DS-TMF-GF135-MFC-eng
January, 2017

Data Sheet

GF135
Digital Mass Flow Controller

Thermal Mass Flow

Model GF135

Pressure Transient Insensitive Mass Flow Controller with Real-Time Flow Error Detection and Advanced Diagnostics

Overview

Designed for the next step in semiconductor etch, thin film and other advanced process gas control applications, the GF135 combines all of the benefits provided by the most advanced pressure transient insensitive mass flow controller (MFC) and adds real-time flow error detection with advanced diagnostics.

Device manufacturers are driving programs to improve wafer level yield. The current downstream quality control approach can allow hundreds of wafers to be processed before issues are detected. Process gas stability and repeatability have been identified as critical to meeting yield enhancement goals and MFC accuracy has been identified as critical to maintaining process control.

The GF135 provides third generation pressure transient insensitivity, market leading process gas accuracy and ultra fast flow settling times for reduced process cycle time and to address advanced 3D device processing requirements. This platform also offers patent pending real-time flow error trending using Rate of Decay (ROD) techniques that are immune to typical MFC failure/degradation modes ensuring accurate and reliable diagnostic capabilities. After a baseline is established at tool start-up, the GF135 can detect changes in flow rate to within 2% of set point. These advanced diagnostic capabilities provide a shift from downstream quality control to real-time quality assurance and predictive maintenance resulting in higher yield and improved uptime.

Product Description

The GF135, with integral real-time ROD flow error detection, drops into the standard ultra high purity surface mount or VCR® MFC footprint providing an easy path to upgrade critical gas lines on existing systems.

With the GF135, the user will be able to take advantage of enhanced process gas accuracy, market leading pressure transient performance and MFC health indicators such as automatic trending of sensor stability and valve shutdown (leak-by). Using these health indicators and user programmable alarm limits, via MFC service port or remote digital commands, the user can establish limits to improve the yield and/or manage maintenance schedules to maximize uptime.

BROOKS® INSTRUMENT

Features and Benefits

Features	Benefits
Real-time flow error detection	Support yield improvement programs by capturing wafer impacting flow deviations
Sensor stability tracking	Improves system uptime by supporting predictive maintenance
Valve leak-by tracking	Allows user to monitor and set limits to minimze first wafer effects
Enhanced process gas accuracy	Meet process gas chemistry control challenges at 10nm
Market leading ultra-fast flow settling time	Optimize wafer process cycle time by reducing non-productive flow stabilizaton steps. Supports advanced 3D device processing
Enhanced pressure insensitivity	Superior process gas control for enhanced etch and deposition control
Corrosion resistant Hastelloy® sensor	Provides unmatched long-term sensor stability ensuring maximum yield and throughput
Drop-in upgrade for surface-mount and VCR MFCs	Easy upgrade for critical gas lines on existing systems

Product Description

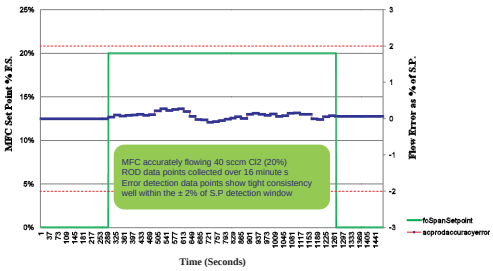
Real-time Flow Error Detection

Process contamination buildup in the flow sensor results in higher than indicated actual flow. Process contamination buildup in the flow restrictor results in lower than indicated actual flow. Process contamination on the valve orifice or seat results in leak past the valve. All of these situations can cause lost wafers and cost thousands. When using a standard MFC, these errors cannot be detected without stopping production to run a flow check. The GF135 has patent pending real-time flow error detection and trending using Rate of Decay (ROD) techniques that are immune to typical MFC failure/degradation modes ensuring accurate and reliable diagnostic capabilities. After a baseline is established at tool start-up, the GF135 can detect changes in flow, drift and leak rate.

