SENIOR DESIGN PROJECT REPORT

RESIDENTIAL & LIGHT COMMERCIAL SYSTEMS ENGINEERING STANDARD

TITLE: Final Report for Mini-Code tester

Submitted to

Professor David Goodman
Engineering Technology Department
By
Daniel Ortman
Chase Rumple

Dec 1, 2019

EXECUTIVE SUMMARY

The Mini-Code tester was a senior design project provided by Carrier Corporation. The mini code tester was an already implemented system that was outdated and needed redesigned to improve operator usability and increase measurement accuracy. The device is used to test airflow leakage on furnace cabinets and fan coil cabinets designed at Carrier Corporations residential engineering laboratory. This project was focus on automating a completely manual system. The old Mini-Code tester's instrumentation was manually measured, and data produced by the system was all hand recorded by a technician in an excel spreadsheet. For the upgrade the device was fitted with digital sensors and a data acquisition system to both tighten the accuracy of the system and to digitally record data. The specifications provided by Carrier Corporation were met and satisfied the customers' requirements for the testing performed on the device. The sensors were selected to meet ASHRAE Standards and Guidelines for this type of system. While this project focused specifically on the hardware and software portion of the redesign; the Mini-Code tester's measurement duct also underwent a complete redesign outside of the scope of the project that occurred simultaneously. This work was completed by engineers and technicians at Carrier Corporation.

Table of Contents

Table of Contents Continued

REVISION HISTORY

Rev Letter	Description	Originated By	Date
A	**Polished draft**	**Daniel Ortman & Chase Rumple**	**11/26/19**
B	**Final Draft**	**Daniel Ortman & Chase Rumple**	**12/9/19**

Introduction

The Mini Code Tester is used at the Carrier Residential Engineering Laboratory in Indianapolis. The Mini Code Tester is used to get performance information on furnace and fan coil cabinet leak rates at various static pressures. It is also used to test inducer fan motors to generate airflow curves used by product development teams when designing furnaces. The redesign focused on the control and data acquisition of the system and improving the measurement uncertainty and test variability by implementing sensors and a data collection system. The redesign has taken place over the course of two semesters from January to December in 2019.

Our Customer

Our customer was the Carrier Corporations Residential Engineering Laboratory. The mini code tester is utilized by various departments for various tasks that involve low airflow measurements. The engineering services department owns the current system because they support the entire lab.

Our Project Champion

Mark Singer- Mark has had several roles at Carrier's Residential engineering laboratory over 20+ years. He has been the cooling lab supervisor, a product development engineer in the cooling group. He has been the manager of the engineering services department but most recently he has transitioned into a Lab Engineer. In this position he is responsible for ensuring lab productivity and troubleshooting issues with the lab equipment on a system level.

Our Competition

The code tester was designed and built by a former engineer at Carrier and is not commercially available however similar products can be acquired from Test Chamber engineering firms that supply HVAC testing products to various industries. CTS Climatic Testing Systems and Q Corporation are both supplies of this type of airflow measurement system. Their products offer a much higher end UI then we were able to produce for this project, but the cost of this project was be significantly lower than the competition while providing a lot of the desired benefits of an upgrade.

Scope

Identification

To redesign and update the Mini Code Tester by implementing sensors and data collection using a DAQ with a Lab VIEW interface. The Lab VIEW interface is user friendly to the technician(s) trained on the system. A control box includes the necessary measurement equipment for the data collection and route the information to a PC dedicated to the code tester, then record the data in an EXCEL spreadsheet. Various sensors such as: relative humidity, barometric, temperature and static pressure sensors, are installed on the new code tester. A variable frequency drive was installed on the motor that allows the system to control the static pressure to achieve the desired pressure set points. The calculated airflow channels to meet the ASHRAE 41.2 guidelines specified for systems of this type.

Old System

The old system utilized slope gauges for pressure measurements used to determine airflow through the system. These gauges need to be leveled and zeroed prior to use for an accurate reading so if they are improperly setup the system could produce measurement errors that would negatively affect the data produced by the system. All of the measurements used to calculate airflow were manually recorded by a technician in an excel spreadsheet where formulas calculate airflow through the system. This process is tedious and is prone to error if data is entered incorrectly. That has resulted in invalid testing done on the system which can delay projects and result in lost time.

Figure 1

The Original Mini-Code Tester System

System Upgrade Overview

- Update data collection process using an Excel based data format.
- Improve instrument measurement accuracy by 10%, for low pressure readings critical to airflow measurement.
- Create a Lab VIEW User Interface that is easy to use by technicians trained on the equipment.
- Integrate VFD and/or Automated Damper for Static Control (PID)
- Calculate Airflow channels that meet ASHRAE 41 guidelines

Low Level Design and Hardware Selection

Engineering Specifications

Table 1

Applicable Standards

Title	Source	Comment
ASHRAE 193 Method of Test for Determining the Airtightness of HVAC Equipment	American Society of Heating, Refrigerating, and Air-Conditioning Engineers	This standard applies to leak testing a required application of this system.
ASHRAE 41 Standard Methods for Measurement	American Society of Heating, Refrigerating, and Air-Conditioning Engineers	This standard series covers accepted methods for conducting a variety of measurements that are used in the system.
ASHRAE 51 Laboratory Methods of Testing Fans for Aerodynamic Performance Rating	American Society of Heating, Refrigerating, and Air-Conditioning Engineers	This standard applies to testing a fans performance a required application of this system.
ASME 19.5 Flow Measurement	American Society of Mechanical Engineers	This standard covers different types of flow measurement devices.
The National Electrical Code	National Fire Protection Association	This standard covers the electrical system design requirements.

Table 2
Standard Requirements and Hardware Specs

Standard Accuracy Requirements:			
Measurement	ASHRAE 193	ASHRAE 41.2	ASHRAE 51
Temp	±2F	±0.5F	±2F
Humidity	N/A		2F(wet bulb)
Low Pressure	±0.004 inWC	±0.1 inWC	±.005inWC
Barometric Pres.	±0.15 inHg	Not Defined	±.05 in Hg
Time	Not Defined	±0.5% of elapsed time	Not defined
RPM	N/A	N/A	±0.5% of reading

System Wide Design Decisions

The design decisions included in this document are the DAQ, humidity sensor, and barometer selection. These are high cost and important elements to the design of the project.

DAQ C&E Matrix Description

Categories in the matrix are weighted from 1-10, 10 being high priority to 1 being low priority. For example, resolution is weighted at a 10 making that category the highest priority. High resolution was wanted for this device for accuracy purposes. Each device was then weighted by the categories based on specifications needed for this device. Based on specifications from manufacture datasheets compared to required specifications for the code tester. The cDAQ-9185 was chosen based on the industrial design of the chassis and cards. The cards are removable allowing the ability to change them out for better quality and input and output variability. This data acquisition device is designed to work in industrial formats. Along with the chassis, the input card gives 16 inputs using the NI-9208 card and 8 outputs using NI-9264 output card. Overall specs resulting in 100 S/s/ch update speed, 24 bits of resolution for pinpoint accuracy and communication over Ethernet.

Figure 2
DAQ C&E Matrix

C&E Matrix								
	DAQ requirements:	1Hz	12bit	6CH	2CH			
	Type	Update Speed	Resolution	Analog Input	Analog Outputs	Cost	Connection Type	Totals
	Part Number	5	10	6	5	8	8	
1	DS-USB-1808	5	8	5	4	7	5	251
2	cDAQ-9185	4	10	6	5	4	8	277
3	OMB-DAQ-2416	3	10	6	4	5	5	251
	Totals	60	280	102	65	128	144	
	Type	Update Speed	Resolution	Analog Input	Analog Outputs	Cost	Connection Type	
	Part Number							
	DS-USB-1808	200kS/s	18bit	8	2	899	USB	
	cDAQ-9185	100S/s/ch	24bit	16	8	2556	Ethernet	Chassis w/Cards
	OMB-DAQ-2416	1000Hz	24bit	16	4	1207	USB	
	cDAQ-9185	1207						
	cards	Type	channels	Update Speed	Resolution	cost	QT	
	NI-9208	An. Input	16	500S/s/ch	24Bit	749	1	
	NI-9264	An. Output	8	25kS/s	16Bit	654	1	

Humidity Sensor C&E Matrix Description

In this humidity sensor selection matrix, the important factors were the resolution and the accuracy because of the need for high measurement accuracy desired for the airflow calculations. Another important element was the cost of the sensor, due to the relatively low budget, the sensor needed to have a low cost. Also, due to the sensor being installed in a 4" tube a smaller process connection would be easier to install and would not obstruct the airflow in the system. The PTU 333 was selected because it had a high accuracy/precision compared to the HX200, relatively low cost and smaller process connection than the Optidew.

Figure 3
Humidity Sensor C&E Matrix

Humidity Sensor						
	Type	Resolution	Accuracy	Cost	Process Connection	Totals
	Part Number	8	10	10	8	
	Optidew	10	10	2	3	224
	PTU333	8	8	5	10	274
	HX200	8	5	7	10	264
	Totals	208	230	140	184	

Type	Resolution	Accuracy	Cost	Process Connection	Output Type
Part Number					
Optidew	.01RH	.15 c dewpoint	5160	M36	4-20mA
PTU333	.1RH	1%rh	3000	1/2"NPT	4-20mA/0-5/10
HX200	.1RH	1 dgC dewpoint	805	1/2" NPT	4-20mA
Requirements	1F WB(1.5F dewpoint , 2.5% RH	2F WB (3 deg F DP/ 5%RH)			

Barometer C&E Matrix Description

In this selection matrix the repeatability, accuracy, cost, and output type were considered. The accuracy and the repeatability are important because of the need for high measurement accuracy desired for the airflow calculations. Another important element was the cost of the sensor, due to our relatively low our budget, our sensor needed to have a low cost. The PTU333 was selected because it has both the humidity and barometric pressure readings in one transmitter that made it lower cost compared to the other options. It also had the best accuracy and had selectable outputs making it flexible.

Figure 4
Barometer C&E

Barometer						
	Type	Repeatability	Accuracy	Cost	output type	Totals
	Part Number	8	10	10	8	
	P-30	5	5	5	10	220
	PTU333	10	10	5	10	310
	PX02K1-26A5T	8	7	8	10	294
	Totals	184	220	180	240	

Type	repeatability	Accuracy	Cost	Output Type
Part Number				
P-30	Not defined	.05%FS	1700	4-20ma
PTU333	±0.03 hPa	±0.10 hPa	3000	4-20ma/0-5/10V
PX02K1-26A5T	±0.05% FS	0.25% FS	828	4-20mA
Requirements	N/a	.05inHg		

Final Design Specifications

Table 3
Instrumentation Specs

Instrumentation Specs:						
Make	Sensor M/N	Transmitter M/N	Measurement	Output	Accuracy	Range
M-System	PT100 Class A RTD	B3FR	Temperature	4-20mA	±0.2% FS (+/-0.3F)	0-150 Deg F
Vaisala	Humicap 180	PTU333	Humidity	4-20mA	±1% RH	0-100 %RH
Vaisala	Barocap	PTU333	Barometric Pressure	4-20mA	±0.03 inHg	500 - 1100 hPa
MKS	Baratron 698A	Signal CON 670	Static Pressure	0-5V	±0.12% rdg	0 -5 .36 inWC
MKS	Baratron 698A	Signal CON 670	Pressure Differential	0-5V	±0.12% rdg	0 - 5.36 inWC
Banner/ Red Lion	BT23S	PAX	RPM	4-20mA	±0.17% FS	0-5000 RPM

Table 4
Data Acquisition Specifications

DAQ Specs:			
Make	Model	Specs	Inputs/Outputs
National Instruments	cDAQ-9185	4 Slot Chassis	Ethernet Communication
National Instruments	NI 9207	16 AI Channels24 Bit, 500 S/s/CH	(8)+/- 20mA inputs(8) +/-10V inputs
National Instruments	NI 9375	16 Channel Digital IO module 0-30VDC	(8) Digital Inputs(8) Digital Outputs
National Instruments	NI 9266	8 AO Channels16 bit, 24kS/s/CH	(8) 0 to 20mAOutput Channels

Table 5

Computer Specifications

PC Specs:	
Make	Model
Dell Insperon	Insperon 3268
Specs:	
OS:	Windows 10 Pro
CPU:	Intel i3-7100
Memory:	4GB DDR4
Graphics	Intel HD630
Storage	1TB HDD
	DVD+/-RW Drive
Ports:	4 USB 2.0
	2 USB 3.0
	1 HDMI
	1 VGA
	1 RJ45
	1 PCIe x1
	1 PCIe x16

New System

Figure 5

New Completed System

Figure 6

Electrical Enclosure

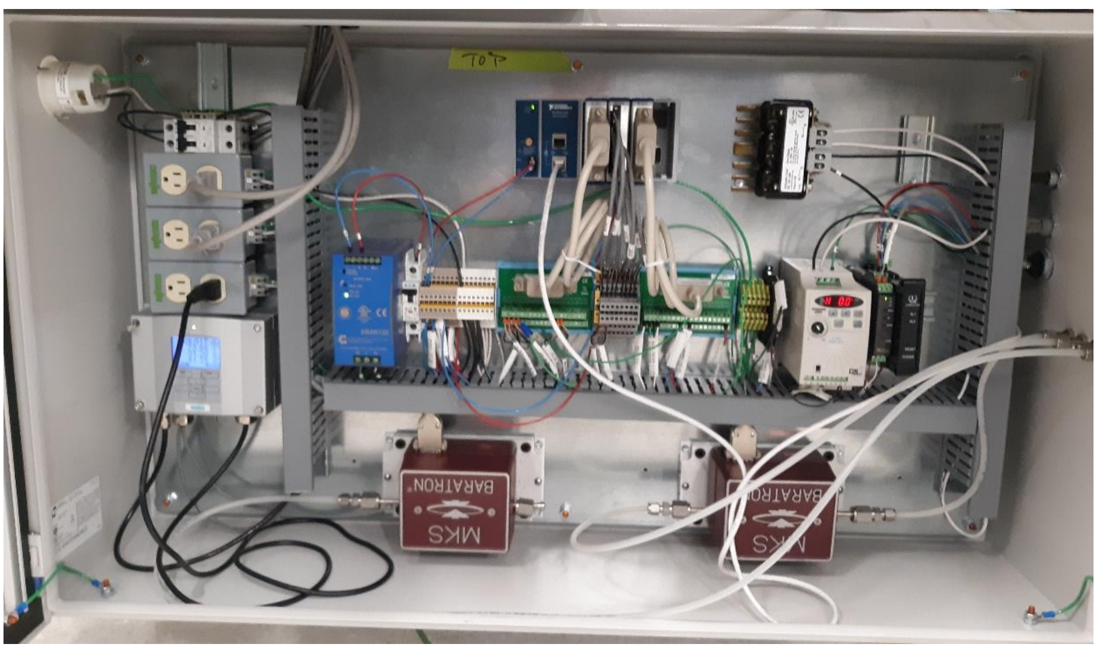


Figure 7

Signal Conditioners

New System Features

- PID static control via auto damper or variable frequency drive
- Digital high accuracy sensors
- Lab VIEW user interface
- Ability to graph live data of up to five measurement parameters
- Automated report generation
- In software calibration
- Ability to generate configuration files to customized user interface
- ASHRAE 41.2 compliant airflow calculations
- Ability to average report data points over a specified time
- Stability indicators that show when system has reached steady state conditions
- Nozzle installation detection updates calculations to reflect the current system configuration
- Password protection of sensitive system parameters

Theory of operation

The system is a type of differential flow meter that utilizes the principles of conservation of mass and energy to derive flow through the system. The measured parameters needed for the system to calculate airflow are temperature, humidity, and barometric pressure, static and differential pressure. The temperature humidity and barometric pressures are used to calculate the density of the air in the system. Once the density of the air is known; the static and differential pressures are used to determine the airflow through the system. The proper dimensions of the measurement device are defined in ASHRAE 41.2; the construction of the measurement device was out of the scope of this project but was completed by a team of engineers at Carrier Corporation. The exact equations utilized by the software to calculate airflow through the system are defined in ASHRAE 41.2 (ASHRAE, 2019).

