

# PIVOTAL

S Y S T E M S

GFC5™

GFC20™

GFC200™

GFC1000™

GFC2000™

The Future of  
Flow Control



**Widest Flow Range with Accuracy (Actual Gas)**      *0.5–100% Full Scale*

**Best Flow Accuracy**      *±0.5% of Setpoint for 0.5–100% Full Scale*

**Fastest Settling Time for Turn-On and Turndown**      *10%-100% FS ≤ 100 ms*  
*0.5%-10% FS ≤ 300 ms*

**Effect of Pressure and Temperature**      *Invariant*

**Automated In Situ Calibration**      *NIST Traceable*

**Innovative Control Technology**      *Robust Design, No Orifice*

## Introduction

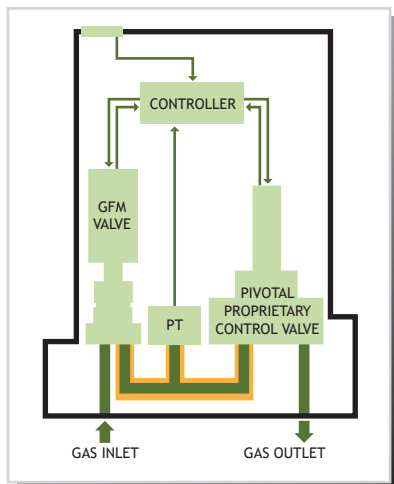
As process geometries within the semiconductor industry continue to shrink to 10 nm and beyond, the need for highly accurate, responsive and repeatable gas flow control during wafer processing is essential. With the emergence of low gas flow rates, short processing times and continuous plasma processing, best-in-class MFCs are struggling to meet the accuracy, settling time and repeatability requirements demanded to ensure high yield and matched chambers.

Pivotal Systems' GFC paves the way for the future of gas flow control. The GFC combines Pivotal's patented, high accuracy GFM™ system with patented control valve technology. As such, it leapfrogs the current MFC technology by offering an order of magnitude improvement on key flow metrics, thereby enabling advanced wafer-manufacturing processes.

## Feature Description

### Automated Calibration and In Situ Diagnostics

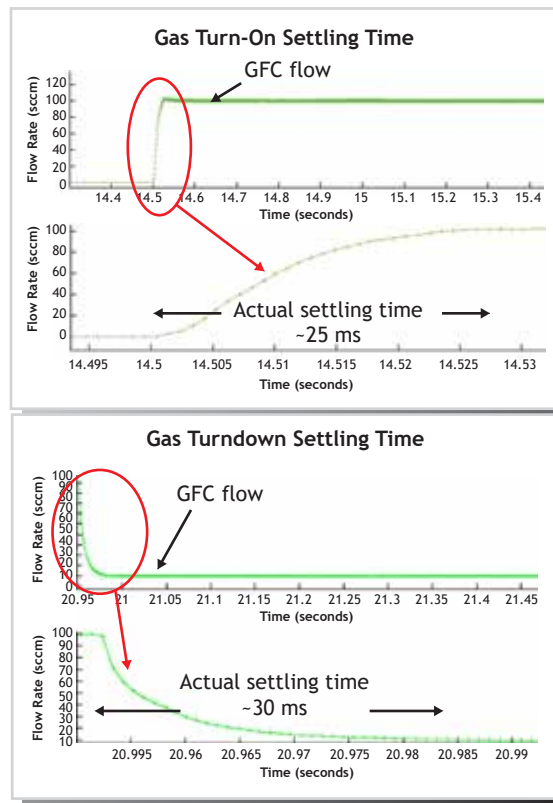
The GFC executes a robust calibration sequence on every run. This feature, unique to the Pivotal GFC, results in highly accurate NIST traceable measurements run-to-run and reduces downtime significantly.



PT PRESSURE TRANSDUCER  
 NIST TRACEABLE CALIBRATED VOLUME

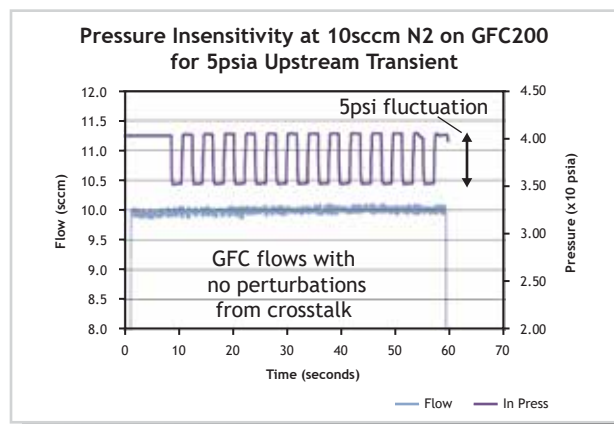
## Settling Time

The GFC offers best-in-class settling times for flow controllers by providing settling times below 100 ms for both the gas turn-on and gas turndown. Refer to the following graphics.