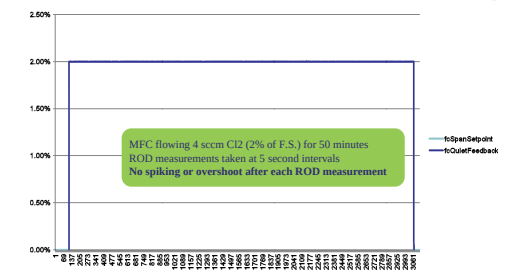
After installing the GF135, a commissioning routine creates a performance baseline at actual process conditions. During wafer processing, the device automatically takes flow error detection readings at each new process set point and compares the result to the baseline. The proprietary ROD measurement technique momentarily stops the upstream delivery of gas from the tool supply while maintaining flow into the process chamber at the requested flow rate. A highly accurate pressure measurement is taken while the gas is being depleted from the inlet volume and an advanced signal processing algorithm calculates ROD flow rate in real time. Before the flow to the process is affected by the diminishing pressure, the upstream supply is re-established with no perturbation to the delivered flow. By calculating flow at various set points during wafer processing, the MFC detects any sensor or bypass clogging. It also detects if a sensor offset is developing since the effects of clogging and drift manifest themselves differently at different set points. The same method is used when the MFC is given a zero set point to calculate valve leak. This enables the MFC to measure zero offset. The MFC can report the valve leak, sensor offset and flow offset to the tool through a documented interface protocol, as well as auto-correcting itself if the user enables that feature. Finally, the MFC stores this data for one year and can report on the changes using the historical data.

By providing automated monitoring of flow rate changes, the GF135 is able to arm the user with real time warnings of wafer impacting flow deviations.

Model GF135 on Gas Stick



OEM Test: GF135 Critical Flow Accuracy with Error Detection Monitoring Active



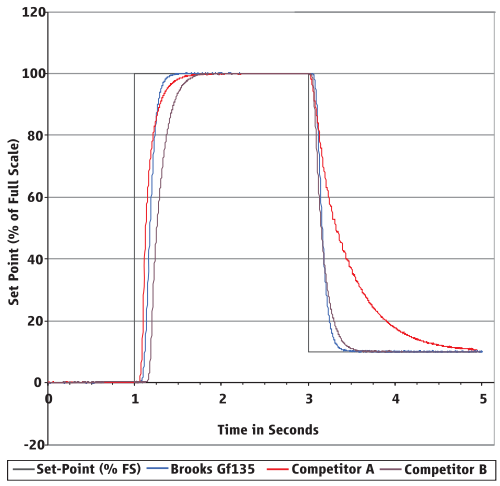
OEM Test: Flow Stability While Running Continuous Flow Error Detection Measurements at Critical 2% Set Point

Product Description (continued)

Ultra-Fast Response

By combining Brooks' patented flow sensor technology with a high speed ARM processor and fast acting diaphragm free valve assembly, the GF Series delivers up to 3 times faster response and settling time compared to other mass flow controllers, enabling:

- Improved wafer throughput by reducing nonproductive flow settling steps
- Critical Etch and 3D device processes requiring ultra-fast sub 500 millisecond etch steps
- Reduced diverted gas consumption and associated abatement costs
- Time-sensitive gas delivery steps in Atomic Layer Deposition (ALD)
- Processes requiring a slow ramped gas turn-on or time critical transitions between flow rates with user programmable ramp function

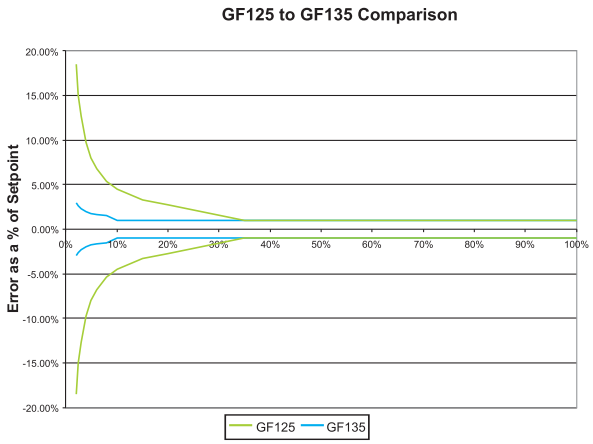


Comparison of GF135 vs Competititor's Response Time to Ascending & Descending Set Points