System Components

Measurement Hardware

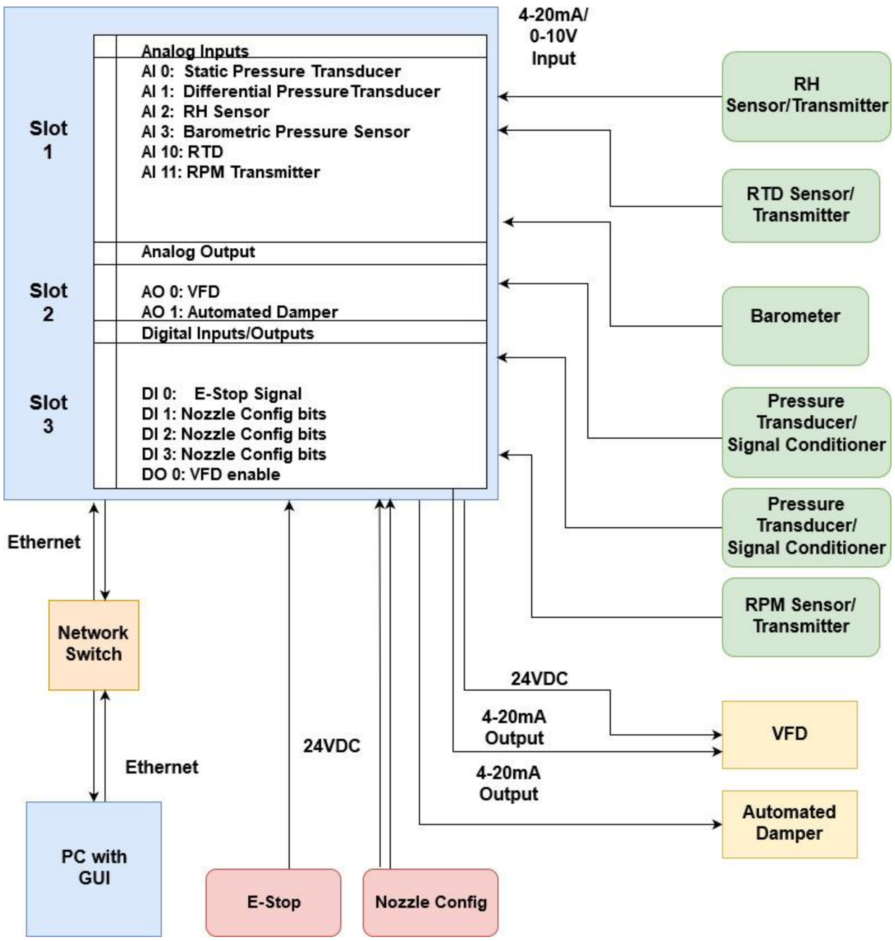
- DAQ
- RH sensor/Transmitter
- Temperature sensor/Transmitter
- Barometric pressure sensor/Transmitter
- Static pressure sensor/Transmitter
- Differential Pressure switch/Transmitter
- Power Meter
- Dedicated PC –Dell PC

Control & Electrical Hardware

- VFD / Automated Damper
- Electrical enclosure
- Fuses/ Disconnect
- Terminals
- Din rail
- Wire/ Cables and harnesses
- Wire Traces
- Labels
- Din Rail mounted 120V Outlets

Figure 8

Hardware Block Diagram

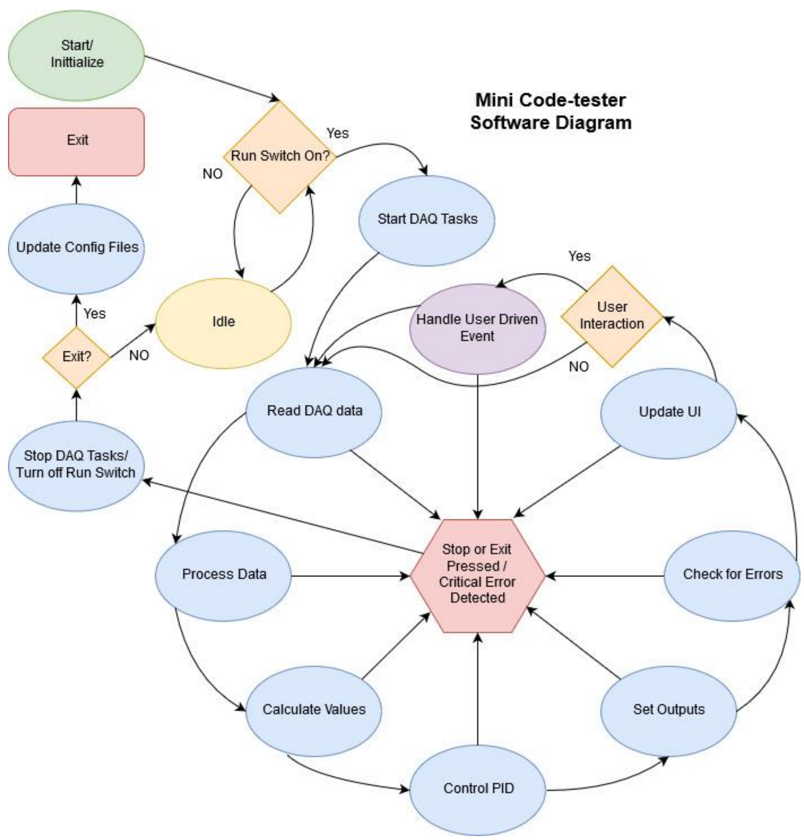


Hardware Block Diagram Description

To the right on the block diagram are the inputs and outputs. The inputs are feeding 4 to 20 mA / 0-5V signals into the Data Acquisition System (DAQ). The analog inputs include a Relative Humidity Sensor, RTD Sensor, Barometer, and two Pressure transducers. The outputs are a Variable Frequency Drive and an automated damper. The DAQ's information is transmission to the PC via Ethernet. The digital inputs include an E-stop and a set of bits utilized by the system to detect the installed nozzle so the system can calculate the airflow based on the size of the nozzle without requiring input from the user.

Figure 9

Software Block Diagram

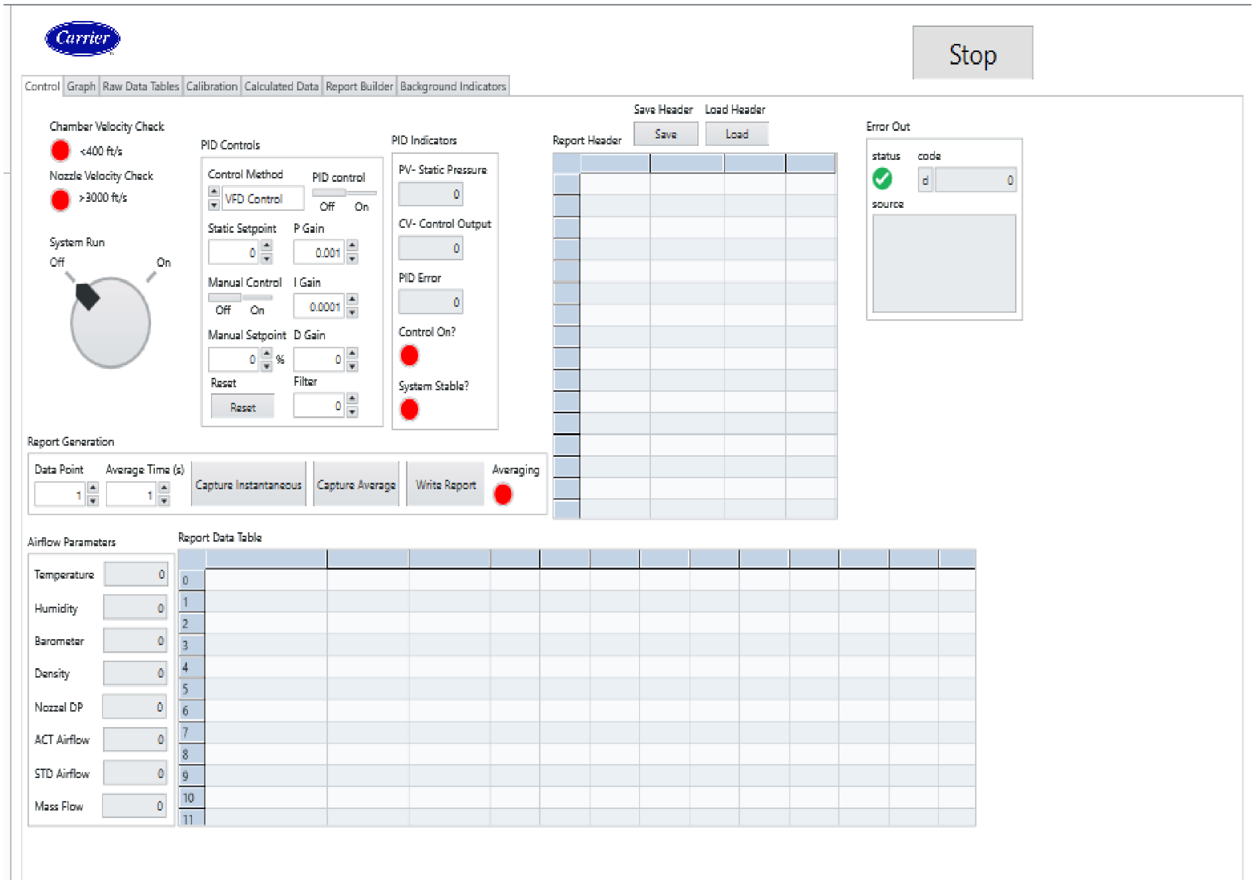


Software Diagram Description

This diagram highlights the flow of the software execution. When the software is opened it goes through an initialization process that loads data from the latest configuration files utilized by the system. Controls and indicators are also updated to their default state. Once the user switches the System Run switch on the program starts the DAQ tasks and begins collecting and processing data in the continuous loop shown.

The system handles user events as interrupts to the loop process and then continues the loop where it left off. Errors or the stop button will kick the system of the loop and some critical errors may cause the program to stop. The configuration files are updated prior to the software exiting so the latest values will be updated and can be referenced on the next startup, so the system starts up where the user left off.

Figure 10
The User Interface



UI description:

This is the main control panel for the system operator. The System Run Switch starts the software and begins collecting data.

The PID control section in the top left turns on and off the VFD/Damper control with the PID control checkbox. The Control can be set to Manual or Automatic and the operator can change the desired static pressure set point for the system as well as the PID parameters. The PID indicators Cluster gives the user feedback about the state of the PID control process.

The Manual Report Generation Control cluster is used to capture data points in the Report Data Table by selecting the Capture Instantaneous button or the Capture Average button.

Points can be retaken by changing the value in the data point control index. Once a test is complete the user can generate a report from the data entered into the Report Header Table and the data collected by the system in the Report Data Table. A file dialog box will open to allow the user to enter a save location for the file and once the operation is complete the data in the Report Data Table is cleared.

The error section will notify the user of any issues with the software and hardware installed on the system.

The Airflow Parameters indicate the latest airflow measurement values calculated by the system. These indicators update once per second by the system when the run switch is activated.

Troubleshooting and Design Changes

VFD and Estop Circuit

Once the wiring was complete on the hardware the system was ready to test. The system powered up properly and all the hardware functioned as designed. However, the VFD control circuit needed some adjustments to work properly.
On startup The VFD was initialized with the nameplate settings from the motor and the input settings desired for the application and control methods. However, it was determined that the original design needed some adjustments for safety concerns. Originally the VFD was going to be stopped by the software in the event of an emergency however this was determined to be a safety issue if the hardware lost communication with the software. So, the design adjustment was to have the E-stop physically break a circuit to disable the motor and then have a feedback signal to let the software know the VFD was pressed to alert the user.

In the new design the VFD is enabled with a digital output 0 from the DAQ when control is enabled through the software. This output goes to a relay that jumpers the digital input on the VFD to the VFD common. A physical E-stop is added in series with the relay to a normally closed contact that will open the circuit if a safety issue occurs and a technician presses the button. This circuit must be completed to allow the VFD to operate and works independently of the software. A separate circuit is utilized to feed 24V from the power supply through a normally open contact in the E-stop to a digital input on the DAQ. This is utilized by the software to let the operator know the E-stop has been pressed.

Measurement issues

During the initial testing of the system the readings from the hardware all seemed to work properly when tested. The measurements seemed accurate and appropriate so during initial testing the airflow measurements were being properly recorded everything looked well. After some tuning of the system PID parameters the system was able to control static pressure effectively but not quite as well as expected. After plotting the measurements on the graph tab and testing the control of the system the control seemed to be working great but the measurements for static and differential pressure had some fluctuations that were small but were affecting the stability of the system too much. The system couldn't quite hold a 1% tolerance on airflow measurement all the time and had a particularly difficult time doing so at low airflows.

The first though was that the sampling interval of 1 second per channel was contributing to the instability so the software was updated to allow for additional samples from the hardware within the update rate of the software. These additional samples would be averaged, and the average would be used by the system for the reading of that analog channel at the 1 second update rate of the software.

This adjustment did have some improvement on the system performance but did not entirely fix the stability issues from the measurement system. Multiple sample rates were tested from 10 -100S/ch/s the problem persisted. So, a 10 second running average was added to the measurements to add additional filtering to the signals. This fixed the issue of measurement stability but caused a control issue were the PID was responding to quickly and throwing the system into wild oscillations.

A patch was added to allow the PID control to utilize the pressure measurement unfiltered by the 10 second running average for control while the measurement system utilized the 10 second running average signal to calculate airflow through the system. This solved the issue with the PID control and the problems with measurement stability the system worked as intended. The PID was able to control static pressure effectively and the airflow measurements were stable enough to maintain a 1% tolerance.

To improve the fix from a software readability standpoint some investigation was done on the filtering option available within Lab VIEW NXG. This investigation led to testing filter options on raw readings from the system hardware to test filter designs and other possible solutions. While recording this data and visualizing it in real time some irregular patterns were discovered on the analog inputs. Irregular signal fluctuations seemed to affect all the channels on the analog input card. Upon further analysis using an FFT of a measured signal it was determined to be 60Hz line noise on the analog input DAQ card; it looked like the system may have had a wiring issue.