## Pressure and Temperature

The unique design of the Pivotal valve results in the GFC being unaffected by variations in the upstream or downstream pressure or temperature. The GFC does not need a temperature coefficient. Highly sensitive sensors monitor the gas pressure and temperature every milli-second and the control scheme accounts for any variations.



# GFC Specifications

Performance	Flow range	0.025 - 2000 sccm (5 part numbers to cover this range)
	Flow Accuracy	±0.5% of Setpoint for actual gas: 0.025 - 5 sccm (GFC5) 0.1 - 20 sccm (GFC20) 1 - 200 sccm (GFC200) 5 - 1000 sccm (GFC1000), 10 - 2000 sccm (GFC2000)
	Settling Time	10% - 100% FS ≤ 100 ms, 0.5% - 10% FS ≤ 300 ms *
	Leak Integrity	≤ 1E-9 atm.cc/sec (He)
	Leak By Rate	0.0025 sccm (GFC5), 0.01 sccm (GFC20), 0.1 sccm (GFC200), 0.5 sccm (GFC1000), 1.0 sccm (GFC2000)
	Repeatability	10-100% FS ±0.2% of setpoint, 0.5-10% of FS ±0.02% of FS
Operating Conditions	Supply Pressure	Standard: 100 - 300kPaG (14.5 - 43.5 psig) Low pressure gases C4H9F, SiH2Cl2, C3H10Si, BCl3, C4F6, C4F6-q, C4F8, C5F8, SiCl4 and WF6 the inlet pressure range can be as low as -81 kPaG (-11.7 psig) Refer to the Gas Bin Table on page 5 & 6 for the specific ranges.
	Downstream Pressure	Vacuum to 53 kPa (0 - 400 Torr)
	Proof Pressure	2.07 MPaG (300 psig)
	Design Pressure (Burst Pressure)	2.65 MPaG (385 psig)
	Operating Temperature	15 - 50 °C
Materials	Wetted Surface	316 SS per Semi F20
	Surface Finish	5 µin average Ra
	Seals	Metal (PCTFE - Optional)
Electrical	DeviceNet	11 - 24 VDC, 5 W
	Analog and RS-485	±15 VDC, 150 mA
	In-Rush Current	<200 mA

\* There is a setpoint hold-time of 60 milliseconds during Analog control. This time is in addition to the reported settling time of this device. When running using Analog control, the GFC has a minimum setpoint sensitivity of ±50mV. The flow accuracy is unaffected. The measured setpoint and corresponding flow feedback may be different from the commanded setpoint by up to that amount. Analog calibration is recommended to align device input to the controller output.

## Communication Protocols

### Supported Protocols

The GFC supports analog, DeviceNet, RS-485 and Ethercat communication protocols.

### Analog and RS-485 Interface

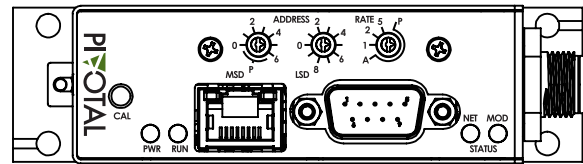
A 9-pin male D-sub connector on top of the GFC enclosure (right) is for operating in the analog and RS-485 modes.

### DeviceNet Interface

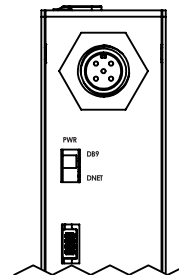
The industry standard, ODVA-compliant DeviceNet *thin* cable with a *micro* connector is located on the side of the GFC enclosure. The table on the right defines this connector's pins.

### Ethercat Interface

A 5 pin M8 power connector is located on the side of the GFC enclosure. The table on the right defines this connector's pins. Please refer to page 9 for a diagram of the communications port locations. Contact a sales representative for the ESI file.

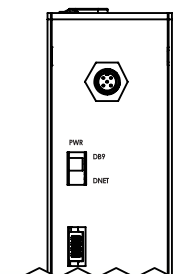


For the analog and RS-485 modes, a suitable mating connector is Tyco PN# 1-747943-6.



#### DeviceNet

Pin	Signal Name	Specification
1	Drain	
2	V+	+11 VDC to +24 VDC
3	V-	0 VDC
4	CAN_H	
5	CAN_L	



#### Ethercat

Pin	Signal Name	Specification
1	V+	+24 VDC
2	Chassis Ground	
3	Power Common	
4	Unassigned	
5	Unassigned	