Enhanced Process Gas Accuracy

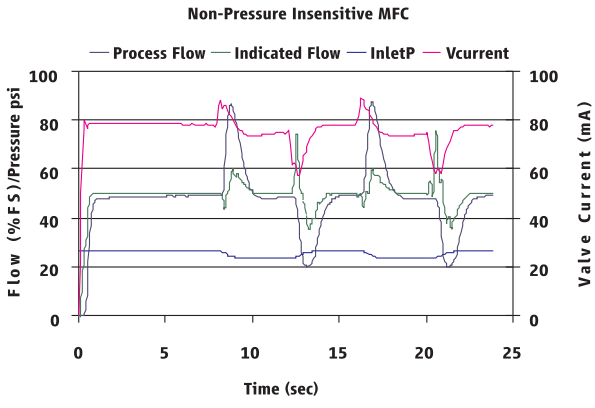
A major advancement over traditional single point gas conversion factors, Brooks delivers up to a three-times improvement in process gas accuracy. This is achieved through advanced gas modeling optimized through actual gas testing providing compensation for non-linear gases.

Similar to the GF125 High Accuracy (HA), the GF135 is a gas and range specific device for critical gas process applications requiring the widest working range with tightest flow control accuracy. A typical application is for multi-step processes requiring a high flow rate (up to 5 slpm) and a very accurate low flow rate. Traditionally this has been addressed by using two mass flow controllers. With wide turndown (100:1) and superior accuracy offered by the GF135, it is often possible to replace two mass flow controllers with one, providing immediate cost savings while freeing up a gas line for greater gas panel flexibility.



Pressure Transient Insensitivity

Cost and space constraints have driven gas panel designers to remove point of use pressure regulators and pressure monitoring components, placing more burden on the mass flow controller to control accurately under dynamic pressure conditions. Conventional mass flow controllers react strongly to small inlet pressure fluctuations resulting in unstable performance and unpredictable accuracy (see Non-Pressure Insensitive MFC). This drove Brooks to develop Pressure Transient Insensitive mass flow controller technology (PTI-MFC). The GF135 PTI-MFC is a third generation PTI-MFC utilizing a patented control algorithm that inverts the pressure signal, compares it to the pre-fluctuation signal and drives real-time valve position compensation to maintain stable flow. Enhanced pressure transient insensitivity is achieved through faster sensing, faster processing, and a reduction in internal dead volume between the sensors and valve orifice.



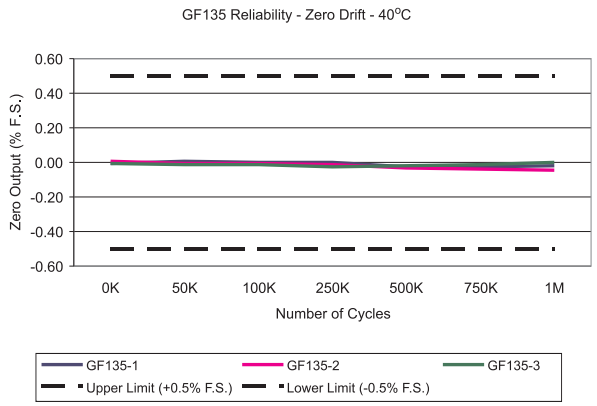
Pressure Fluctuations in Non-Pressure Transient Insensitivity MFC

Product Description (continued)

Advanced Thermal Flow Measurement Sensor

Brooks' sensor technology combines:

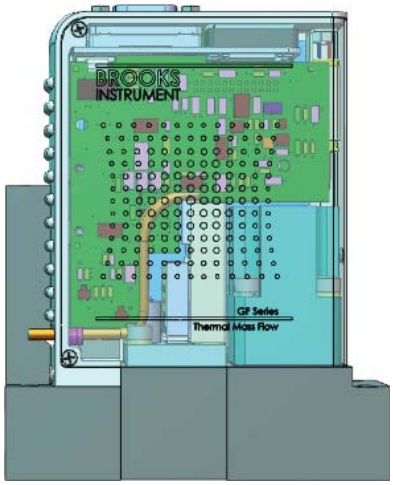
- Improved signal to noise performance for improved accuracy at low setpoints
- Improved reproducibility at elevated temperatures through new isothermal packaging, onboard conditioning electronics with ambient temperature sensing and compensation
- Improved long-term stability through enhanced sensor manufacturing and burn in process
- Highly corrosion resistant Hastelloy C-22 sensor tube
- Optimized temperature profile for gases prone to thermal decomposition



High Purity Flow Path

All metal, corrosion resistant flow path with reduced surface area and un-swept volumes for faster dry-down during purge steps:

- SEMI F-20 compliant wetted flow path
- 4µ inch Ra surface finish standard
- Highly corrosion resistant Hastelloy C-22 valve seat and jet orifice



GF135 Diagram

User Interface

The user interface has a high visibility electronically rotatable LCD display that provides a local indication of Flow (%), Temperature (°C), Pressure (PSIA/KPa) and Network Address, selectable through the Display button. A Zero button provides a simple means to re-zero the mass flow controller as part of scheduled maintenance.