After some investigation of the system hardware and the hardware datasheets it was determined that the common section of the DAQ card was not properly referenced to system ground. So, the hardware was adjusted to tie the analog input card to system ground via a jumper wire. After referencing the DAQ card to ground the 60Hz line noise was gone and the signal fluctuations were reduced significantly. This fix and the implementation of running average filtering and increased sampling rates for analog input channels the system measurement, control, and stability increased drastically. The system is now able to hold a 1% measurement tolerance with ease.

Figure 11
Static Pressure Signal with grounding Issue

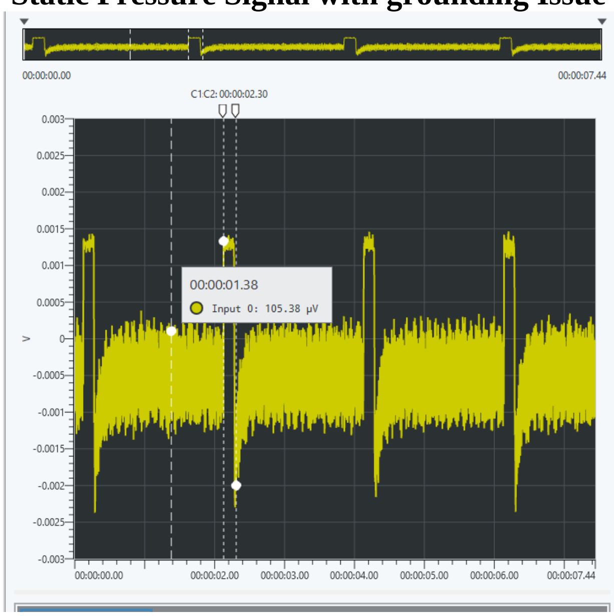
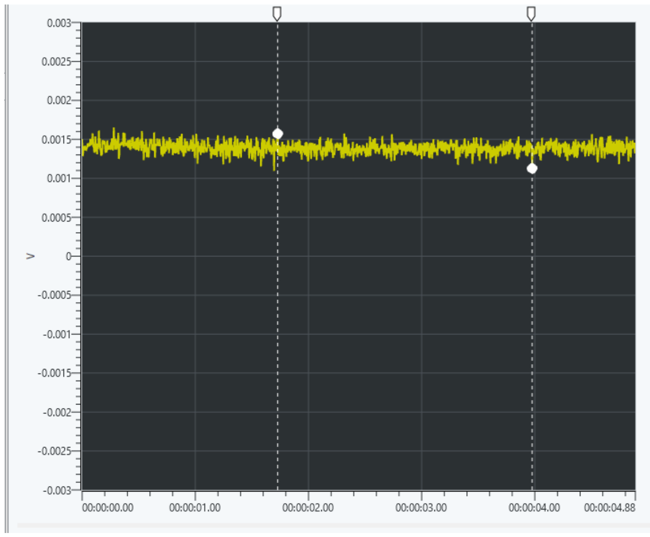


Figure 12
Static Pressure Signal with Proper Grounding



Gauge R&R

Gauge R&R Test Procedure

In order to validate the new measurement system and determine the impacts on improved measurement performance and test variability a gauge R&R was conducted to measure the impact of the changes implemented on the new system and compare its results to the old system.

32 tests were performed with one repeat on each system totaling 64 unique measurements per system. The tests were designed to look at the measurement range of one nozzle and they were performed randomly to determine the variability of each measurement system. Two PVC end caps were constructed with the same sized 1.33” holes to simulate a unit leak rate. These caps were installed twice during the testing in random orders. For each install the system was controlled to 4 different set points in a randomly determined run order: -.5inWC static, -.75inWC static, 1” delta P and 2” delta P. This process was then repeated by another technician to allow for even more variability to be determined. The gauge R&R results were then analyzed using Minitab to determine the variability within each measurement system and to compare that variability system to system.

Figure 13

PVC End Caps Used to Test the Systems

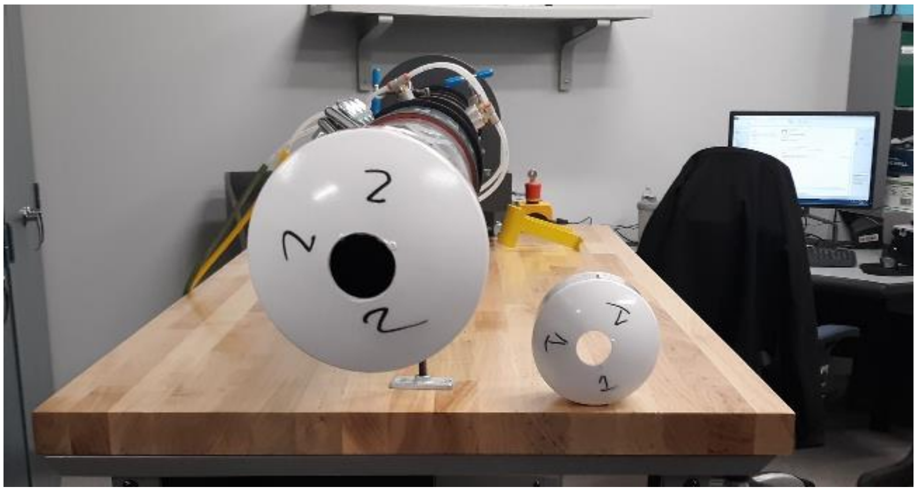


Table 6
Gauge R&R Test Matrix Old System Tech-A Install 1

Test#	Repeat	Test Stand	Plug (Parts)	Technician (Operator)	Install	Test Point
1	1	Old	2	A	1	0.5" ESP
1	2	Old	2	A	1	0.5" ESP
2	1	Old	2	A	1	1" PV
2	2	Old	2	A	1	1" PV
3	1	Old	2	A	1	0.75" ESP
3	2	Old	2	A	1	0.75" ESP
4	1	Old	2	A	1	2" PV
4	2	Old	2	A	1	2" PV
5	1	Old	1	A	1	2" PV
5	2	Old	1	A	1	2" PV
6	1	Old	1	A	1	0.75" ESP
6	2	Old	1	A	1	0.75" ESP
7	1	Old	1	A	1	1" PV
7	2	Old	1	A	1	1" PV
8	1	Old	1	A	1	0.5" ESP
8	2	Old	1	A	1	0.5" ESP

Gauge R&R Results

-0.5 inWC Test Point Data

Figure 14
Summary of Old System SCFM Data Taken @ -0.5 inWC

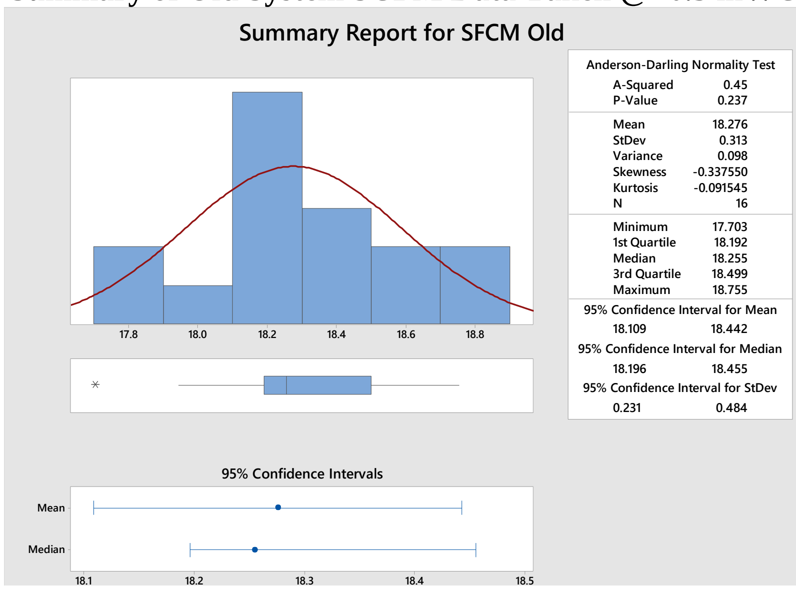
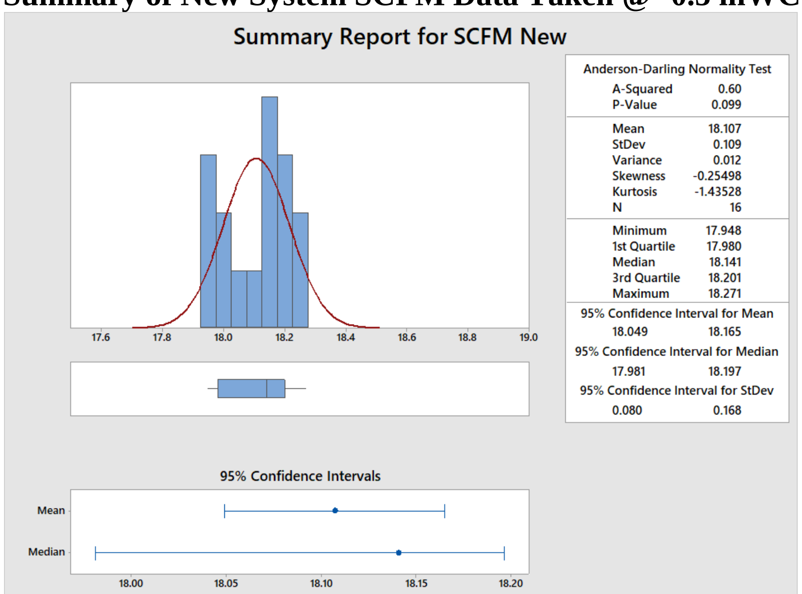


Figure 15
Summary of New System SCFM Data Taken @ -0.5 inWC



-0.5 inWC Test Point Data Summary Analysis

From the two data sets its clear the data spread is much less on the new system. There was a reduction in the sample standard deviation from 0.313 on the old system to 0.109 on the new system a 287% reduction. The new systems data is less skewed and has a lower variance than the old system. The P values from both data sets are >0.05 showing that they cannot be determined to be non-normal distributions. So one can assume that both data sets are normal distributions (Minitab, 2019).

Two Sample T-Test

A Two Sample T test was conducted on the data set for the -0.5 in WC test point to determine if there was a statistical difference between the SCFM measurement on the two test stands.

Two-Sample T-Test and CI: SCFM old, SCFM NEW

Method

μ_1: mean of SCFM old

μ_2: mean of SCFM NEW

Difference: $\mu_1 - \mu_2$

Equal variances are not assumed for this analysis.

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
SCFM old	16	18.276	0.313	0.078
SCFM NEW	16	18.107	0.109	0.027

Estimation for Difference

Difference	95% CI for Difference
0.1685	(-0.0053, 0.3424)

Test

Null hypothesis	H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis	H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
2.04	18	0.057

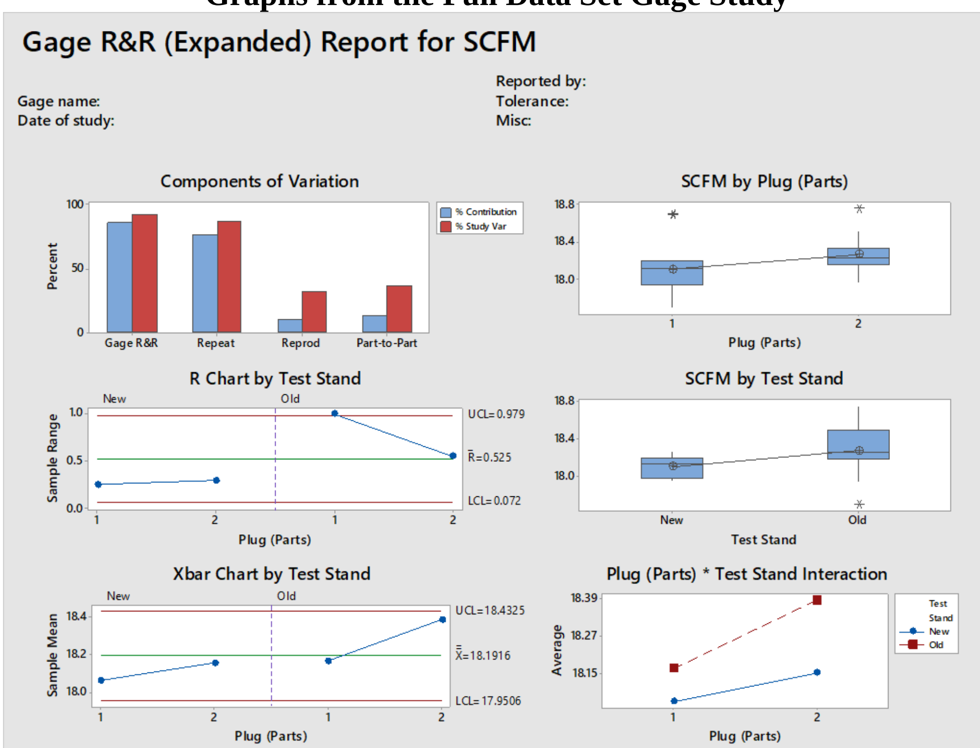
Two Sample T-Test Analysis

The P value of 0.057 from the test shows that there is not a statistically significant difference between the two data sets. This means that the updated system has not made statically significant difference on the airflow measurement through the system. The p-value indicates that the difference in the two measurement data sets could be due to random variation 5.7% of the time. Ideally this test would have showed that there was a significant difference between the two measurement systems. However, the p-value was relatively low so that is encouraging, and the reduction and the spread of the data set shows that the new system is doing a good job of reducing variation. This result shows that the new system and the old system produced similar results (Minitab, 2019).

Gauge R&R of -0.5 inWC Test Point with Full Data Set

A gage study was conducted on the whole data set to conclude if the systems could determine the part to part variation of the PVC end caps used to test the systems.

Figure 16
Graphs from the Full Data Set Gage Study



Gage R&R Study: SCFM versus Plug (Parts), Test Stand, ... n (Operator)

Factor Information

Factor	Type	Levels	Values
Plug (Parts)	Random	2	1, 2
Test Stand	Fixed	2	New, Old
Install	Random	2	1, 2
Repeat	Fixed	2	1, 2
Technician (Operator)	Fixed	2	A, B

ANOVA Table with All Terms

Source	DF	Seq SS	Adj SS	Adj MS	F-Value	P-Value
Plug (Parts)	1	0.19212	0.19212	0.192121	3.57	0.070
Test Stand	1	0.22724	0.22724	0.227239	4.22	0.050
Install	1	0.01130	0.01130	0.011304	0.21	0.651
Repeat	1	0.03465	0.03465	0.034645	0.64	0.430
Technician (Operator)	1	0.00517	0.00517	0.005167	0.10	0.759
Repeatability	26	1.40017	1.40017	0.053853		
Total	31	1.87065				

α to remove interaction term = 0.05

Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.0611155	86.27
Repeatability	0.0538528	76.02
Reproducibility	0.0072627	10.25
Test Stand	0.0071012	10.02
Technician (Operator)	0.0001615	0.23
Part-To-Part	0.0097244	13.73
Plug (Parts)	0.0086417	12.20

Install	0.0000000	0.00
Repeat	0.0010827	1.53
Total Variation	0.0708399	100.00

Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	0.247216	1.48329	92.88
Repeatability	0.232062	1.39237	87.19
Reproducibility	0.085221	0.51133	32.02
Test Stand	0.084269	0.50561	31.66
Technician (Operator)	0.012707	0.07624	4.77
Part-To-Part	0.098612	0.59167	37.05
Plug (Parts)	0.092961	0.55777	34.93
Install	0.000000	0.00000	0.00
Repeat	0.032904	0.19742	12.36
Total Variation	0.266158	1.59695	100.00

Number of Distinct Categories = 1

Gage R&R (Expanded) Report for SCFM

Gauge R&R of -0.5 inWC Test Point with Full Data Set Analysis

The results of the gauge R&R on a single test point show that most of the variation on the data set comes from the systems themselves. Ideally the total gauge R&R %Study Var would be less than 30% here it is over 90%. This shows that the systems cannot properly determine the variance between parts (Minitab, 2019).

