ID:
The device is addressed with a single character unit ID from A thru Z, with A being the default. All serial commands must be preceded by the device ID. Command examples below will use A as the example device ID. All commands must be followed by a <Carriage Return> before they take effect. The ‘*’ character will address all devices on the serial line and can be used to query the unit ID if it is unknown. This should only be used if a single device is connected otherwise the responses will be corrupted from multiple devices trying to write at the same time.

To assign the unit a new address, type *@=X where X is the new address. Care should be taken not to assign an address to a unit if more than one unit is on serial line, as all of the addresses will be reassigned. Instead, substitute * with the specific device’s old address, e.g. A*@=B if you know the address of the device you wish to change is A.
Modbus ID:
The device supports the Modbus/RTU device addresses from 1-247. The factory default ID is 1.

The command ARM will return the current ID.
The command AWM=X will set the Modbus device ID to X. Values outside the range 1-247 will be ignored.

Changing the Baud Rate:
The command ARB will display the current baud rate value, either 4,800, 9,600, 19,200, 38,400, 57600 or 115200 baud. To change the baud rate, type AWB=X, where X is desired baud rate on the table below. The device will respond with the new baud rate. For example, AWB=2 will set the baud rate to 19,200.

Note: When changing the device’s baud rate, your COM port must change its own baud rate in time to successfully receive the response confirming the new baud rate.

Device Full-scale Range:
The command AF will return the device’s full-scale range.

Polling the Device:
The unit measures the flow normally, but only sends a line of data when it is “polled”. Sending the unit ID (or ‘*’) by itself will cause the device to send its data frame which contains the device temperature, current flow rate, setpoint and gas abbreviation.

Choosing the Setpoint Source:
The command ARS will display the device’s current setpoint source. AWS=X will set the setpoint source where X is one of the following:
- A: 0-5 Vdc analog input
- D: Digital serial value saved to flash
- U: Digital serial value not saved to flash.

If a digital setpoint value is saved to flash, it will be restored after a power cycle of the device. The default power-up setpoint is 0. If you are frequently changing the setpoint it is recommended to switch the source to unsaved digital (U) to reduce wear on the device’s flash memory. If a non-zero power-up setpoint is desired, you can set desired value with the source set to D before switching source to U.

After writing the setpoint source, the computer will respond by acknowledging that the source has been changed.

Sending a Setpoint via RS-485:
AXXXX where XXXX denotes a number between 0 and 4095 (2% over range), where 4000 denotes full-scale flow rate, will change the digital setpoint. A data frame will be returned and the setpoint column and flow rates should change accordingly. If they do not, try hitting <Carriage Return> a couple of times and repeating your command. The formula for performing a linear interpolation is as follows:

\[(\text{Desired Setpoint} \times 4000) / \text{Full Scale Flow Range} = \text{Value}\]

For example, if your device is a 1000 sccm full-scale unit and you wish to apply a setpoint of 250 sccm you would enter the following value:

\[(250 \text{ sccm} \times 4000) / 1000 \text{ sccm} = 1000\]

The setpoint above would be sent by typing:

A1000

Setting a Setpoint Watchdog:
The command AWW=X will set a communication watchdog timeout of X milliseconds. If the setpoint source is set to U (Un-saved digital setpoint) and no serial communication is received by the device in Xms the device will return to a zero setpoint and close its valve. The command ARW will return the current watchdog value. Setting the watchdog to 0 will disable this feature. Valid values are 0-5000ms.
Changing the Gas:
Units calibrated with Air have built-in correction equations that allow you to use the gas select command to switch to Argon, Carbon Dioxide, Nitrogen, Oxygen, or Nitrous Oxide.
To change the gas send A$$GX, where X is the gas number from the table to the right. The device will respond with the device address, the selected gas number, and the gas abbreviation.

Note: Units calibrated with Hydrogen or Helium can function only with that gas.

Note: BC-C1000 units that are set to Carbon Dioxide or Nitrous Oxide are limited to a maximum flow rate of 750 SCCM instead of 1000 SCCM due to the correction factor equations used for these gases.