Communication Interface

The GF135 supports analog 0-5 Vdc, RS485, and DeviceNet™ communication protocols. A range of low profile adapter cables facilitate replacing older mass flow controllers with the GF Series eliminating the need to carry mass flow controllers of same gas/range but different electrical connectors.

Communication Interface

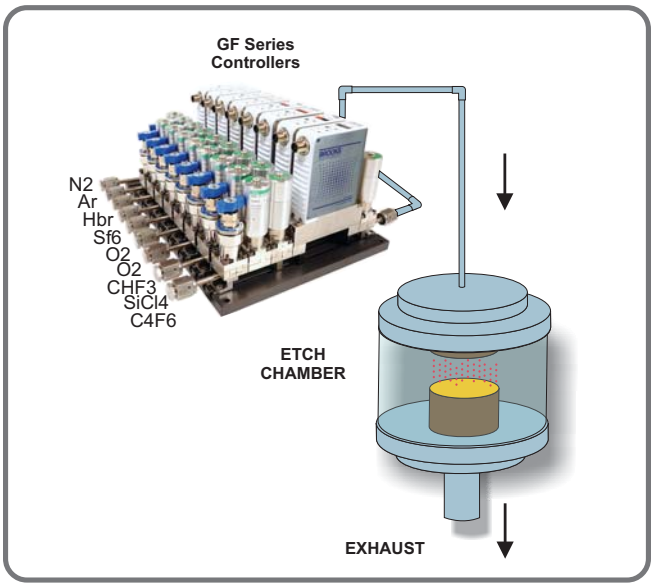
Product Application

Etch Process

The transition to 22nm and 10nm nodes and complex 3D device geometries place greater profile and variability control challenges on the etch tool and its gas delivery sub system.

Creating and maintaining highly reproducible gas chemistry requires leading edge mass flow control.

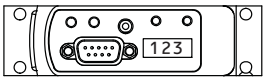
The GF135 is the preferred mass flow controller for demanding etch applications. With ultra fast 300msec flow settling time, market leading pressure transient insensitivity, wide rangeability, process gas accuracy and real-time flow error detection with advanced diagnostics, the GF135 is the right choice for these demanding applications.



Electrical Interface Options

PDC Ordering Code G2

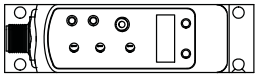
Description: Industry standard Analog / RS485 interface



Pin No.	Signals	
1	Valve Control	
2	Output (0-5 Vdc)	
3	+15 Vdc	+24 Vdc
4	Pwr Com	NC
5	-15 Vdc	Pwr Com
6	Setpoint (0-5 Vdc)	
7	Signal Common	
8	RS-485 (DX+)	
9	RS-485 (DX-)	

PDC Ordering Code D0-D9 and DA-DX

Description: Industry standard ODVA compliant DeviceNet interface



M12 Pin No.	Signals
1	Drain
2	V+ (11-25 Vdc)
3	V-
4	CAN-H
5	CAN-L

Product Specifications

Performance

Full Scale Flow Range:	3 sccm to 5 slm (N2 Eq.)
Gasses Supported:	N2, O2, Ar, H2, SF6, NH3, CO2, Cl2, HBr, NF3, CF4, CH4, CH3F, CH2F2, SiCl4 (@ 100 Torr), C4F6-q (@ 800 Torr), C4F8 (@ 1200 Torr), N2O, CHF3, SiH2Cl2, C5F8, He
Flow Accuracy:	+/-1.0% S.P. (10-100% F.S.), +/-1% S.P. plus +/-0.04% F.S. (2-10% F.S.)
Repeatability & Reproducibility:	< +/- 0.15% S.P.
Linearity:	Included in accuracy
Settling Time (to within +/- 2% FS):	<300ms (<860 sccm N2 Equivalent), <400ms (861-5000 sccm N2 Equivalent)
Pressure Insensitivity:	< 1% S.P. up to 5 psi/sec upstream press. spike
Control Range:	1-100%
Valve Shut Down:	< 0.5% of F.S. N2
Zero Stability:	< +/- 0.5% F.S. per year
Temperature Coefficient:	Span: 0.05% setpoint per °C, Zero: 0.005% F.S. per °C
Rate-of-Decay Performance:	(ROD by default is disabled/off. It should not be enabled until after MFC is installed and properly commissioned)
Flow Rate:	Maximum flow rate for which an ROD measurement can be obtained is 800 sccm
Temperature Sensitivity:	+/- 0.04% S.P./Deg C
Pressure Sensitivity:	+/- 0.04% F.S./psi
Minimum Detectable Change from Commissioning Baseline:	Zero Drift: +/- 0.02% F.S. Valve Leak: +0.1% F.S. Repeatability: +/- 0.3% S.P. (SiCl4 +/- 0.5% from 5-100% S.P. up to 100 sccm flow)