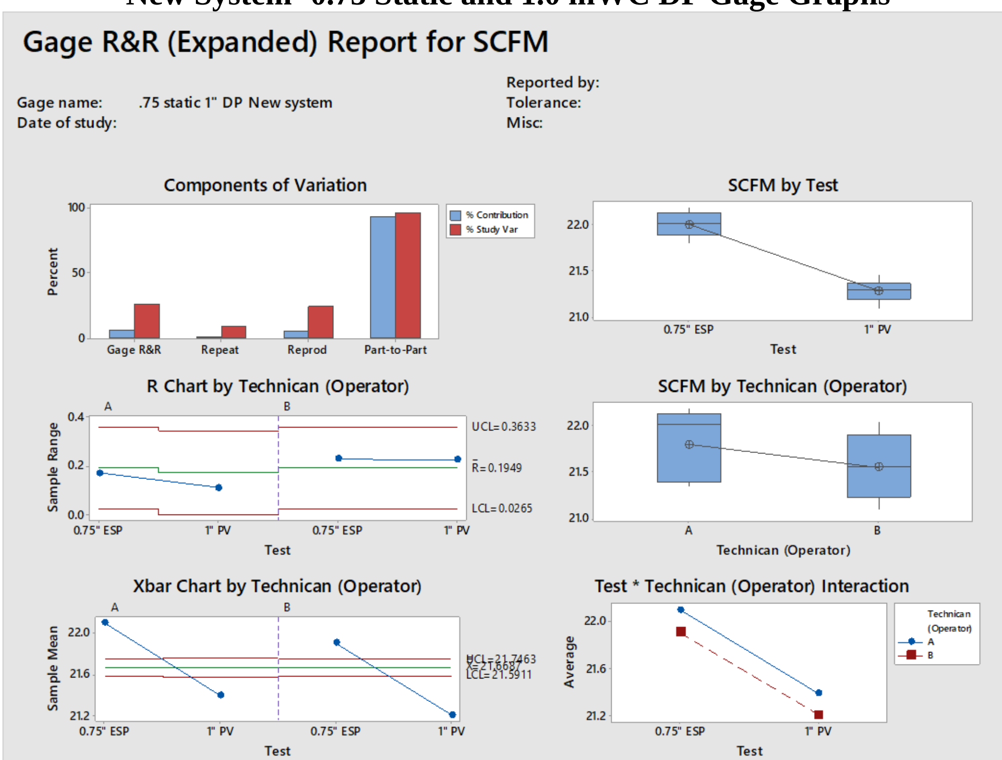
A good measurement system would show that the part to part variation represents most of the variability of the system. This tells us that our test parts are too similar for the system to adequately determine a difference in the parts. Perhaps utilizing two parts with the same sized holes was not the best method for determining the system variability in this way (Minitab, 2019).

This test may have also not been the best method to determine the effectiveness of the system because the way this system is utilized. This code tester is used to determine leak rates for different types of systems not repeatedly test different units of the same type of system. A better test may be to compare how the systems measure from test point to test point.

Gauge Study of -0.75inWC static and 1.0 inWC DP Test Point

For this gauge study the tests are setup to compare each of system's ability to differentiate between data taken at the -0.75inWC set point and 1.0 inWC Differential pressure set point. These test points happened to generate very similar airflows with the size of the holes in the end cap test parts. On the updated system the static pressure was set to -0.70 inWC to generate approximately 1" Differential pressure for that test point because the system can only control static. The same test point was used through all the testing on that system. So effectively the differences between these test points are approximately .05inWC static pressure.

Figure 17
New System -0.75 Static and 1.0 inWC DP Gage Graphs



New System -0.75 Static and 1.0 inWC DP Results:

Gage R&R Study: SCFM versus Test, Technician ... t, Plug (Parts), Install

Factor Information

Factor	Type	Levels	Values
Test	Random	2	0.75" ESP, 1" PV
Technician (Operator)	Random	2	A, B
Repeat	Random	2	1, 2
Plug (Parts)	Random	2	1, 2
Install	Random	2	1, 2

ANOVA Table with All Terms

Source	DF	Seq SS	Adj SS	Adj MS	F-Value	P-Value
Test	1	3.83057	3.68275	3.68275	1539.84	0.000
Technician (Operator)	1	0.26682	0.24716	0.24716	103.34	0.000
Repeat	1	0.00038	0.00038	0.00038	0.16	0.694
Plug (Parts)	1	0.07533	0.07212	0.07212	30.15	0.000
Install	1	0.00355	0.00355	0.00355	1.48	0.235
Repeatability	24	0.05740	0.05740	0.00239		
Total	29	4.23404				

α to remove interaction term = 0.05

Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.019080	6.94
Repeatability	0.002392	0.87
Reproducibility	0.016689	6.07
Technician (Operator)	0.016689	6.07
Part-To-Part	0.255766	93.06
Test	0.250933	91.30

Repeat	0.000000	0.00
Plug (Parts)	0.004754	1.73
Install	0.000079	0.03
Total Variation	0.274846	100.00

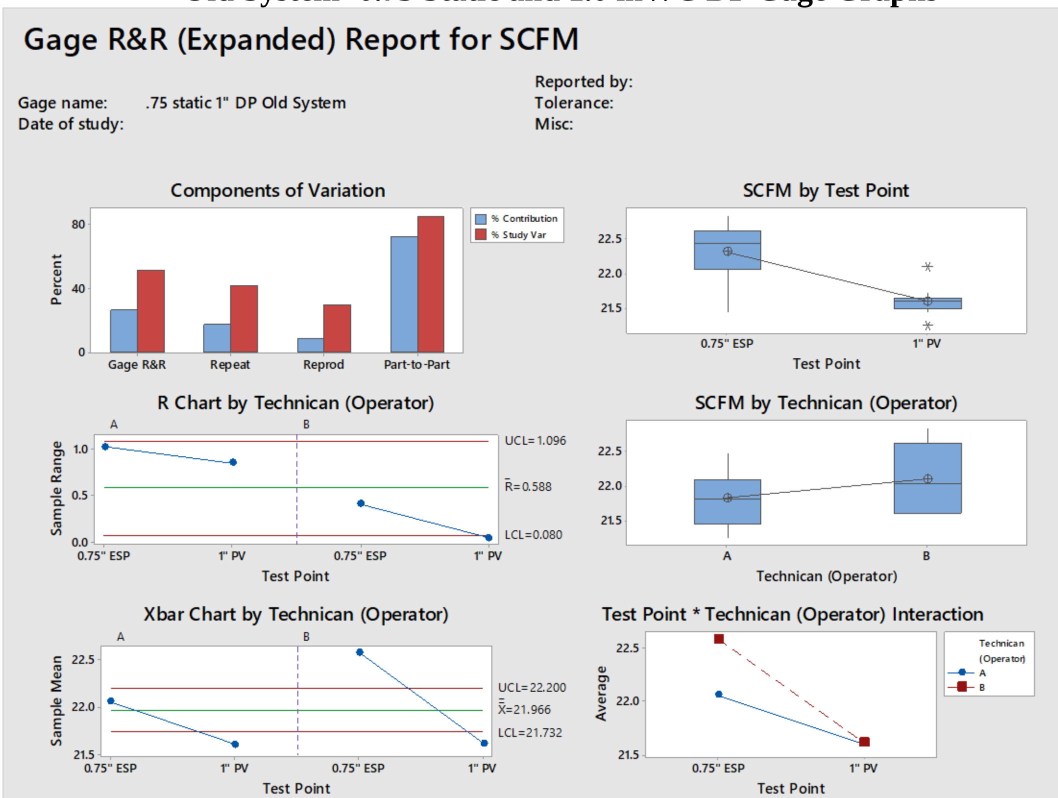
Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	0.138131	0.82879	26.35
Repeatability	0.048904	0.29343	9.33
Reproducibility	0.129184	0.77511	24.64
Technician (Operator)	0.129184	0.77511	24.64
Part-To-Part	0.505733	3.03440	96.47
Test	0.500932	3.00559	95.55
Repeat	0.000000	0.00000	0.00
Plug (Parts)	0.068950	0.41370	13.15
Install	0.008870	0.05322	1.69
Total Variation	0.524258	3.14555	100.00

Number of Distinct Categories = 5

Gage R&R (Expanded) Report for SCFM

Figure 18
Old System -0.75 Static and 1.0 inWC DP Gage Graphs



Old System -0.75 Static and 1.0 inWC DP Results

Gage R&R Study: SCFM versus Test Point, Technician ... g (Parts), Install

Factor Information

Factor	Type	Levels	Values
Test Point	Random	2	0.75" ESP, 1" PV
Technician (Operator)	Random	2	A, B
Repeat	Fixed	2	1, 2
Plug (Parts)	Random	2	1, 2
Install	Random	2	1, 2

ANOVA Table with All Terms

Source	DF	Seq SS	Adj SS	Adj MS	F-Value	P-Value
Test Point	1	4.13310	4.13310	4.13310	64.20	0.000
Technician (Operator)	1	0.58027	0.58027	0.58027	9.01	0.006
Repeat	1	0.03922	0.03922	0.03922	0.61	0.442
Plug (Parts)	1	0.15548	0.15548	0.15548	2.41	0.132
Install	1	0.00190	0.00190	0.00190	0.03	0.865
Repeatability	26	1.67390	1.67390	0.06438		
Total	31	6.58386				

α to remove interaction term = 0.05

Variance Components

Source	VarComp	%Contribution (of VarComp)
Total Gage R&R	0.096624	27.00
Repeatability	0.064381	17.99
Reproducibility	0.032243	9.01
Technician (Operator)	0.032243	9.01
Part-To-Part	0.261214	73.00
Test Point	0.254295	71.06
Repeat	0.001226	0.34
Plug (Parts)	0.005693	1.59
Install	0.000000	0.00
Total Variation	0.357838	100.00

Gage Evaluation

Source	StdDev (SD)	Study Var (6 × SD)	%Study Var (%SV)
Total Gage R&R	0.310843	1.86506	51.96

Repeatability	0.253733	1.52240	42.42
Reproducibility	0.179563	1.07738	30.02
Technician (Operator)	0.179563	1.07738	30.02
Part-To-Part	0.511091	3.06655	85.44
Test Point	0.504277	3.02566	84.30
Repeat	0.035011	0.21006	5.85
Plug (Parts)	0.075455	0.45273	12.61
Install	0.000000	0.00000	0.00
Total Variation	0.598195	3.58917	100.00

Number of Distinct Categories = 2

Gage R&R (Expanded) Report for SCFM

Gauge Study of -0.75inWC static and 1inWC DP Test Point Analysis

From these studies a clearer picture begins to emerge from the data about how the updates system performs when compared to the legacy system. In both cases the part to part variation makes up the majority of the variability in both data sets however, the new system does perform better with part to part variation accounting for 96% of the data variation compared to 85% on the legacy system (Minitab, 2019).

Part to Part Variation

The new system was variability was less impacted by test point repeats than the legacy system, in fact the impact was so low that it was omitted from the results. This confirms that the PID control effectively reduces the system measurement variability. However, installs were a source of detectable variability on the new system and not on the old system. This may be due to the fact that the PVC end caps sealed well on their own on the old system but needed to be taped up to seal them on the new system although the impact was fairly low <2% (Minitab, 2019).

Gauge R&R Conclusions

When looking at the total gauge R&R results it's clear that the new system can effectively determine the difference between test points where the old system cannot. The total Gauge R&R %Study Var was reduced from 52% on the old system to 26% on the new system. The repeatability of the new system was reduced from 18% on the old system to 9.3% on the new system an impressive result (Minitab, 2019).

The effect of the operator was also reduced from 30% on the old system to 25% on the new system. This is most likely due to the method of measurement between the two systems. The new system is not as subjective when it comes to recording measurements from the instrumentation (Minitab, 2019).

Job Hazard Analysis

Table 7
Risk Assessment

Job or Operation Title:	**Name of Building / Location**	**Title of Employee Doing Job:**
Mini Code tester Operation	Building 9	Technician
Date Performed: **11/26/19**	**JHA Performed By:** Daniel Ortman	**Verified By:** Ben Mowery
Special or Primary Hazards:	Moving parts	**Risk Assessment Value:** 4E
Personal Protective Equipment	Gloves & safety glasses Machine guarding	**Risk Level:** Medium
Basic Job Steps:	**Existing and/or Potential Hazards:**	**Corrective Measures:**
Install Unit	Cut or pinch	Wear PPE – Gloves safety glasses
Operate test stand to record airflow	Moving Mechanical parts	Machine Guarding
Uninstall unit	Cut or pinch	Wear PPE – Gloves safety glasses

Table 8

Risk Assessment Table

Frequency of Occurrence								
A- Frequent	5A	4A	3A	2A	1A			High
B- Probable	5B	4B	3B	2B	1B			Serious
C- Occasional	5C	4C	3C	2C	1C			Medium
D- Remote	5D	4D	3D	2D	1D			Low
E- Improbable	5E	4E	3E	2E	1E			
	5- Negligible	4- Marginal	3- Severe	2- Critical	1- Catastrophic			
	Severity							

Frequency of Occurrence		Severity		
A- Frequent	Continuous / Hourly	1- Catastrophic	Death	Examples
B- Probable	Daily	2- Critical	Serious Injury	Broken bone, Concussion, Severe burn or cut
C- Occasional	Weekly	3- Severe	Recordable	Needing medical care, stitches, cut, burn
D- Remote	Monthly	4- Marginal	Minor injury	Band-aid, twisted ankle
E- Improbable	Yearly +	5- Negligible	Slight injury	Bump, scrape

Risk Assessment Results

With guarding installed on the system the risk from the mechanical operation of the system moves from a remote chance of critical injury occurring 2D to an improbable risk of a negligible injury resulting in a 5E rating for the operation of the system.

The install and uninstall of the system could result in a severe cut or strain on the employee installing the system. By requiring the use of PPE during the installation procedure only minor injuries could result from installing the equipment. They would be improbable with the proper use of PPE. So, the risk associated with operation of the installation and uninstallation of equipment would be 4E as determined from the table above. This is the highest risk associated with the job of testing a system the job so therefore the job is classified as having a 4E risk to the operators.