# Product Description Code

Code	Description	Option	Option Description													
I	Base Model	GFC	Gas Flow Controller													
II	Special Application	XX	Standard Application													
		LP	Low Pressure Gases*													
III	Configurability	C	Multi-gas Standard Bins													
		X	Gas Configured													
IV	Gas or Standard Bins	XXXX XXXX	Specific Semi Gas Code and Range													
		PS00-005C	Pivotal Systems Standard Bin 00 0.025-5 sccm N2													
		PS01-020C	Pivotal Systems Standard Bin 01 0.1-20 sccm N2													
		PS02-200C	Pivotal Systems Standard Bin 02 21-200 sccm N2 **													
		PS03-001L	Pivotal Systems Standard Bin 03 201-1000 sccm N2 **													
		PS04-002L	Pivotal Systems Standard Bin 04 1001-2000 sccm N2 **													
V	Fitting & Body Width	01	VCR 1.125"													
		02	C-Seal 1.125"													
		03	W-Seal 1.125"													
		04	C-Seal 1.125" with Poke Yoke													
		05	W-Seal 1.5"													
		06	VCR 1.125" with PCTFE valve seats													
		07	C-Seal 1.125" with PCTFE valve seats													
		08	W-Seal 1.125" with PCTFE valve seats													
VI	Valve Configuration	C	Normally Closed													
VII	Downstream Condition	V	Vacuum													
		A	Atmospheric - This option can be used for all gases except low pressure gases. Inlet pressure must be ≥60 psia													
VIII	Communication Options	Option	I/O	Connector	Power on State	Full Scale Setting	Full Scale Setting	Full Scale Setting	Poll I/O Instance Producer	Poll I/O Instance Consumer	Poll I/O State Transition	SP Delay in ms	External Baud Rate	Mac ID		
		DA	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	2	7	Executing	0	500KB	63		
		DB	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	21	7	Executing	0	500KB	63		
		DC	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	2	8	Executing	0	500KB	63		
		DD	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	21	8	Executing	0	500KB	63		
		DE	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	6	8	Executing	0	500KB	63		
		DF	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	22	7	Executing	0	500KB	63		
		DG	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	3	7	Executing	0	500KB	63		
		DH	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	3	7	Executing	0	500KB	63		
		DI	DeviceNet	5 Pin Micro	Idle	SCCM	Float	6000h	14	19	Executing	0	500KB	63		
		DJ	DeviceNet	5 Pin Micro	Idle	SCCM	Float	6000h	23	20	Executing	0	500KB	63		
		DK	DeviceNet	5 Pin Micro	Idle	SCCM	Float	7FFFh	13	19	Executing	0	500KB	63		
		DL	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	6	8	Executing	0	500KB	63		
		DM	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	2	7	Executing	0	500KB	63		
		DN	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	22	7	Executing	0	500KB	63		
		DO	DeviceNet	5 Pin Micro	Idle	Count	Integer	6000h	22	8	Executing	0	500KB	63		
		DP	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	3	7	Executing	500 ms	500KB	63		
		DQ	DeviceNet	5 Pin Micro	Idle	Count	Integer	7FFFh	1	8	Executing	0	500KB	63		
		EA	Ethercat	Comm: RJ45 Pwr: 5 pin Nano	INIT	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	
		RA	RS-485	9-Pin D	NA	NA	NA	NA	NA	NA	NA	NA	NA	115200	63	
		RB	RS-485	9-Pin D	NA	NA	NA	NA	NA	NA	NA	NA	NA	115200	63	
		RC	RS-485	9-Pin D, RJ45	NA	NA	NA	NA	NA	NA	NA	NA	NA	115200	63	
		<b>Analog DB9 Pin-Out</b>														
			Option	I/O	Connector	Valve Override	Flow Feedback	Power Supply +	Power Supply Common	Power Supply -	Flow Setpoint	Signal Ground	RS 485 +	RS 485 -	Test Point	
			AA	Analog	9-pin D	1	2	3	4	5	6	7	8	9	NA	
			AB	Analog	9-pin D	1	2	3	4	5	6	7, 8	NA	NA	9	
			AC	Analog	20-pin Honda	14	3	4	2	16	11	12	8	9	NA	
			AD	Analog	20-pin Honda	14	3	4	2	16	5	12	8	9	NA	
			AE	Analog	Card Edge	NA	3	4	2	F	A	B+C	NA	NA	NA	
	AF	Analog	Card Edge	D	3	4	2	F	A	B+C	NA	NA	NA			
	AG	Analog	Card Edge-RJ11	J	3	4	2	F	A	B+C+10	3, 4	2, 3	NA			
	AH	Analog	DB9 to DB15	NA	NA	7	5	5	8	NA	NA	NA	NA			
	AK	Analog	20-pin Honda	1	2	3	4	5	6	7, 8	NA	NA	NA			
IX	Special Request	XXXX	Customer Special Request Number													

\* Required for low pressure gases C4H9F, SiH2Cl2, C3H10Si, C5F8, SiCl4, BCl3, C4F6, C4F6-q, C4F8 and WF6.

\*\* Not applicable when selecting Special Application LP (low pressure gases).

\*\*\*The 1.5" W-seal is not available for 5 sccm (Bin 0) and 20 sccm GFC (Bin 1)

Note: If other configurations are required, please contact your sale representative.