Ratings

Operating Temperature Range:	10-50°C
Differential Pressure Range:**	3-860 sccm = 7-45 psid, 861- 5000 sccm = 10-45 psid **Typical pressure drop. Actual pressure drop will be gas and flow dependent. Argon gas applications require higher differential pressure. Low vapor pressure gases require an inlet pressure of > 100 Torr, with vacuum on outlet (example SiCl4). Contact Brooks Technical Support for more information.
Maximum Operating Pressure:	100 psia max
Pneumatic Valve Operating Pressure:	43.5 psia - 72.5 psia
Leak Integrity (external):	1x10-10 atm. cc/sec He

Mechanical

Valve Type:	Normally Closed
Wetted Materials:	SEMI F20 UHP Compliant 316L VIM/VAR, Hastelloy C-22,316L Stainless Steel, 304 Stainless Steel, KM-45
Surface Finish:	4µ inch Ra (0.1 µm Ra)

Diagnostics & Display

Status Lights:	MFC Health, Network Status
Alarms:	Sensor Output, Control Valve Output, Over Temperature, Power Surge/Sag, Network Interruption, Sensor Drift, Flow Error, Valve Leak
Display Type:	Top Mount Electronically Rotatable Integrated LCD
Viewing Distance:	Fixed / 10 feet
Units Displayed / Resolution:	Flow (%), Temp. (°C), Pressure (psia, kPa) / 0.1 (unit)

Electrical

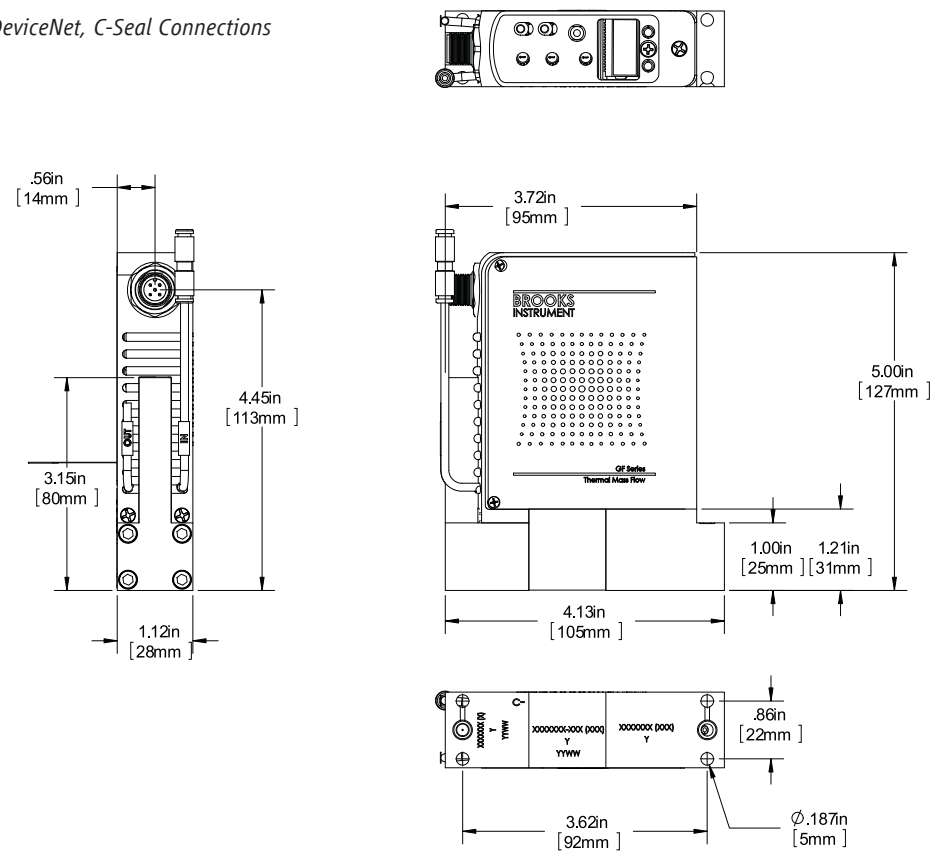
Electrical Connection:	Analog/RS-485 via 9-Pin "D" connector, DeviceNet via 5-Pin "M12" connector
Digital Communication:	RS485+ (model specific), DeviceNet (model specific), RS485 Diagnostic Port (all models)
Diagnostic / Service Port:	RS485 via 2.5 mm jack
Power Supply/Consumption:	DeviceNet: +11-25 Vdc., 545 mA max. @ 11 Vdc., 250 mA (max.) @ 24 Vdc., Analog /RS485: +/-15 Vdc. (+10%), 6 Watts (max) or +24 Vdc +/-10%