Figure 19
Potential mechanical hazards from motor

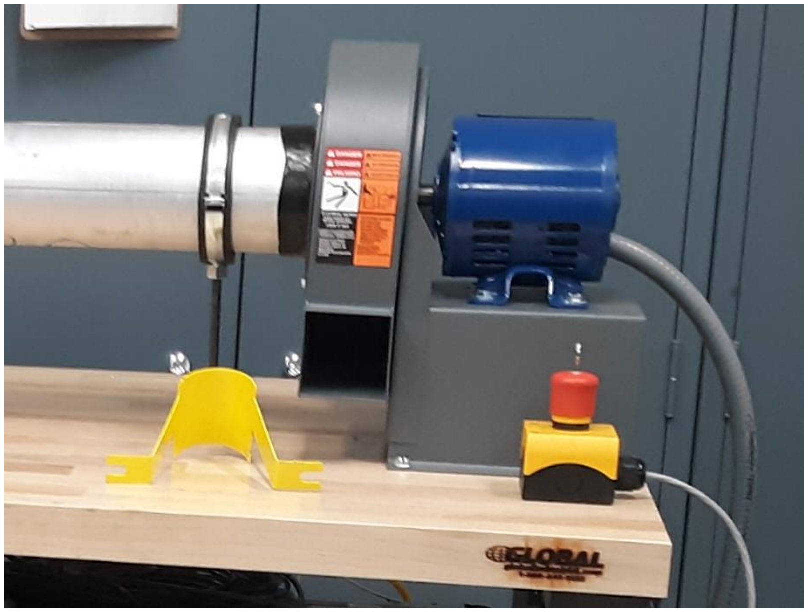


Figure 20
Machine Guarding

Project Conclusions

This redesign was focused on upgrading the measurement and data acquisition system of the Mini-Code Tester. New digital transducers were selected to meet the engineering requirements associated with the testing performed on the system. The engineering requirements conformed to various ASHRAE standards that define the testing requirements that govern the tests performed by the system. These standards played an instrumental role in defining what instrumentation was selected for the system.

A LabVIEW NXG user interface was developed to automate the control and data acquisition from the sensors and hardware installed on the system. All the measurements needed to calculate airflow are connected to a system dedicated National Instruments cDAQ device. This allows the system to function independently of other equipment in the laboratory. This new system allows a technician to control and measure and record airflow through the system through a personal computer without the need for additional devices.

The software developed for this new system allows users to graph up to 5 measurements on a historical chart and common configurations can be saved and loaded from a file. Users can update channel names on the system with new names that can be saved and loaded from configuration files. Users can define testing templates that can also be saved and loaded from a configuration file. Sensor calibrations can be made within the software allowing for system wide calibrations that improve accuracy of measurements performed by the system.

Overall the performance of the system has been improved when comparing the gauge R&R data between the old system and the upgraded system. The range of data produced by the new system at the typical test setpoint of -0.5 inWC static pressure decreased from 1 SCFM on the old system to 0.32 SCFM on the new system. Overall the system repeatability increased, while the test variability decreased confirming that the new system controls better and produces more reliable data that is less prone to operator errors.

References

American Society of Heating, Refrigerating, and Air-Conditioning Engineers. (2018). *ASHRAE Standard 41.2: Standards for Airflow Measurement* (Standard No. 41.2-2018).

American Society of Heating, Refrigerating, and Air-Conditioning Engineers. (2016). *ASHRAE Standard 51: Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating* (Standard No. 51-2016).

American Society of Heating, Refrigerating, and Air-Conditioning Engineers. (2010). *ASHRAE standard 193:* Method of Test for Determining the Airtightness of HVAC Equipment (Standard No. 193-2010).

American Society of Mechanical Engineers. (2004). *ASME PTC 19.5 Flow Measurement* (Standard No. 19.5-2004).

Minitab, LLC. (2019). *Interpret the key results for 2-Sample t*. Retrieved November 26, 2019, from https://support.minitab.com/en-us/minitab/18/help-and-how-to/statistics/basic-statistics/how-to/2-sample-t/interpret-the-results/key-results/.

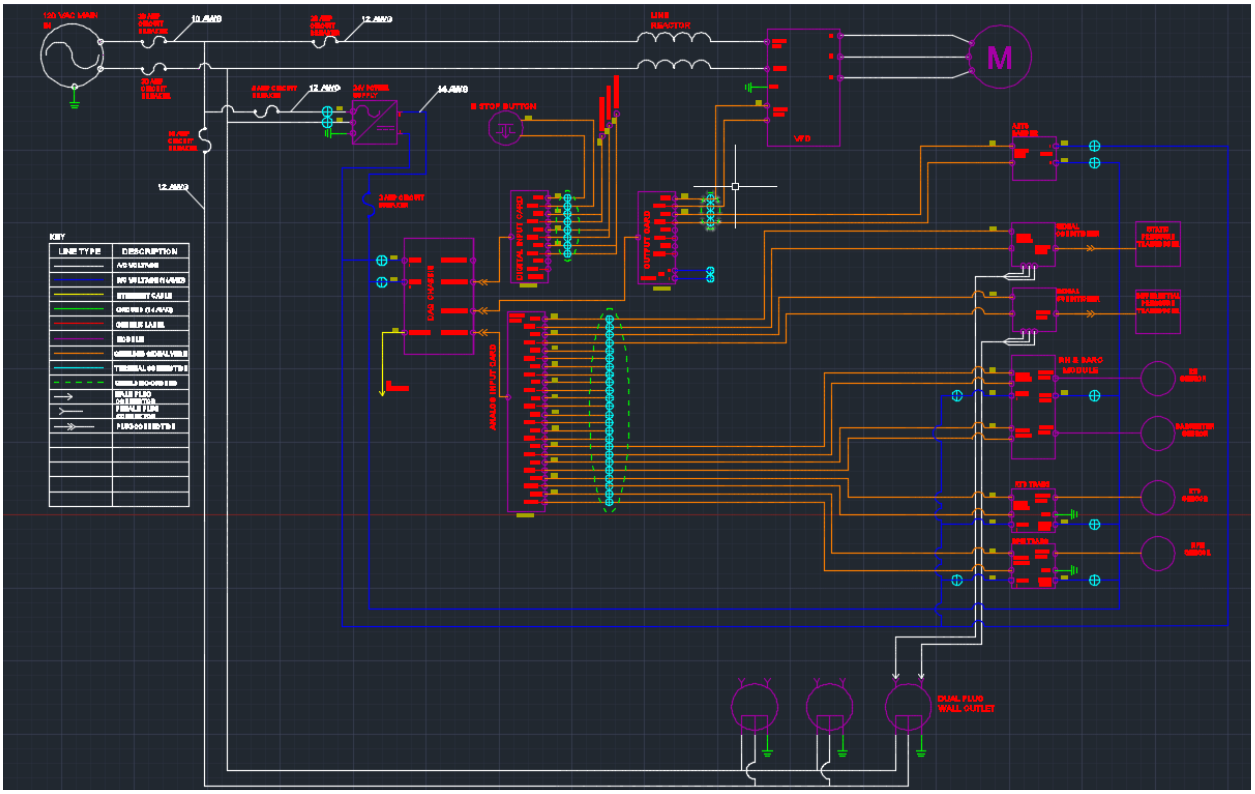
Minitab, LLC. (2019). *Interpret the key results for Expanded Gage R&R Study*. Retrieved November 26, 2019, from https://support.minitab.com/en-us/minitab/18/help-and-how-to/quality-and-process-improvement/measurement-system-analysis/how-to/gage-study/expanded-gage-r-r-study/interpret-the-results/key-results/.

National Fire Protection Association. (2017). *NFPA 70 National Electric Code* (Standard No. NEC 2017)

Appendix

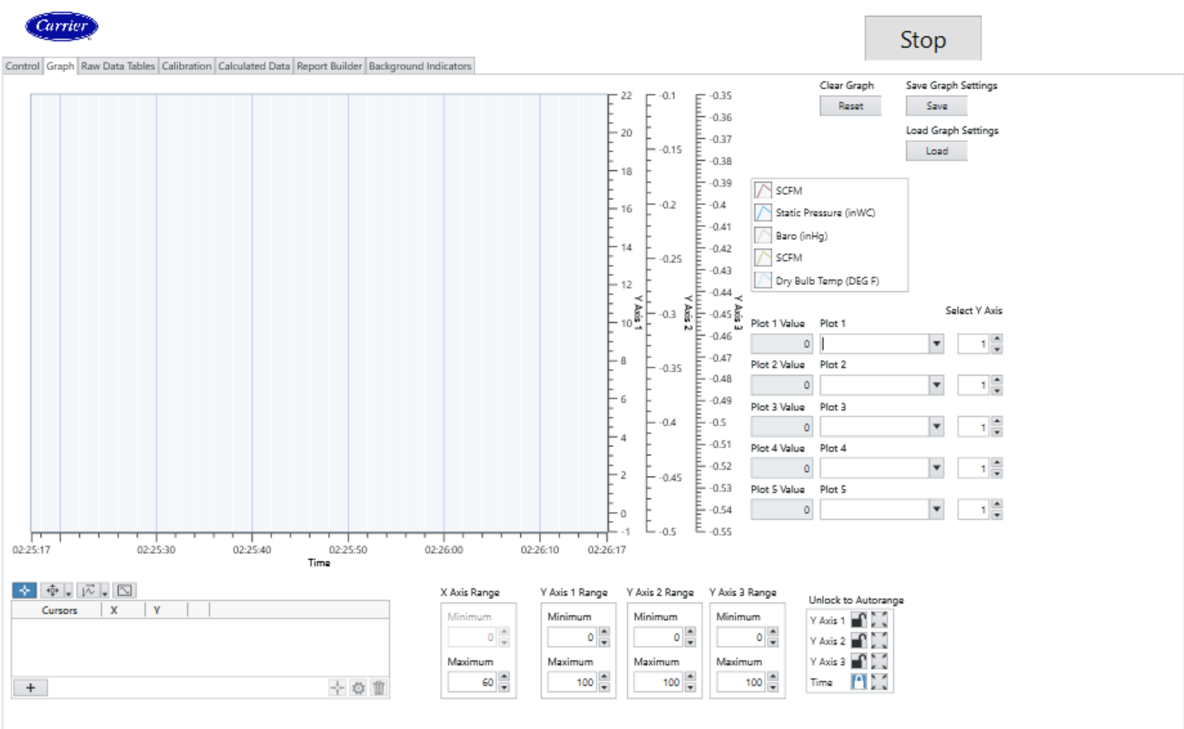
Figure 21

Schematic



Schematic CAD drawing of the electrical circuitry utilized by the upgraded code tester system

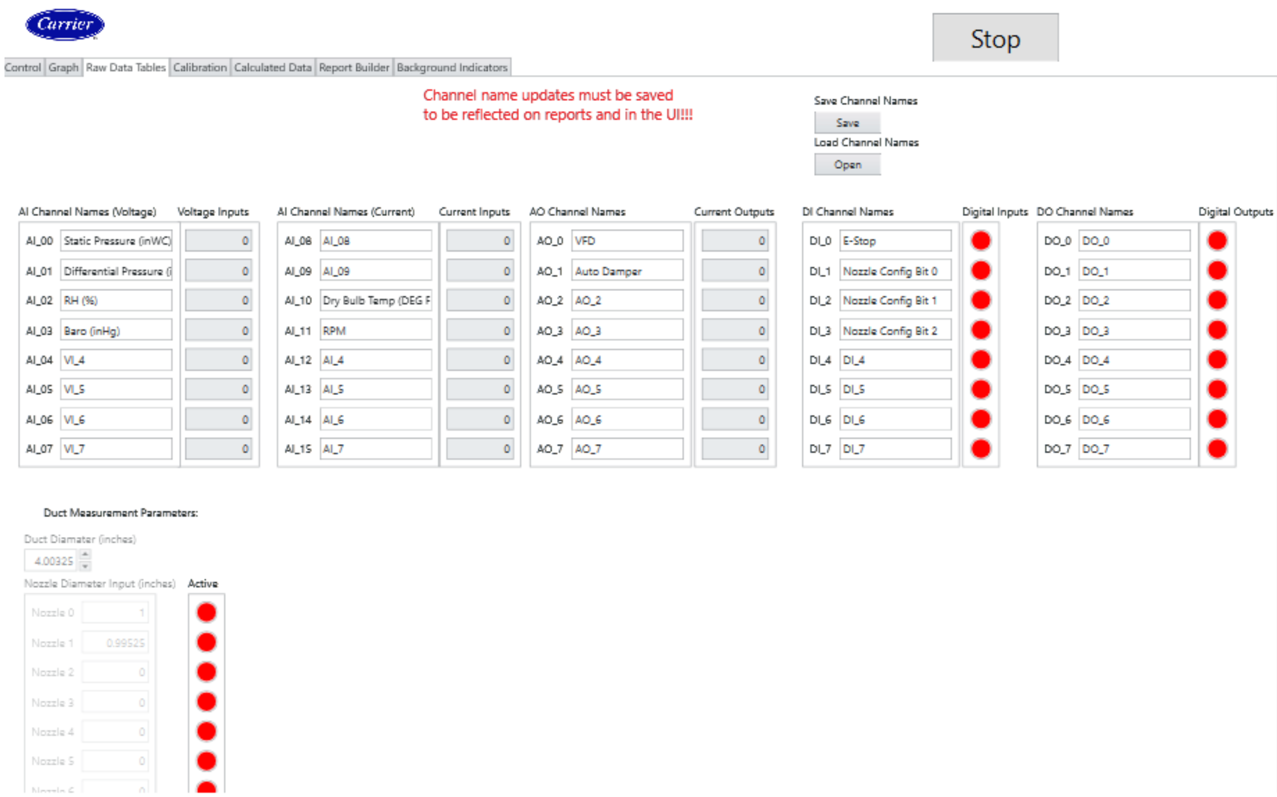
Figure 22
Graph Tab



The Graph tab is where users can plot various data channels over time. Up to 5 measurements can be plotted simultaneously using three different measurement scales. Settings can be saved and loaded to and from configuration files.