## Gas Bin Table (Page 1 of 2)

Title Gas	Gas #	Bin 0: 5 sccm			Bin 1: 20 sccm			Bin 2: 200 sccm			Bin 3: 1000 sccm			Bin 4: 2000 sccm			Inlet Pressure Range (psig)	Max Down- stream Pressure (Torr)
		Min Flow	FS		Min Flow	FS Setting		Min Flow	FS Setting		Min Flow	FS Setting		Min Flow	FS Setting			
			Min	Max		Min	Max		Min	Max		Min	Max		Min	Max		
Air	8	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
Ar	4	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
BCl3	70	0.025	1	5	0.1	6	10	1	11	100	5	101	500	-	-	-	0.3 - 8.2	400
C2F6	118	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	-	-	-	14.5 - 43.5	400
C3F6	138	0.025	1	5	0.1	6	20	1	21	200	5	201	500	-	-	-	3.3 - 43.5	400
C3H2F4	393	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
C3H6	61	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
C3H10Si (TMS)	190	0.025	1	5	0.1	6	20	1	21	200	5	201	500	-	-	-	3.3 - 7.2	400
C4F6	270	0.025	1	5	0.1	6	10	1	11	100	5	101	500	-	-	-	0.3 - 22.6	400
C4F6-q	297	0.025	1	5	0.1	6	10	1	11	100	5	101	500	-	-	-	0.3 - 15.9	400
C4F8	129	0.025	1	5	0.1	6	20	1	21	200	5	201	500	-	-	-	3.3 - 29.2	400
C4H9F	387	0.025	1	5	0.1	6	20	1	21	200	5	201	500	-	-	-	-3.7	Vacuum
C5F8	266	0.025	1	5	0.1	6	10	1	11	100	5	101	500	-	-	-	-3.7 - -0.2	Vacuum
CF4	63	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	-	-	-	14.5 - 43.5	400
CH2F2	160	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	1500	14.5 - 43.5	400
CH3F	33	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	1500	14.5 - 43.5	400
CHF3	49	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	1200	14.5 - 43.5	400
CH4	28	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
Cl2	19	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	1500	14.5 - 43.5	400
CO	9	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
CO2	25	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
COS	34	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	1500	14.5 - 43.5	400
COS-Special	5022	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	1500	14.5 - 43.5	400
F2	18	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400

Note: When the gas is flowing to atmosphere for verification tests the inlet pressure must be greater than 60 psia.

For any flows higher than the listed values, the upstream and downstream pressure conditions change from the standard, so please contact your sales representative to verify the pressure.

For low pressure gases C4H9F, SiH2Cl2, C3H10Si, C5F8, SiCl4, BCl3, C4F6, C4F6-q, C4F8 and WF6 a LP GFC is required.

Inlet Pressures are calculated based on gas properties at 25 °C

For SiCl4, the minimum flow is 1 sccm assuming the pressure requirements are met.

If other configurations are required, please contact your sale representative.

Sample Standard Application Model Code									
I	II	III	IV	V	VI	VII	VIII	IX	
GFC	XX	X	0004-500C	02	C	V	DA	XXXX	

Sample Pivotal System Blank Model Code									
I	II	III	IV	V	VI	VII	VIII	IX	
GFC	XX	C	PS02-200C	03	C	V	DI	XXXX	

Sample LP Application Model Code									
I	II	III	IV	V	VI	VII	VIII	IX	
GFC	LP	X	0266-500C	01	C	V	AA	XXXX	

## Gas Bin Table (Page 2 of 2)

Title Gas	Gas #	Bin 0: 5 sccm			Bin 1: 20 sccm			Bin 2: 200 sccm			Bin 3: 1000 sccm			Bin 4: 2000 sccm			Inlet Pressure Range (psig)	Max Downstream Pressure (Torr)
		Min Flow	FS Setting		Min Flow	FS Setting		Min Flow	FS Setting		Min Flow	FS Setting		Min Flow	FS Setting			
			Min	Max		Min	Max		Min	Max		Min	Max		Min	Max		
H2	7	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
HBr	10	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	-	-	-	14.5 - 43.5	400
He	1	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
Kr	5	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
N2	13	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
N2O	27	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
NF3	53	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
NH3	29	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
O2	15	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
SF6	110	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	-	-	-	14.5 - 43.5	400
Si2H6	97	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	1500	14.5 - 43.5	400
SiCl4	108	-	-	-	-	-	-	-	-	-	1	10	100	-	-	-	-11.7 - -10.1	Vacuum
SiH2Cl2	67	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	-	-	-	3.3 - 13.6	400
SiH4	39	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
SO2	32	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
WF6	121	0.025	1	5	0.1	6	10	1	11	100	5	101	500	-	-	-	-2.7 - 3.7	Vacuum
Xe	6	0.025	1	5	0.1	6	10	1	11	100	5	101	500	-	-	-	14.5 - 43.5	400
5% B2H6 in Ar	615	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
5% B2H6 in N2	654	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
6% B2H6 in N2	927	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
2.7% C2H4 in He	897	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
4% H2 in N2	607	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
30% O2 in He	604	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
50% PH3 in SiH4	632	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400
20% SiH4 in He	529	0.025	1	5	0.1	6	20	1	21	200	5	201	1000	10	1001	2000	14.5 - 43.5	400

Note: When the gas is flowing to atmosphere for verification tests the inlet pressure must be greater than 60 psia.