Compliance

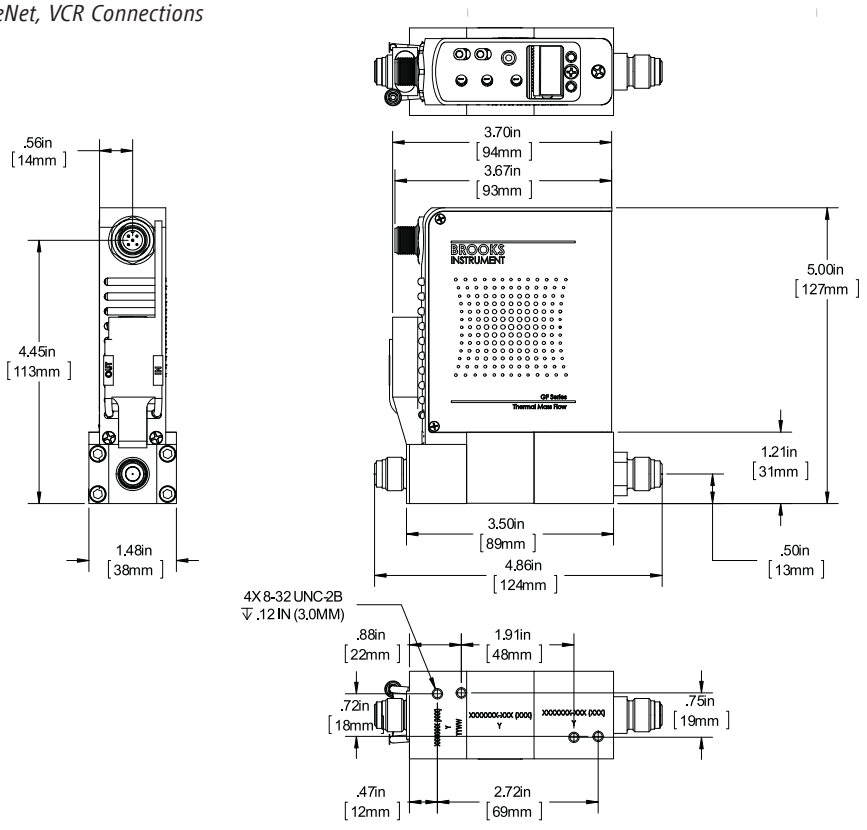
EMC	EC Directive 2004/108/EC CE: EN61326: 2006 (FCC Part 15 & Canada IC-subset of CE testing)
Environmental Compliance	RoHS Directive 2011/65/2006
	Reach Directive EC 1907/2006