Figure 23

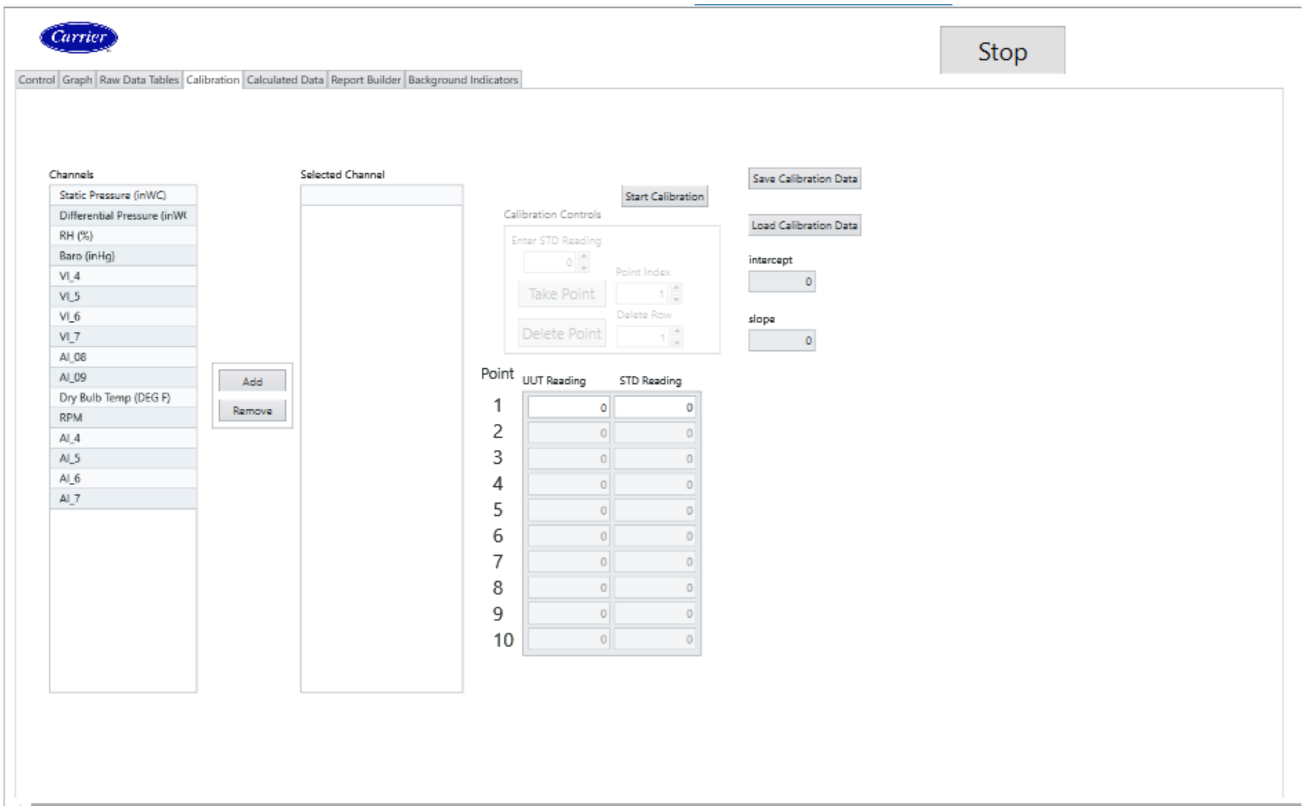
Raw Data Tables Tab



The Raw Data Tables tab shows all the current readings from the DAQ prior to the calibration offsets being applied. These raw readings are from the various instruments installed on the system. On this tab users can define new channel names for each of the IO channels on the DAQ and load and save copies to the hard drive.

Figure 24

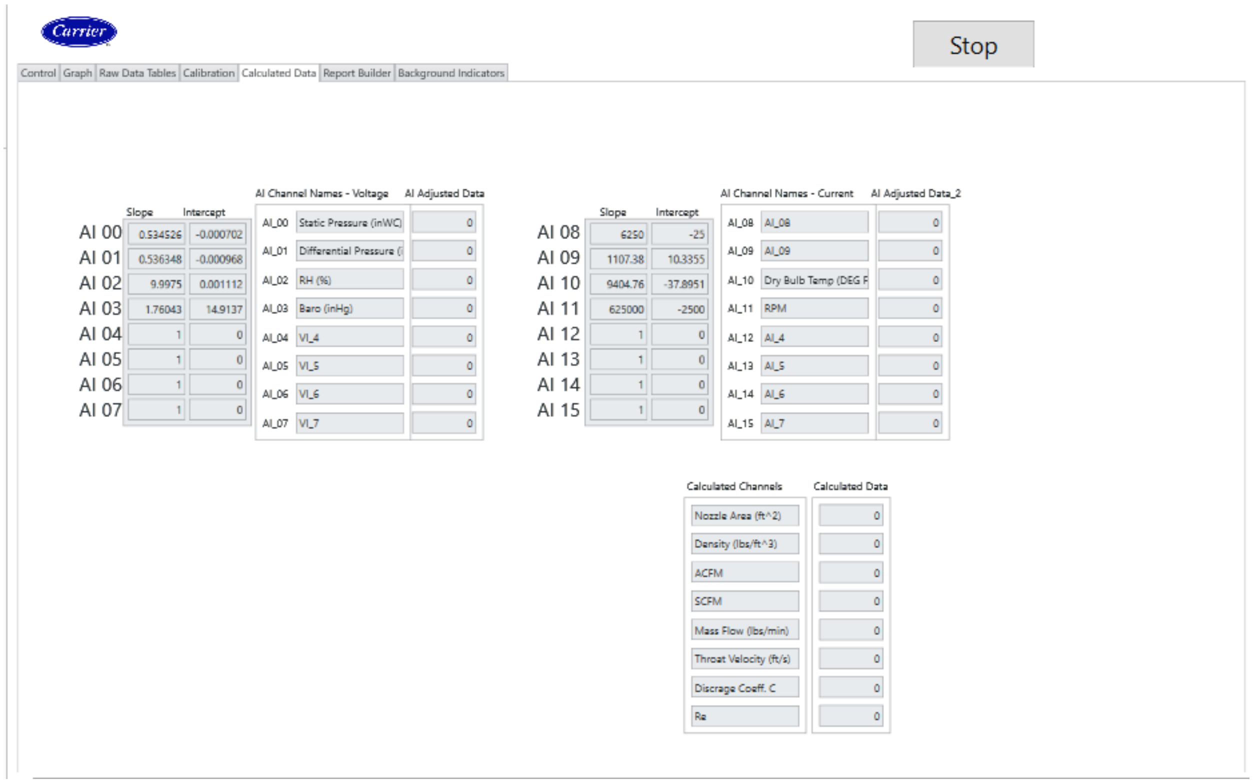
Calibration Tab



The Calibration tab is used to calibrate the various instruments installed on the system. A user can take data points and input readings from a calibration standard to generate a data set that is then passed through a linear regression calculator to create calibration coefficients for that channel. These coefficients are used by the system to process data from a sensor installed on a DAQ channel into engineering units. The coefficients are then saved to a configuration file that can be opened in the software by a user. The system references the latest calibration configuration file on startup.

Figure 25

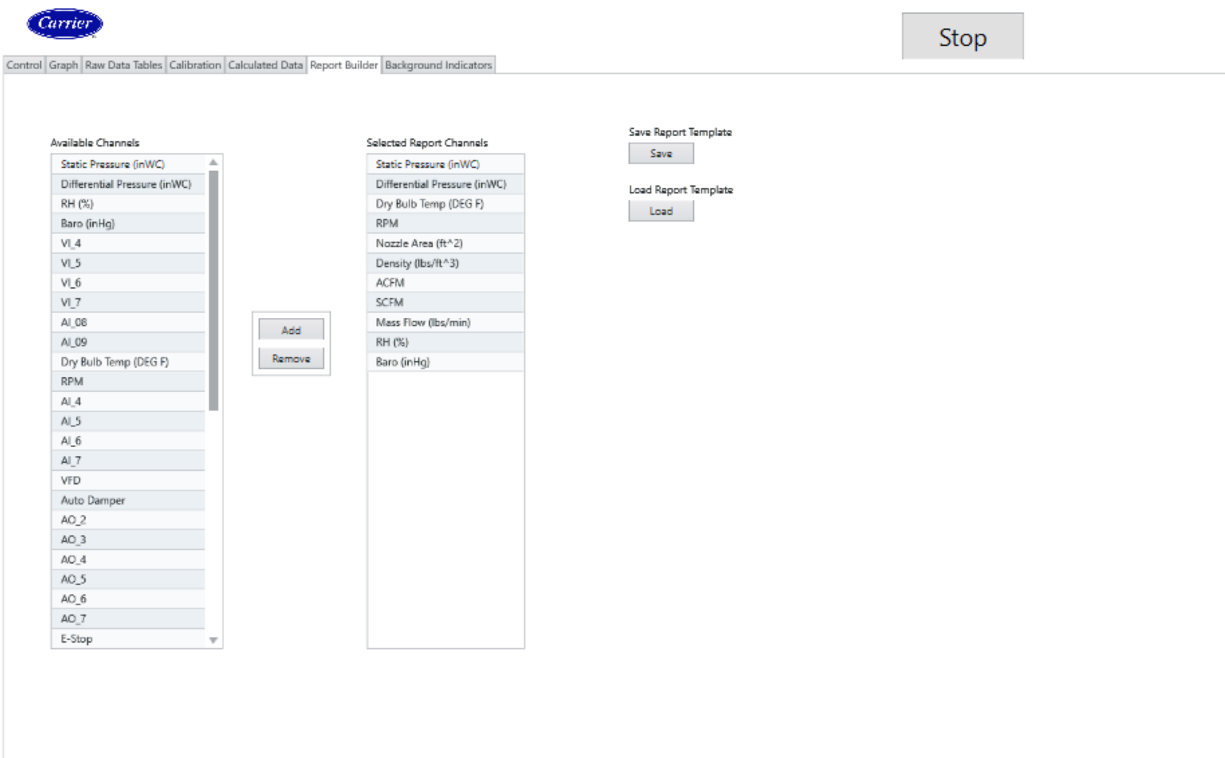
Calculated data Tab



The Calculated Data tab shows the latest readings from each of the systems channels after the calibration coefficients are applied. The calibration coefficients stored for each channel are also shown on this tab.

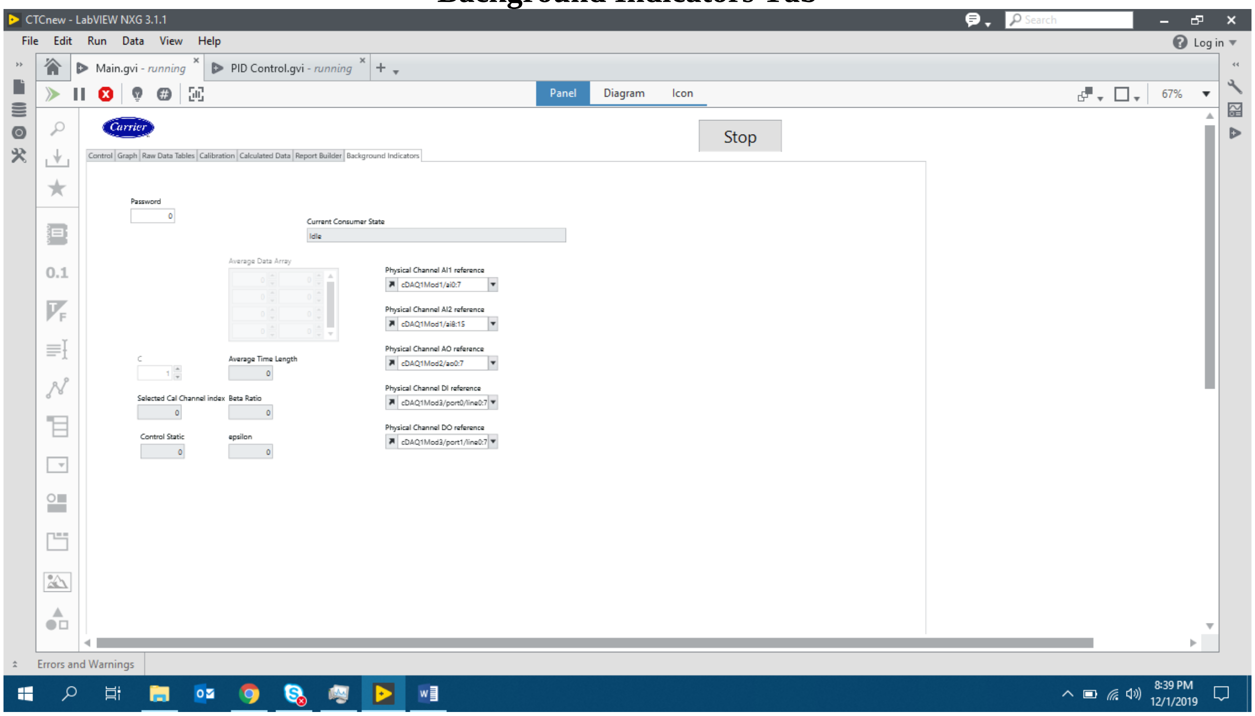
Figure 26

Report Builder tab



The Report Builder tab is used to select channels to be included on the report. Templates can be saved and loaded from configuration files. Users add the desired channels to the selected report channels list box by highlighting them in the available channels list and pressing the add button.

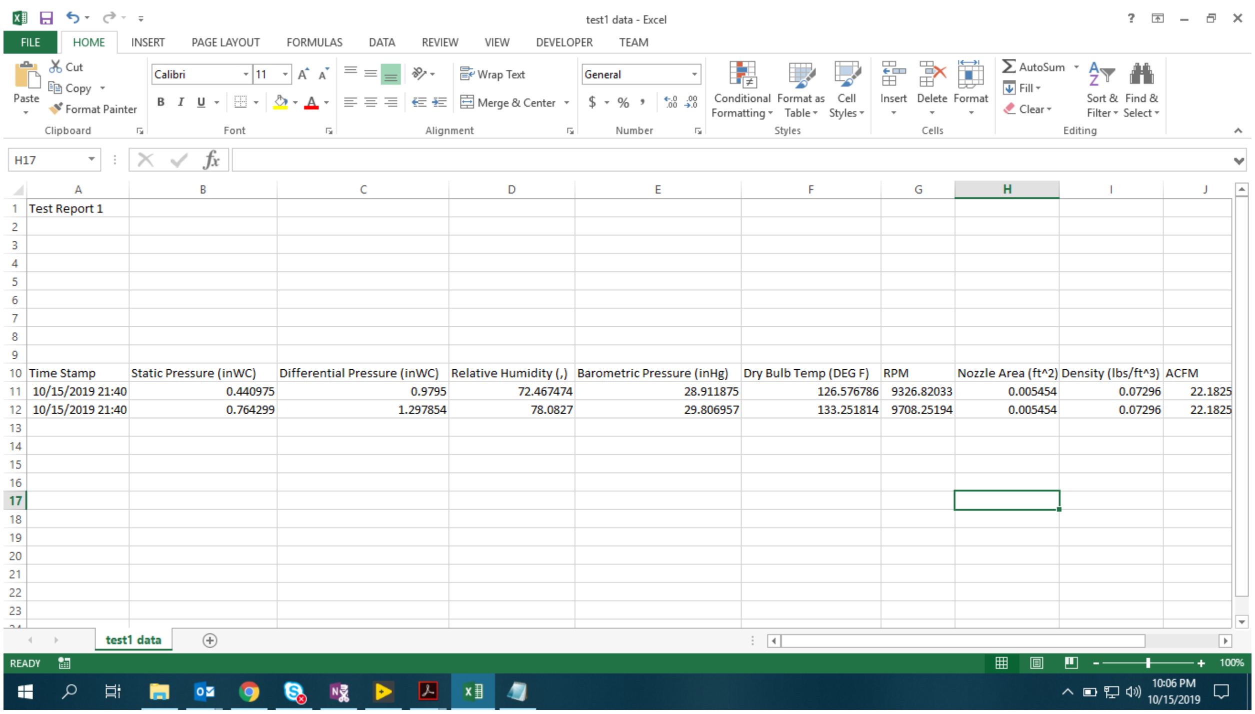
Figure 27
Background Indicators Tab



The Background indicators tab provides feedback on the internal processes of the software and can aid in troubleshooting the system if the need arises. Some controls are locked by the password control on this tab and can be unlocked by entering the correct value into this control. This keeps the users from damaging sensitive settings in the system that may need to be updated in the future.