Adjusting the Proportional and Derivative (P&D) terms via RS-485:
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 setpoint (controls the overshoot).
The command ARP returns the current “P” or proportional term of the PD controller, while ARD returns the current “D” or derivative term. Valid values are 0-9999.
It is good practice to write these values down before changing them so you can return to the factory settings if necessary.
To make changes, type AWP=X or AWD=X where X is between 0-9999 to change the “P” or “D” terms respectively.
The unit will respond with the new setting to confirm it was changed.
Test your settings for a step change by changing the setpoint. To do this, type A2000 to give the unit a ½ full scale setpoint.Monitor the unit’s response to the step change to ensure it suits your needs.

Adjusting the Valve Offset Value:
The valve offset value determines how much the valve initially opens after a setpoint change from zero to any setpoint greater than zero. The appropriate value would allow the device to respond quickly to a setpoint change from zero to a non-zero setpoint without a large overshoot.
The inlet pressure is the main factor in determining the appropriate valve offset value, as higher inlet pressures will require a higher valve offset value.
To query offset value of the valve, type ARO.
The computer will respond with the current value for the valve offset between 0-9999.
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 using the correct serial command. For example, if you wished to try an offset value of 2500, you would type AWO=2500.
The unit will confirm that Offset=2500.
Test your settings for a step change by changing the setpoint. To do this, type A0 to give the unit a zero setpoint.
Then type A60 unit a 1.5% full scale setpoint.
Monitor the unit’s response to the step change to ensure it suits your needs.

Tare:
The command A$$V will issue a tare to the device.

Exhaust:
The command A$$E will place the valve into full-open exhaust mode.
The command A$$C will cancel the exhaust and return to PD control mode.

Note: While in exhaust mode the EXH status will be appended to the data frame.
SERIAL COMMAND RESPONSE EXAMPLES

Baud Rate:
Send – ARB<CR> (Device ID + R + B + Carriage Return) Response – BAUD=38400<CR>
Send – AWB=1<CR> (Device ID + W + B + = + Baud[0 – 3] + Carriage Return)
Response – BAUD=9600<CR>

Device Full-scale Range:
Send – AF<CR> (Device ID + F + Carriage Return)
Response – FULL SCALE: 1000.0SCCM<CR>

Polling the device:
Send – A<CR> (Device ID + Carriage Return)
Response – A 17.8C 0000.0SCCM 0000.0SP Air<CR>
(Device ID + Temperature + Mass Flow + Setpoint + Gas + Carriage Return)

Setpoint Source:
Send – ARS<CR> (Device ID + R + S + Carriage Return)
Response 1 – ANALOG<CR>
Response 2 – SAVED DIGITAL<CR>
Response 3 – UNSAVED DIGITAL
Send – AWS=A<CR> (Device ID + W + S + = + A + Carriage Return)
Response – ANALOG<CR>
Send – AWS=D<CR> (Device ID + W + S + = + D + Carriage Return)
Response – SAVED DIGITAL<CR>
Send – AWS=U<CR> (Device ID + W + S + = + U + Carriage Return)
Response – UNSAVED DIGITAL<CR>

Setting Setpoint:
Send – A4000<CR> (Device ID + Setpoint[0 – 4095] + Carriage Return)
Response – SP=1000.0SCCM<CR>

Setpoint Watchdog:
Send – ARW<CR> (Device ID + R + W + Carriage Return)
Response – SP WATCHDOG=0ms<CR>
Send – AWW=1000<CR> (Device ID + W + W + = + 1 + 0 + 0 + 0 + Carriage Return)
Response – SP WATCHDOG=1000ms<CR>

Change Device ID:
Send – *@=B<CR> (Device ID + @ + = + New Device ID + Carriage Return)
Response – B 18.0C 0000.0SCCM 0000.0SP Air<CR>
(Device ID + Temperature + Mass Flow + Setpoint + Gas + Carriage Return)

Modbus/RTU Device ID:
Send – ARM<CR> (Device ID + R + M + Carriage Return)
Response – MODBUS_ID=1<CR>
Send – AWM=2<CR> (Device ID + W + M + = + ID[1-247] + Carriage Return)
Response – MODBUS_ID=2<CR>

P Gain:
Send – ARP<CR> (Device ID + R + P + Carriage Return) Response – P=0125<CR>
Send - AWP=150<CR> (Device ID + W + P + = + Pgain[0 – 9999] + Carriage Return)
Response – P=0150<CR>

D Gain:
Send – ARD<CR> (Device ID + R + D + Carriage Return) Response – D=25
Send - AWD=40<CR> (Device ID + W + D + = + Dgain[0 – 9999] + Carriage Return)
Response – D=40<CR>