For any flows higher than the listed values, the upstream and downstream pressure conditions change from the standard, so please contact your sales representative to verify the pressure.

For low pressure gases C4H9F, SiH2Cl2, C3H10Si, C5F8, SiCl4, BCl3, C4F6, C4F6-q, C4F8 and WF6 a LP GFC is required.

Inlet Pressures are calculated based on gas properties at 25 °C

For SiCl4, the minimum flow is 1 sccm assuming the pressure requirements are met.

If other configurations are required, please contact your sale representative.

Sample Standard Application Model Code									
I	II	III	IV	V	VI	VII	VIII	IX	
GFC	XX	X	0654-750C	06	C	V	AB	XXXX	

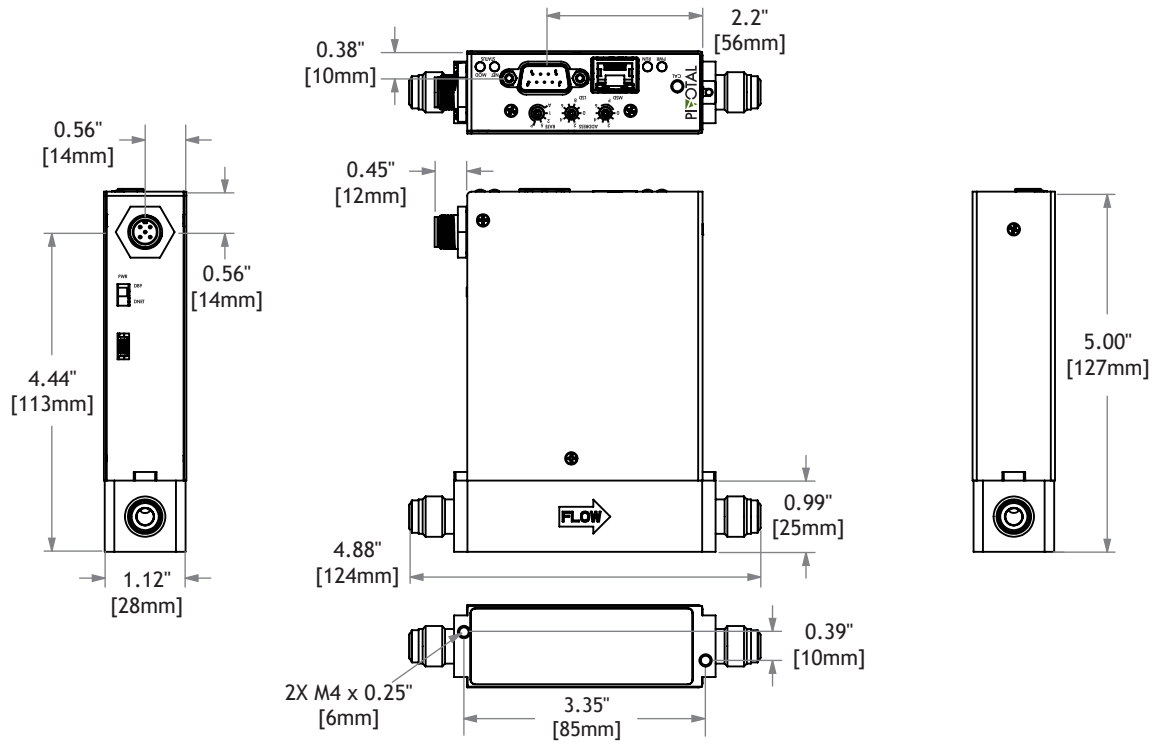
  

Sample Pivotal System Blank Model Code									
I	II	III	IV	V	VI	VII	VIII	IX	
GFC	XX	C	PS04-002L	07	C	V	RA	XXXX	