Product Dimensions GF135, DeviceNet

Model GF135, DeviceNet, C-Seal Connections

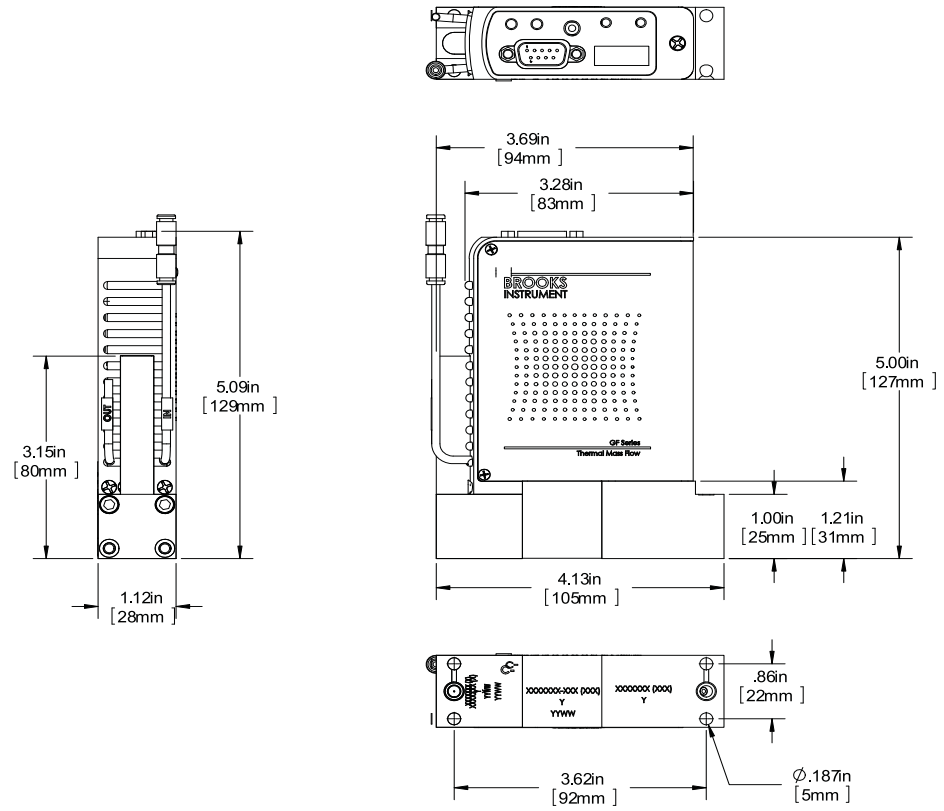


Model GF135, DeviceNet, VCR Connections

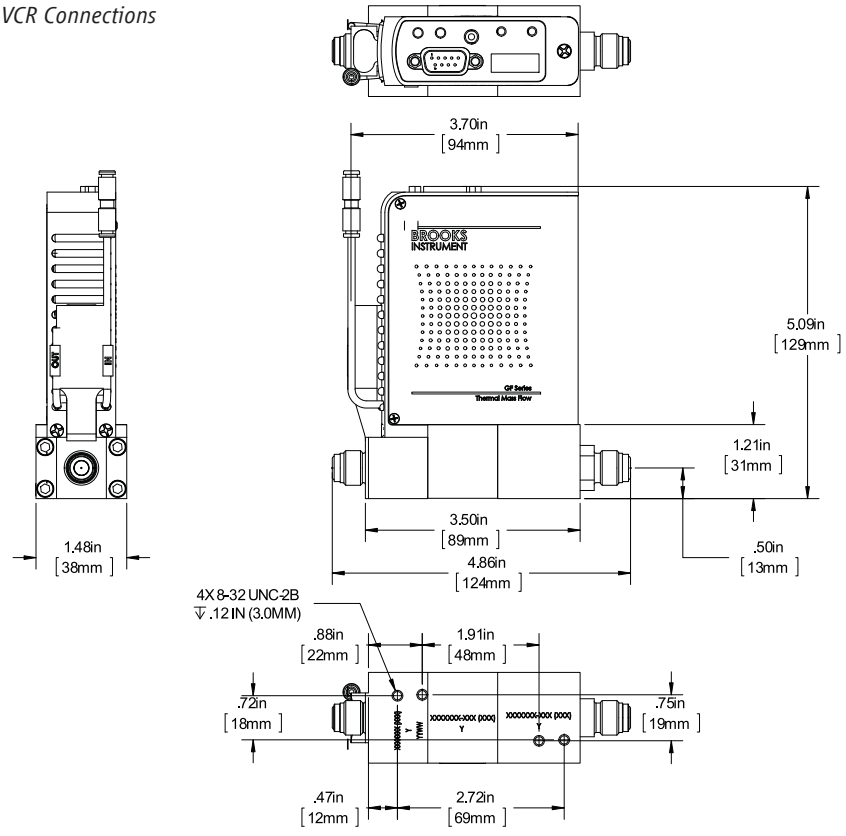


Product Dimensions GF135, RS485

Model GF135, RS485, C-Seal Connections



Model GF135, RS485, VCR Connections



Model Code

Code Description	Code Option	Option Description
I. Base Model Code	**GF**	
II. Package/FinishSpecifications	**135**	Pressure Transient Insensitive (PTI) Ultra High Purity Advanced Diagnostic MFC
III. Configurability	**X**	Gas specific
IV. Special Application	**XX**	Standard Application
V. Valve Configuration	**C**	Normally Closed Valve
VI. Specific Gas Code & Range,	**XXXX XXXX**	Specify Gas Code & Range, i.e. "0004" = Argon and "010L" = 10 slpm
VII. Fitting	**VX**	1 1/2" VCR 1/4"
	CX	1 1/8" C Seal 92mm
	WX	1 1/8" W Seal 92mm
VIII. Downstream Condition	**A**	Atmosphere
	V	Vacuum
IX. Sensor	**O**	Default Orientation

X. Connector		DeviceNet Standard Configuration Parameters									
		I/O	Connector	Power On State	Full Scale Setting	Full Scale Setting	Full Scale Setting	Poll IO Instance Producer	Poll IO Instance Consumer	Poll IO State Transition	External Baud Rate
	D0	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	2	7	Executing	500KB
	D1	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	21	7	Executing	500KB
	D2	DeviceNet	5 Pin Micro	Idle	SCCM	Float	7FFFh	13	19	Executing	500KB
	D3	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	22	7	Executing	500KB
	D4	DeviceNet	5 Pin Micro	Executing	Count	Integer	6000h	22	8	Executing	500KB
	D5	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	6	8	Executing	500KB
	D6	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	3	7	Executing	500KB
	D7	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	6	8	Executing	500KB
	D8	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	3	7	Executing	500KB
	D9	DeviceNet	5 Pin Micro	Executing	Count	Integer	6000h	2	7	Executing	500KB
	DA	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	22	7	Executing	500KB
	DB	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	22	8	Executing	500KB
	DC	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	3	7	Idle	500KB
	DD	DeviceNet	5 Pin Micro	Executing	Count	Integer	7FFFh	22	8	Executing	500KB