Valve Preload Offset:
Send – ARO<CR> (Device ID + R + O + Carriage Return) Response – OFFSET=3500<CR>
Send - AWO=2500<CR> (Device ID + W + O + = + Offset[0 – 9999] + Carriage Return)
Response – OFFSET=2500<CR>

Gas Select:
Send – A$$G2<CR> (Device ID + $ + $ + G + Gas ID Number + Carriage Return)
Response – A G02 CO2<CR>

Tare:
Send – A$$V<CR> (Device ID + W + $ + $ + V + Carriage Return)
Response – A 17.8C 0000.0SCCM 0000.0SP Air<CR>
(Device ID + Temperature + Mass Flow + Setpoint + Gas + Carriage Return)

Exhaust:
Send – A$$E<CR> (Device ID + W + $ + $ + E + Carriage Return) Response – EXHAUST
Send – A<CR> (Device ID + Carriage Return)
Response – A 17.8C 0000.0SCCM 0000.0SP Air EXH<CR>
(Device ID + Temperature + Mass Flow + Setpoint + Gas + Exhaust status + Carriage Return)
Send – A$$C<CR> (Device ID + W + $ + $ + C + Carriage Return) Response – CONTINUE
Modbus/RTU
The Basis MFC device supports input and output using the Modbus/RTU protocol. The following Modbus commands are supported:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x03</td>
<td>Read Holding Register</td>
</tr>
<tr>
<td>0x06</td>
<td>Write Single Register</td>
</tr>
<tr>
<td>0x10</td>
<td>Write Multiple Registers</td>
</tr>
</tbody>
</table>

Modbus registers (unused registers are reserved):

<table>
<thead>
<tr>
<th>Register Number</th>
<th>Access</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>RW</td>
<td>Modbus Device ID (1-247)</td>
</tr>
<tr>
<td>0x02-0x03</td>
<td>RO</td>
<td>Current Mass Flow Rate (32-bit unsigned integer) (100CCM/1000CCM – Output is 1000x the flow in CCM (ie 100000 = 100CCM, 1000000 = 1000CCM), 20LPM – Output is the flow in CCM (ie 20000 = 20LPM))</td>
</tr>
<tr>
<td>0x04</td>
<td>RW</td>
<td>Serial unit ID in ASCII (ie 65 = 'A')</td>
</tr>
<tr>
<td>0x07</td>
<td>RW</td>
<td>Setpoint source (0 – Analog input, 1 – Saved digital, 2 – Unsaved digital)</td>
</tr>
<tr>
<td>0x08</td>
<td>RW</td>
<td>Setpoint in counts from 0-4095.</td>
</tr>
<tr>
<td>0x09-0x0A</td>
<td>RO</td>
<td>Current Setpoint in Mass Flow Rate (32-bit unsigned integer) (Value has the same format as the Current Mass Flow Rate (Registers 0x02-0x03))</td>
</tr>
<tr>
<td>0x0B</td>
<td>RO</td>
<td>Temperature in Degrees C (Value is in hundredths of a degree: ie 2850 = 28.5C)</td>
</tr>
<tr>
<td>0x0C</td>
<td>RW</td>
<td>Gas Index (0-6) (See gas table above for valid values.)</td>
</tr>
<tr>
<td>0x0D</td>
<td>RW</td>
<td>PD Proportional Gain (0-9999)</td>
</tr>
<tr>
<td>0x0E</td>
<td>RW</td>
<td>PD Derivative Gain (0-9999)</td>
</tr>
<tr>
<td>0x0F</td>
<td>RW</td>
<td>Valve Preload Offset (0-9999)</td>
</tr>
<tr>
<td>0x15</td>
<td>RW</td>
<td>Baud Rate (0-3) (See baud table above for valid values.)</td>
</tr>
<tr>
<td>0x24</td>
<td>RO</td>
<td>Maximum Flow Rate (Valid values: 100CCM: 100, 1000CCM: 1000, 20LPM: 2000)</td>
</tr>
<tr>
<td>0x29</td>
<td>RW</td>
<td>Exhaust Mode (0 – Valve under PD control, 1 – Valve in full-open exhaust)</td>
</tr>
<tr>
<td>0x2A</td>
<td>RW</td>
<td>Exhaust Valve-drive Percentage (Valve-drive in hundredths of a percent – ie 5000 = 50%, 10000=100% Only applicable if the valve is in exhaust)</td>
</tr>
</tbody>
</table>