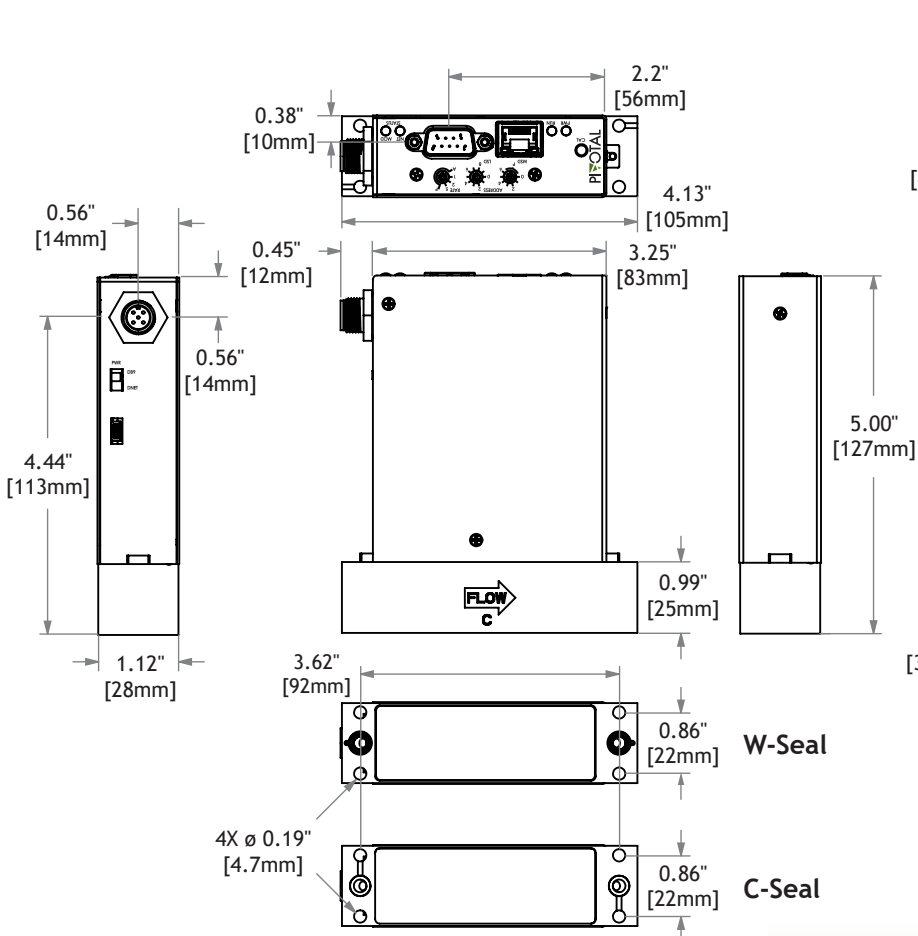
  

Sample LP Application Model Code									
I	II	III	IV	V	VI	VII	VIII	IX	
GFC	LP	X	0121-500C	08	C	V	EA	XXXX	