	DE	DeviceNet	5 Pin Micro	Executing	SCCM	Float	6000h	15	19	Executing	500KB
	DX	DeviceNet	5 Pin Micro	To be defined by CSR							
	G2	Analog/RS485	9 Pin D	NA	NA	NA	NA	NA	NA	NA	NA

XI. Customer Special Request	**XXXX**	Customer Special Request Number
XII. Auto Shut-Off	**A**	Auto Shut Off (Included)
	X	Auto Shut Off (Not Included)
XIII. Auto Zero	**A**	Auto Zero (Included)
	X	Auto Zero (Not Included)
XIV. Reference Temperature	**000**	0°C Reference Calibration (Standard) - Default Setting

Example Model Code

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
GF	135	X	XX	C	XXXX XXXX	VX	A	O	D1	XXXX	A	A	000

Brooks Service and Support

Brooks is committed to assuring all of our customers receive the ideal flow solution for their application, along with outstanding service and support to back it up. We operate first class repair facilities located around the world to provide rapid response and support. Each location utilizes primary standard calibration equipment to ensure accuracy and reliability for repairs and recalibration and is certified by our local Weights and Measures Authorities and traceable to the relevant International Standards.

Visit www.BrooksInstrument.com to locate the service location nearest to you.

START-UP SERVICE AND IN-SITU CALIBRATION

Brooks Instrument can provide start-up service prior to operation when required. For some process applications, where ISO-9001 Quality Certification is important, it is mandatory to verify and/or (re)calibrate the products periodically. In many cases this service can be provided under in-situ conditions, and the results will be traceable to the relevant international quality standards.

CUSTOMER SEMINARS AND TRAINING

Brooks Instrument can provide customer seminars and dedicated training to engineers, end users, and maintenance persons.

Please contact your nearest sales representative for more details.

Due to Brooks Instrument's commitment to continuous improvement of our products, all specifications are subject to change without notice.

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

Toll-Free (USA): 888-554-FLOW
T: 215-362-3500
F: 215-362-3745
BrooksAM@BrooksInstrument.com

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