Figure 28

Test Report Example



Time Stamp	Static Pressure (inWC)	Differential Pressure (inWC)	Relative Humidity (,)	Barometric Pressure (inHg)	Dry Bulb Temp (DEG F)	RPM	Nozzle Area (ft^2)	Density (lbs/ft^3)	ACFM
10/15/2019 21:40	0.440975	0.9795	72.467474	28.911875	126.576786	9326.82033	0.005454	0.07296	22.1825
10/15/2019 21:40	0.764299	1.297854	78.0827	29.806957	133.251814	9708.25194	0.005454	0.07296	22.1825

This is an example of a report generated by the system opened in excel. The report header data is included at the top section of the document and the data is listed below. Channels are separated by columns and each data point is displayed in separate rows.

Figure 29

Bill of Materials

Mini Code Tester Upgrade						
Bill Of Materials						
Item #	**Manufacturer**	**Description**	**QT**	**Part Number**	**Price**	**Cost**
	Sensors					
1	VAILSALA	RH & Barometer	1	PTU333	$2,398.00	$2,398.00
2	WATLOW	RTD Sensor	1	RF1007702	$102.19	$102.19
3	BANNER	RPM Sensor	1	SM312FMHS	$119.00	$119.00
	Transmitters/Transducers					
4	OMEGAETTE	RTD Transmitter	1	TXDIN70	$101.00	$101.00
5	LAUREL ELECTRONICS	RPM Transmitter	1	LT60FR	$247.00	$247.00
6	MKS	Pressure Transducer	2	698A11TRA	$4,300.00	$8,600.00
7	MKS	Signal conditioner	2	670BD21	$4,250.00	$8,500.00
	Networking					
8	DELL	PC Tower	1	INSPIRON 3268	$385.99	$385.99
	DAQ					$2,556.00
9	NATIONAL INSTRUMENTS	Chassis	1	cDAQ-9185	$1,153.00	
10	NATIONAL INSTRUMENTS	Input card	1	NI-9208	$749.00	
11	NATIONAL INSTRUMENTS	Output card	1	NI-9264	$654.00	
	Power and Automation modules					
12	AUTOMATION DIRECT	VFD	1	GSN-10P5	$119.00	$119.00
13	BELIMO	Automated Damper	1	4075-LMB24SR	$236.90	$236.90
14	MULTICOMP	24V Power Supply	1	DRAN120-24A	$96.63	$96.63
	Circuit protection					
15	GE Electrical Distribution	15A Circuit Breaker	1	EP101ULHC15	$24.85	$24.85
16	GE Electrical Distribution	30A Circuit Breaker	1	EP101ULHC30	$24.85	$24.85
17	GE Electrical Distribution	5A Circuit Breaker	1	EP101ULHC5	$24.85	$24.85
	Miscellaneous/wires/connectors/organizers/hardware					
18	Hammond	Enclosure	1	EN4TD244210LG	$504.00	$504.00
19	WAGO	Power Entry Connector	3	51017543	$45.90	$137.70
					Total	$24,177.96

This bill of materials includes the major cost componets of the hardware and software system upgrade.

Figure 30

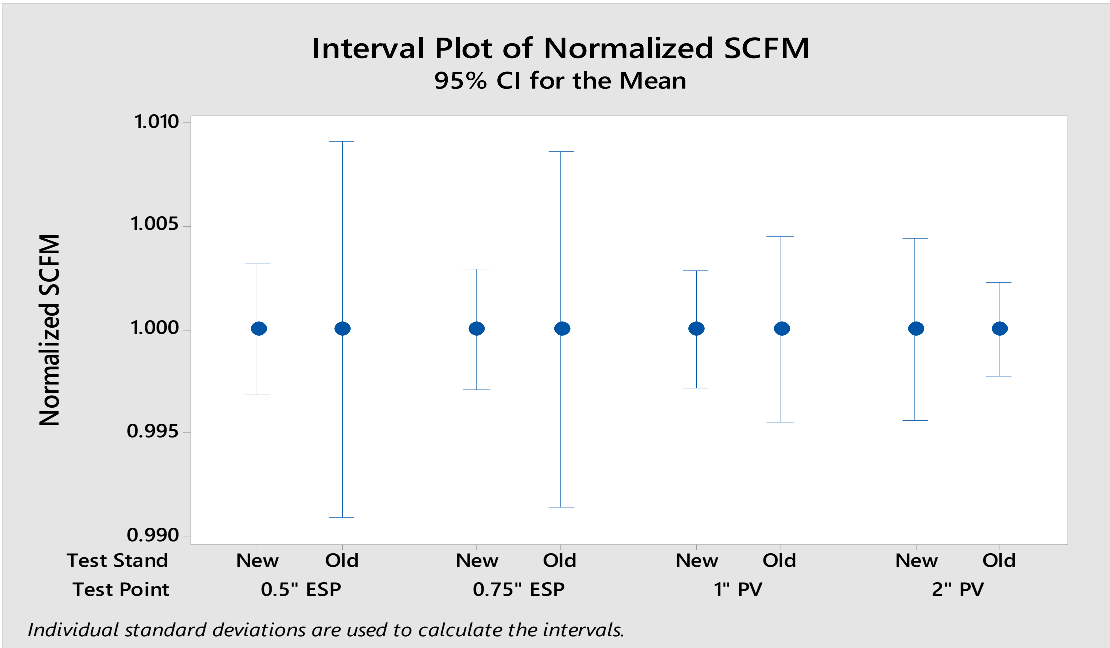
Gantt Chart

Phase 2	**49 days**	**Mon 8/26/19**	**Thu 10/31/19**
Develop Gantt Chart	5 days	Tue 9/10/19	Mon 9/16/19
Finalize Specs	10 days	Tue 9/3/19	Mon 9/16/19
Build Software	**30 days**	**Mon 8/26/19**	**Fri 10/4/19**
Raw data gathering	5 days	Mon 8/26/19	Fri 8/30/19
Calibration Tab	5 days	Mon 9/2/19	Fri 9/6/19
Adjusted Data	5 days	Mon 9/9/19	Fri 9/13/19
Graph tab	5 days	Mon 9/16/19	Fri 9/20/19
Calculations	5 days	Mon 9/23/19	Fri 9/27/19
Finialize Design	5 days	Mon 9/30/19	Fri 10/4/19
Build Hardware	**30 days**	**Mon 8/26/19**	**Fri 10/4/19**
Hardware Layout	10 days	Mon 8/26/19	Fri 9/6/19
Wiring/Labels	10 days	Mon 9/9/19	Fri 9/20/19
finalize Cabinet	5 days	Mon 9/23/19	Fri 9/27/19
Mount to Cart	5 days	Mon 9/30/19	Fri 10/4/19
Finialize Design	**19 days**	**Mon 10/7/19**	**Thu 10/31/19**
Combine System	5 days	Mon 10/7/19	Fri 10/11/19
Test System	14 days	Mon 10/14/1	Thu 10/31/19
Focus on Deliverables	**15 days**	**Fri 11/1/19**	**Thu 11/21/19**
Produce User Manual	5 days	Fri 11/1/19	Thu 11/7/19
Produce JHA / Maintanice documents	5 days	Fri 11/8/19	Thu 11/14/19
Produce Calibration Manual	5 days	Fri 11/15/19	Thu 11/21/19
Final Report	15 days	Fri 11/1/19	Thu 11/21/19

This was the project Gantt chart utilized by the team to keep track of project deliverables and timelines.

Figure 31

Normalized Interval Plot for Gauge R&R Test Data



This plot shows the normalized SCFM readings produced during the gauge R&R. Significant reduction in CI for mean SCFM can be seen in the lower test points performed by the two systems.

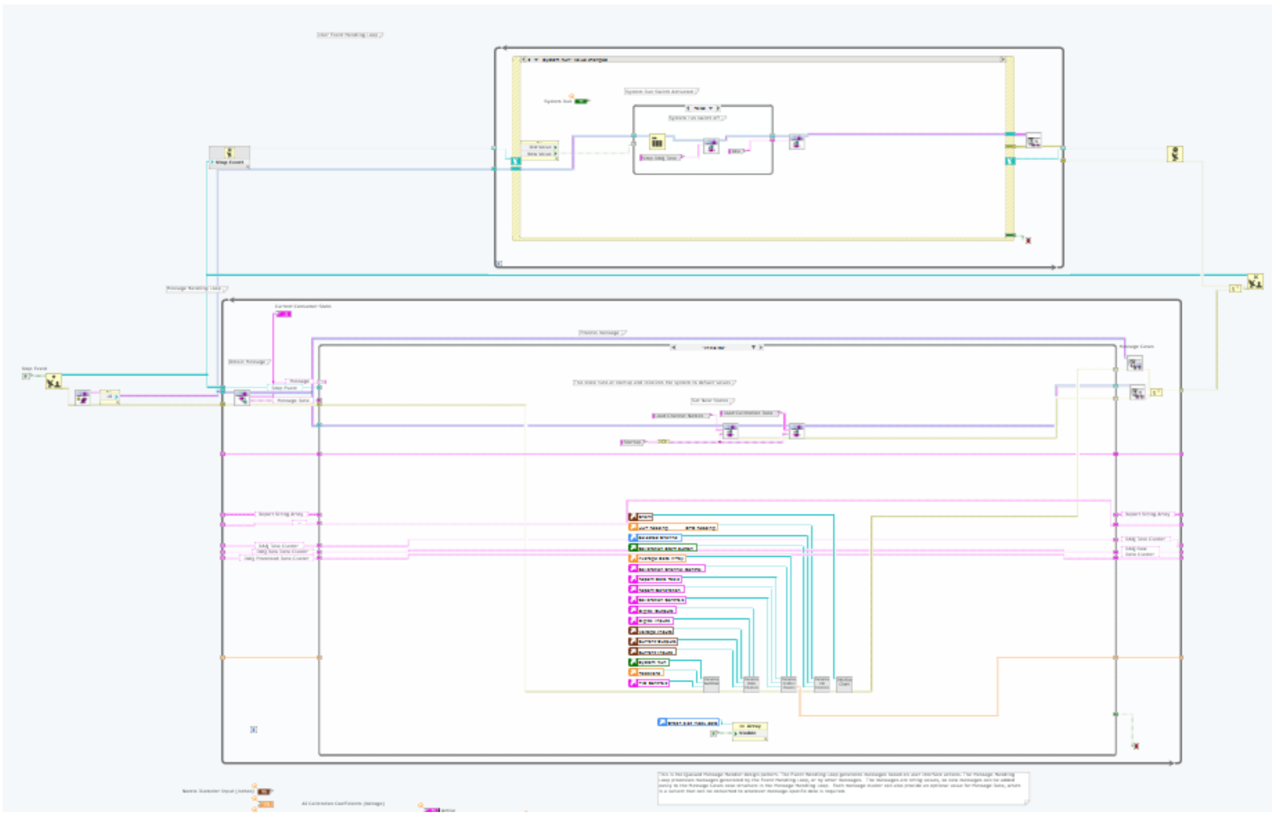
Figure 32

Instrumentation Accuracy Comparisons

.5 static	Old Tolerance +/- .02	Deltas	% difference	New Tolerance +/- 0.12% rdg	Deltas	% difference
.25 differential	SCFM	SCFM	%	SCFM	SCFM	%
SCFM	11.41049663	0.430450381	3.9203%	10.98662794	0.006582	0.059942%
10.98004625	10.53196926	-0.448076996	-4.0808%	10.9734606	-0.00659	-0.059978%
Total Range	0.878527377			0.013167336		

This chart was generated by calculating a nominal SCFM at ambient conditions and that value was compared by adjusting for instrumentation tolerances between the new and old systems. Significant accuracy improvements were made by implementing the new systems low pressure transducers.

Figure 33
Program Block Diagram



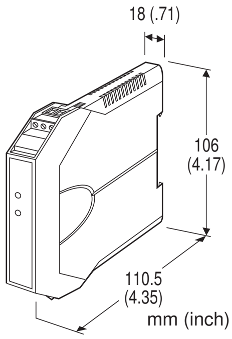
The code section of the software operates under the queued message event handler frame work utilizing two parallel loops. User events are handled by the top loop and messages are generated from user interactions. These messages are added to a queue and passed to the message processing loop below. A case structure identifies the incoming message and handles the message appropriately

Datasheets

Space-saving Two-wire Signal Conditioners B3-UNIT

RTD TRANSMITTER
(field-configurable)

Functions & Features
- Converts a RTD input into an isolated, linearized 4 – 20 mA DC signal
- DIP switch configurable input range
- Linearization and burnout
- Monitor terminals
- High-density mounting



MODEL: B3FR[1]

ORDERING INFORMATION
- Code number: B3FR[1]

Specify a code from below for [1].
(e.g. B3FR/UL/Q)
- Input range (e.g. Pt 100 0 – 200°C)
- If you need the transmitter to be calibrated to a specific range, please specify when ordering.

Non-specified orders will be shipped at default factory setting (Pt 100 0 – 100°C).
- Specify the specification for option code /Q
(e.g. /C01)

INPUT RTD (2- or 3-wire)
Pt 100 (JIS ’97, IEC)
Ni 120
Cu 10 @ 25°C
Note: Consult M-System for 2-wire RTD

[1] OPTIONS (multiple selections)
Standards & Approvals
blank: CE marking
/UL: UL approval, CE marking

Other Options
blank: none
/Q: Option other than the above (specify the specification)

SPECIFICATIONS OF OPTION: Q
COATING (For the detail, refer to M-System's web site.)
/C01: Silicone coating
/C02: Polyurethane coating
/C03: Rubber coating (UL not available)

GENERAL SPECIFICATIONS
Construction: Small-sized front terminal structure
Connection: Euro type connector terminal
(applicable wire size: 0.2 to 2.5 mm^2, stripped length 8 mm)
Housing material: Flame-resistant resin (gray)
Isolation: Input to output
Burnout: Upscale (default), downscale or no burnout selectable
Linearization: Standard
Configuration: DIP and rotary switches
Setting:
- Input Type
- Input Range
- Burnout
- Others

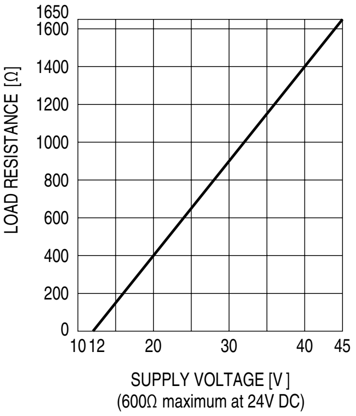
Refer to the instruction manual for details.