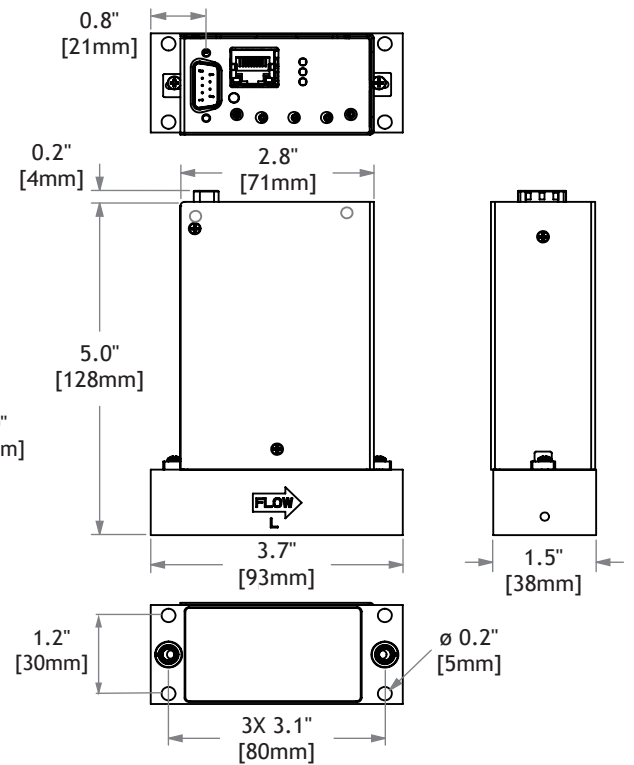
## GFC VCR Dimensions



## GFC C-Seal and W-Seal Dimensions

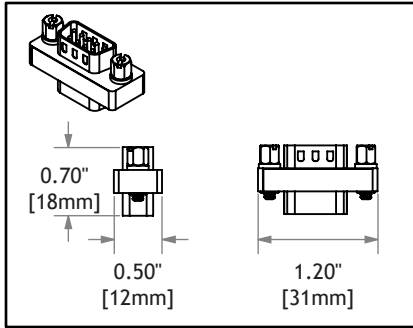


## GFC 80mm W-Seal Dimensions

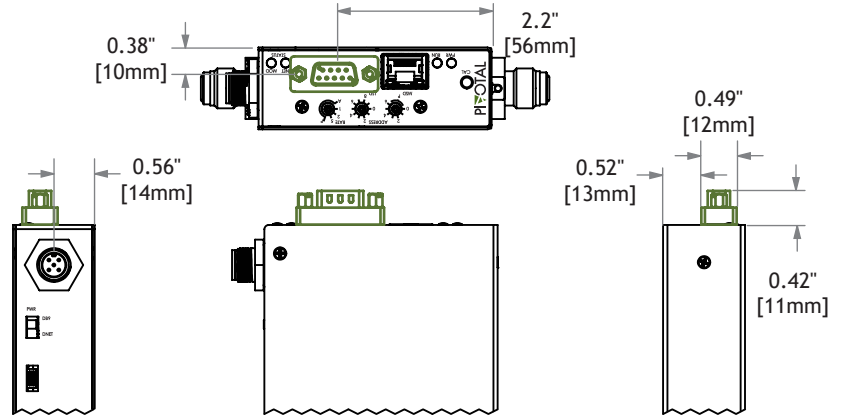




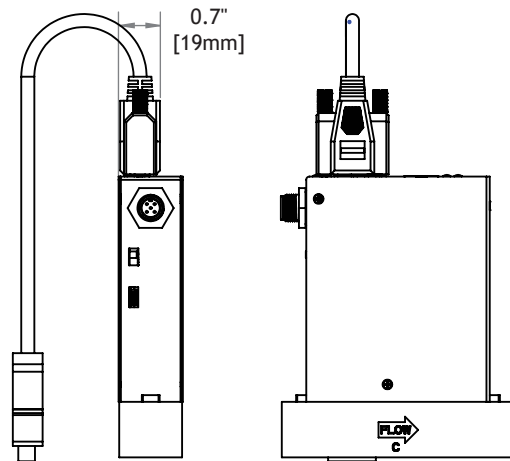
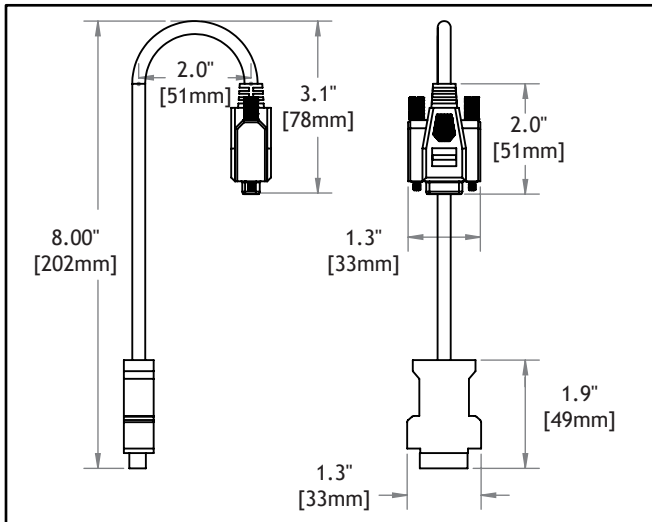
## GFC Analog Adapter (AB)



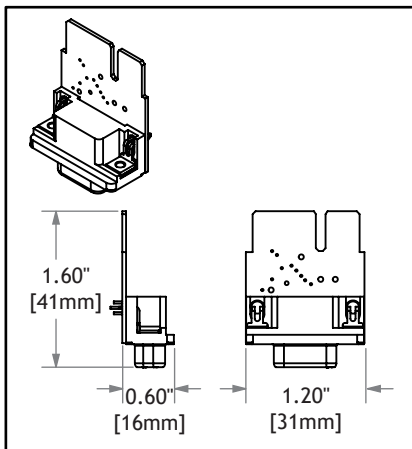
On the right is how the adapter (in green) is attached to the GFC.



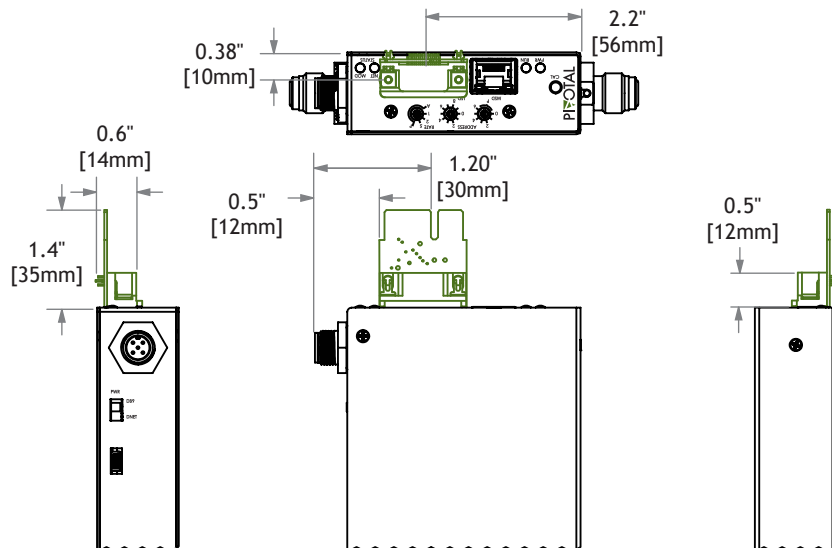
## GFC Honda Adapter (AC/AD/AK)



## GFC Card Edge Analog Adapter (AE/AF)

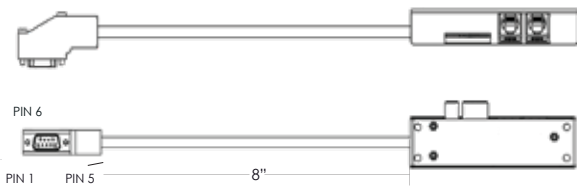


On the right is how the adapter (in green) is attached to the GFC.