Maintenance and Recalibration
BC-Series Flow Controllers require minimal maintenance. The single most important thing that affects the life and accuracy of these devices is the quality of the gas being measured. The controller is designed to measure CLEAN, DRY, NON-CORROSIVE gases. Line filters are available from Alicat. BC-Series Flow Controllers require no periodic cleaning. If necessary, the outside of the controller can be cleaned with a soft dry cloth. Avoid excess moisture or solvents. For repair, recalibration or recycling of this product, contact Alicat.
### Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy at Calibration Conditions</td>
<td>± (1.5% of Reading + 0.5% of Full Scale)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>25% - 100% Setpoint: ± 0.5% Reading</td>
</tr>
<tr>
<td></td>
<td>0% - 25% Setpoint: 0.125% Full Scale</td>
</tr>
<tr>
<td>Zero Shift and Span Shift</td>
<td>± 0.2%  FS / °C</td>
</tr>
<tr>
<td>Long term drift</td>
<td>0.05% Full Scale / Year</td>
</tr>
<tr>
<td>Operating Range / Turndown Ratio</td>
<td>BC-C0100: 1.0% to 100% Full Scale/100:1 Turndown</td>
</tr>
<tr>
<td></td>
<td>BC-C1000: 0.5% to 100% Full Scale/200:1 Turndown</td>
</tr>
<tr>
<td>Maximum Controllable Flow Rate</td>
<td>102% Full Scale</td>
</tr>
<tr>
<td>Typical Response Time</td>
<td>100 ms</td>
</tr>
<tr>
<td>Warm-up Time</td>
<td>70 ms to full scale accuracy</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>0 to +50 °Celsius</td>
</tr>
<tr>
<td>Calibration Conditions</td>
<td>25°C, 14.696 psia</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Full Scale Ranges</th>
<th>Pressure Drop (mbar) at FS Flow venting to atmosphere</th>
<th>Mechanical Dimensions</th>
<th>Process Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC-C0100</td>
<td>10</td>
<td>2.6”H x 2.5”W x 0.9”D</td>
<td>7/16 - 20 SAE thread, J1926 port</td>
</tr>
<tr>
<td>BC-C1000</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notice

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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.

Alicat Scientific, Inc. warrants to the original purchaser that for one year from the date of shipment the instruments manufactured by Alicat Scientific shall be free from defects in materials and 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 any equipment which has not been installed and used in accordance with the specifications recommended by Alicat Scientific for the proper and normal use of the equipment.

Conformity / Supplemental Information:
The product complies with the requirements of the Low Voltage Directive 2006/95/EC and the EMC Directive 2004/108/EC and carries the CE Marking accordingly. Contact the manufacturer for more information.

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### Flow Conversions

- **SCFM to SLP:**
  - 1 SCFM = 366.0768 SCFH
  - 1 SCFH = 0.28316 SLP

- **SCFH to SPM:**
  - 1 SCFH = 1 SPM
  - 1 SPM = 1 SCFH

- **SCM to SLL:**
  - 1 SCM = 3660.7688 SLL
  - 1 SLL = 0.00027 SCM

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### Gas Viscosity, Density and Compressibility

<table>
<thead>
<tr>
<th>Gas</th>
<th>Absolute Viscosity</th>
<th>Density **</th>
<th>Compressibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helium</td>
<td>1.6390</td>
<td>1.0000</td>
<td>0.9997</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>1.1840</td>
<td>1.0000</td>
<td>0.9997</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.9997</td>
<td>1.0000</td>
<td>0.9997</td>
</tr>
<tr>
<td>Oxygen</td>
<td>1.3088</td>
<td>1.0000</td>
<td>0.9997</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>1.8089</td>
<td>1.0000</td>
<td>0.9997</td>
</tr>
<tr>
<td>Oxygen</td>
<td>1.8089</td>
<td>1.0000</td>
<td>0.9997</td>
</tr>
<tr>
<td>Argon</td>
<td>1.0006</td>
<td>1.0000</td>
<td>0.9997</td>
</tr>
</tbody>
</table>

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*Note: Absolute Viscosity and Density are given at 25°C and 101.325 kPa.*