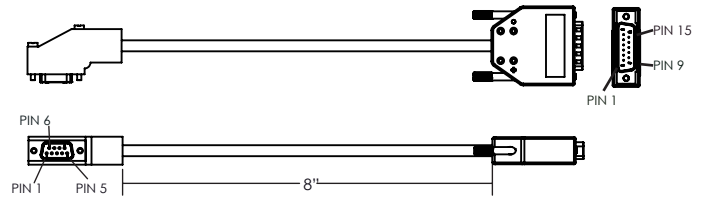




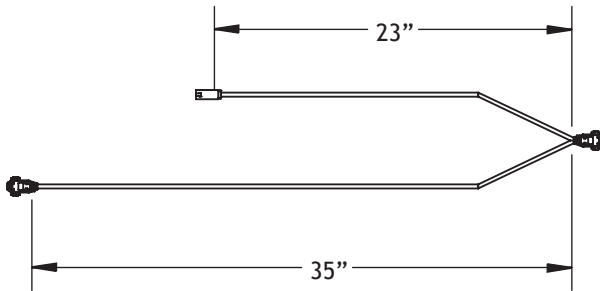
## GFC DB9 to Card Edge - RJ11 Cable (AG)



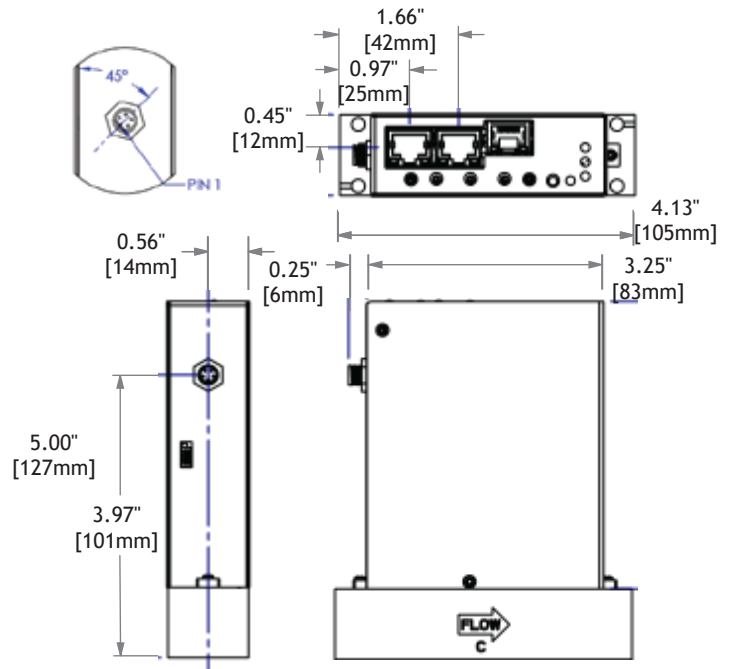
## GFC DB9 to DB15 Adapter Cable (AH)



## GFC FNET Cable (RC)

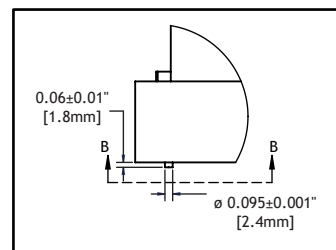
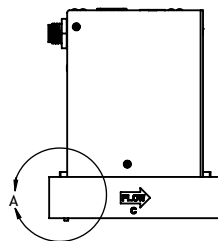


## GFC Ethercat C-Seal and W-Seal Dimensions

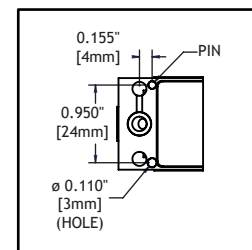


## GFC C-Seal Poke Yoke Dimensions

Refer to the GFC C-seal drawing for more detail.



Detail A



Section B-B

## About Pivotal

Pivotal Systems Corporation provides best-in-class monitoring and process control technology for the semiconductor manufacturing industry. Pivotal's vision is to enable an order of magnitude increase in fab productivity and capital efficiency for current and future technology nodes. This vision is achieved through its real time in situ process monitoring and control solutions. Founded in 2004 and based in Fremont, California, the company is led by veterans from the semiconductor and high-tech industries. For more information about Pivotal, visit [www.pivotal.com](http://www.pivotal.com) or send an email to [support@pivotal.com](mailto:support@pivotal.com).

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