INPUT SPECIFICATIONS
Maximum leadwire resistance: 20 Ω per wire (3-wire)
Sensing current: 1 mA

RTD	USABLE RANGE		MIN. SPAN	
Pt 100 (JIS ’97, IEC)	-50 to +750°C	-58 to +1382°F	300°C	540°F
	-50 to +350°C	-58 to +662°F	100°C	180°F
	-50 to +150°C	-58 to +302°F	50°C	90°F
Ni 120	-50 to +200°C	-58 to +392°F	100°C	180°F
	-50 to +100°C	-58 to +212°F	50°C	90°F
Cu 10 @ 25°C	-50 to +250°C	-58 to +482°F	100°C	180°F

OUTPUT SPECIFICATIONS

Output: 4 – 20 mA DC
Load resistance vs. supply voltage:
Load Resistance (Ω) = (Supply Voltage (V) – 12 (V)) ÷ 0.02 (A) (including leadwire resistance)



INSTALLATION

Supply voltage: 12 – 45 V DC
Operating temperature:
-40 to +85°C (-40 to +185°F)
Max. 55°C (131°F) for UL approval
Operating humidity: 0 to 95 %RH (non-condensing)
Mounting: DIN rail
Weight: 80 g (2.8 oz)

PERFORMANCE in percentage of span

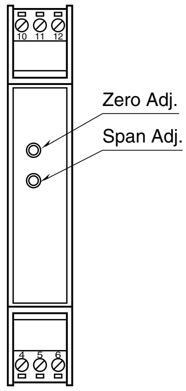
Accuracy
Pt 100, Cu 10: ±0.2 %
Ni 120: ±0.3 %
Temp. coefficient: ±0.02 %/°C (±0.01 %/°F), ±0.03 %/°C (±0.02 %/°F) for Cu 10
Response time: ≤ 0.5 sec. (0 – 90 %)
Burnout response: ≤ 10 sec.
Insulation resistance: ≥ 100 MΩ with 500 V DC
Dielectric strength: 2000 V AC @1 minute (input to output to ground)

STANDARDS & APPROVALS

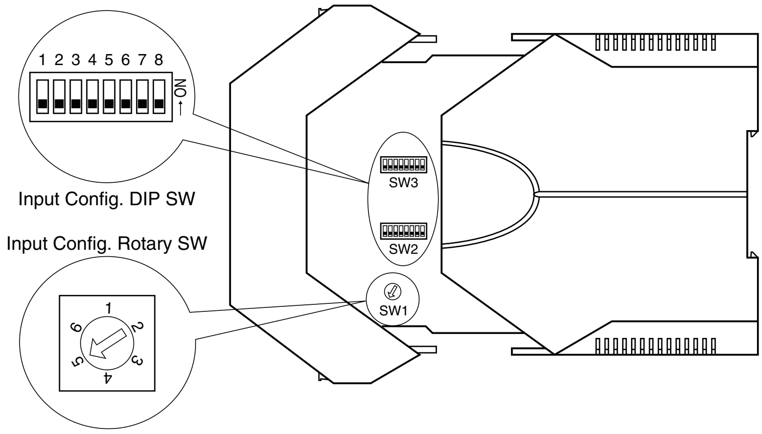
EU conformity:
EMC Directive
EMI EN 61000-6-4
EMS EN 61000-6-2
RoHS Directive
EN 50581
Approval:
UL/C-UL general safety requirements
(UL 61010-1, CAN/CSA-C22.2 No.1010-1)

EXTERNAL VIEW

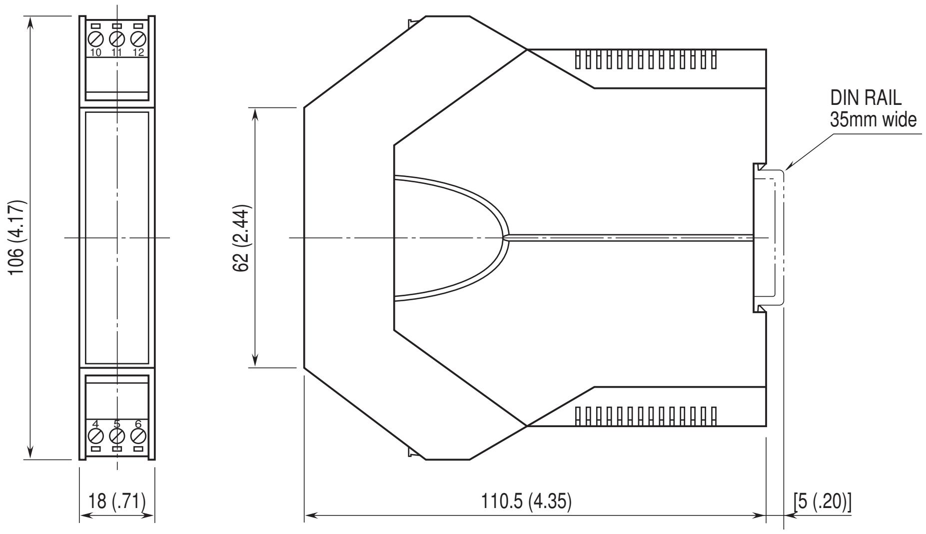
■ **FRONT VIEW**



■ **SIDE VIEW**

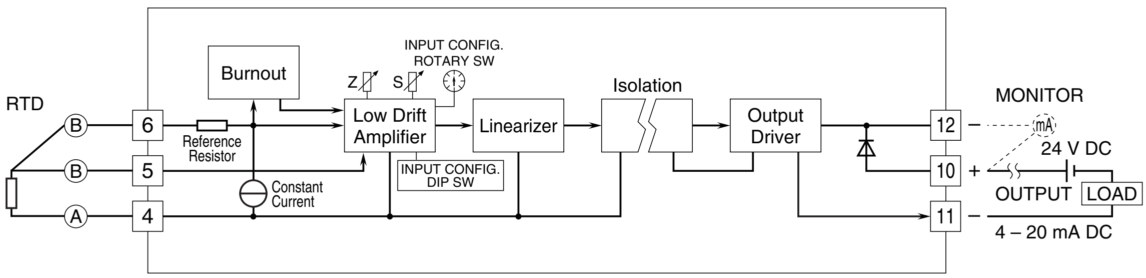


EXTERNAL DIMENSIONS & TERMINAL ASSIGNMENTS unit: mm (inch)



• When mounting, no extra space is needed between units.

SCHEMATIC CIRCUITRY & CONNECTION DIAGRAM



⚠ Specifications are subject to change without notice.

SPECIFICATIONS

cDAQ™-9185

4-Slot, Extended Temperature, Ethernet CompactDAQ Chassis

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

Characteristics describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- *Typical* specifications describe the expected performance met by a majority of the models.
- *Nominal* specifications describe parameters and attributes that may be useful in operation.

Specifications are *Typical* unless otherwise noted.

Conditions

Specifications are valid at 25 °C unless otherwise noted.

Analog Input

Input FIFO size	127 samples per slot
Maximum sample rate[1]	Determined by the C Series module or modules
Timing accuracy[2]	50 ppm of sample rate
Internal base clocks	80 MHz, 20 MHz, 13.1072 MHz, 12.8 MHz, 10 MHz, 100 kHz
Number of channels supported	Determined by the C Series module or modules

[1] Performance dependent on type of installed C Series module and number of channels in the task.
[2] Does not include group delay. For more information, refer to the documentation for each C Series module.

NATIONAL INSTRUMENTS™

Analog Output

Number of channels supported	
Hardware-timed task	
Onboard regeneration	16
Non-regeneration	Determined by the C Series module or modules
Non-hardware-timed task	Determined by the C Series module or modules
Maximum update rate	
Onboard regeneration	1.6 MS/s (multi-channel, aggregate)
Non-regeneration	Determined by the C Series module or modules
Timing accuracy	50 ppm of sample rate
Internal base clocks	80 MHz, 20 MHz, 13.1072 MHz, 12.8 MHz, 10 MHz, 100 kHz
Output FIFO size	
Onboard regeneration	8,191 samples shared among channels used
Non-regeneration	127 samples per slot
AO waveform modes	Non-periodic waveform, periodic waveform regeneration mode from onboard memory, periodic waveform regeneration from host buffer including dynamic update

Digital Waveform Characteristics

Waveform acquisition (DI) FIFO	
Parallel modules	511 samples per slot
Serial modules	63 samples per slot
Waveform generation (DO) FIFO	
Parallel modules	2,047 samples per slot
Serial modules	63 samples per slot
Digital input sample clock frequency	
Streaming to application memory	System-dependent
Finite	0 MHz to 10 MHz

Digital output sample clock frequency	
Streaming from application memory	System-dependent
Regeneration from FIFO	0 MHz to 10 MHz
Finite	0 MHz to 10 MHz
Timing accuracy	50 ppm
Internal base clocks	80 MHz, 20 MHz, 13.1072 MHz, 12.8 MHz, 10 MHz, 100 kHz

General-Purpose Counters/Timers

Number of counters/timers	4
Resolution	32 bits
Counter measurements	Edge counting, pulse, semi-period, period, two-edge separation, pulse width
Position measurements	X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding
Output applications	Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling
Internal base clocks	80 MHz, 20 MHz, 13.1072 MHz, 12.8 MHz, 10 MHz, 100 kHz
External base clock frequency	0 MHz to 20 MHz
Base clock accuracy	50 ppm
Output frequency	0 MHz to 20 MHz
Inputs	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down
Routing options for inputs	Any module PFI, chassis PFI, analog trigger, many internal signals
FIFO	Dedicated 127-sample FIFO

Frequency Generator

Number of channels	1
Base clocks[3]	20 MHz, 10 MHz, 100 kHz
Divisors	1 to 16 (integers)

[3] Base clocks can be synchronized with other chassis using the network synchronization feature.

Base clock accuracy	50 ppm
Output	Any chassis PFI or module PFI terminal

Module PFI Characteristics

Functionality	Static digital input, static digital output, timing input, and timing output
Timing output sources[4]	Many analog input, analog output, counter, digital input, and digital output timing signals
Timing input frequency	0 MHz to 20 MHz
Timing output frequency	0 MHz to 20 MHz

Chassis PFI Characteristics

Maximum input or output frequency	1 MHz
Cable length	3 m (10 ft)
Cable impedance	50 Ω
PFI 0 connector	SMB
Power-on state	High impedance

Table 1. Input/Output Voltage Protection

Voltage	Minimum	Maximum
Input	-20 V	25 V
Output	-15 V	20 V

Maximum operating conditions[5]	
I_{OL} output low current	8 mA maximum
I_{OH} output high current	-8 mA maximum

4 Actual available signals are dependent on type of installed C Series module.
5 Stresses beyond those listed under *Maximum operating conditions* may cause permanent damage to the chassis.

Table 2. DC Input Characteristics

Voltage	Minimum	Maximum
Positive going threshold	1.43 V	2.28 V
Negative going threshold	0.86 V	1.53 V
Hysteresis	0.48 V	0.87 V

Table 3. DC Output Characteristics

Voltage	Conditions	Minimum	Maximum
High	—	—	5.25 V
	Sourcing 100 µA	4.65 V	—
	Sourcing 2 mA	3.60 V	—
	Sourcing 3.5 mA	3.44 V	—
Low	Sinking 100 µA	—	0.10 V
	Sinking 2 mA	—	0.64 V
	Sinking 3.5 mA	—	0.80 V

Digital Triggers

Source	Any chassis PFI or module PFI terminal
Polarity	Software-selectable for most signals
Analog input function	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Analog output function	Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Counter/timer function	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down

Module I/O States

At power-on	Module-dependent. Refer to the documentation for each C Series module.

Time-Based Triggers and Timestamps

Number of time-based triggers	5
Number of timestamps	4
Analog input	
Time-based triggers	Start Trigger, Sync Pulse
Timestamps	Start Trigger, Reference Trigger, First Sample
Analog output	
Time-based triggers	Start Trigger, Sync Pulse
Timestamps	Start Trigger, First Sample
Digital input	
Time-based triggers	Start Trigger
Timestamps	Start Trigger, Reference Trigger, First Sample
Digital output	
Time-based triggers	Start Trigger
Timestamps	Start Trigger, First Sample
Counter/timer input	
Time-based triggers	Arm Start Trigger
Timestamps	Arm Start Trigger
Counter/timer output	
Time-based triggers	Start Trigger, Arm Start Trigger
Timestamps	Start Trigger, Arm Start Trigger

Network Interface

Network protocols	TCP/IP, UDP
Network ports used	HTTP:80 (configuration only), TCP:3580; UDP:5353 (configuration only), TCP:5353 (configuration only); TCP:31415; UDP:7865 (configuration only), UDP:8473 (configuration only)
Network IP configuration	DHCP + Link-Local, DHCP, Static, Link-Local
High-performance data streams	7

Data stream types available	Analog input, analog output, digital input, digital output, counter/timer input, counter/timer output, NI-XNET[6]
Default MTU size	1500 bytes

Ethernet

Number of ports	2 ports, internally switched[7]
Network interface	1000 Base-TX, full-duplex; 1000 Base-TX, half-duplex; 100 Base-TX, full-duplex; 100 Base-TX, half-duplex; 10 Base-T, full-duplex; 10 Base-T, half-duplex
Communication rates	10/100/1000 Mbps, auto-negotiated
Maximum cabling distance	100 m/segment
Maximum hops per line[8]	15

Timing and Synchronization

Protocol	IEEE 802.1AS for network synchronization over 1000 Base-TX, full-duplex
Network synchronization accuracy[9]	<1 μs
Network synchronization accuracy with optimized configuration[10]	<100 ns

[6] When a session is active, CAN or LIN (NI-XNET) C Series modules use a total of two data streams regardless of the number of NI-XNET modules in the chassis.

[7] This allows for line topologies or network redundancy.

[8] With default software configuration. For information about creating reliable Ethernet-based systems, visit `ni.com/info` and enter Info Code `cdaqenet`.

[9] I/O synchronization is system-dependent. Assumes the chassis are connected in a line topology with a typical selection of C Series modules containing a variety of timing architectures. For information about network synchronization accuracy, visit `ni.com/info` and enter Info Code `syncacc`.

[10] I/O synchronization is system-dependent. Assumes a system containing one hop with optimized C Series module selection. For information about achieving high accuracy synchronization, visit `ni.com/info` and enter Info Code `cdaqsync`.

Power Requirements

Caution The protection provided by the cDAQ-9185 chassis can be impaired if it is used in a manner not described in the *cDAQ-9185/9189 User Manual*.

Note Some C Series modules have additional power requirements. For more information about C Series module power requirements, refer to the documentation for each C Series module.

Note Sleep mode for C Series modules is not supported in the cDAQ-9185.

Note When operating the cDAQ-9185 in hazardous locations, you must use the power connector with an external power supply rated for hazardous locations. The power supply included in the cDAQ-9185 kit is intended only for desktop use. For all other applications use the included 2-position power connector plug and a power supply rated for your application power requirements. Visit `ni.com` to find hazardous locations-certified power supplies.

Voltage input range	9 V to 30 V (measured at the cDAQ-9185 power connector)
Maximum power consumption[11]	16 W

Note The maximum power consumption specification is based on a fully populated system running a high-stress application at elevated ambient temperature and with all C Series modules consuming the maximum allowed power.

Power input connector	2 positions 3.5 mm pitch mini-combicon screw terminal with screw flanges, Sauro CTMH020F8-0N002
Power input mating connector	Sauro CTF020V8, Phoenix Contact 1714977, or equivalent

Physical Characteristics

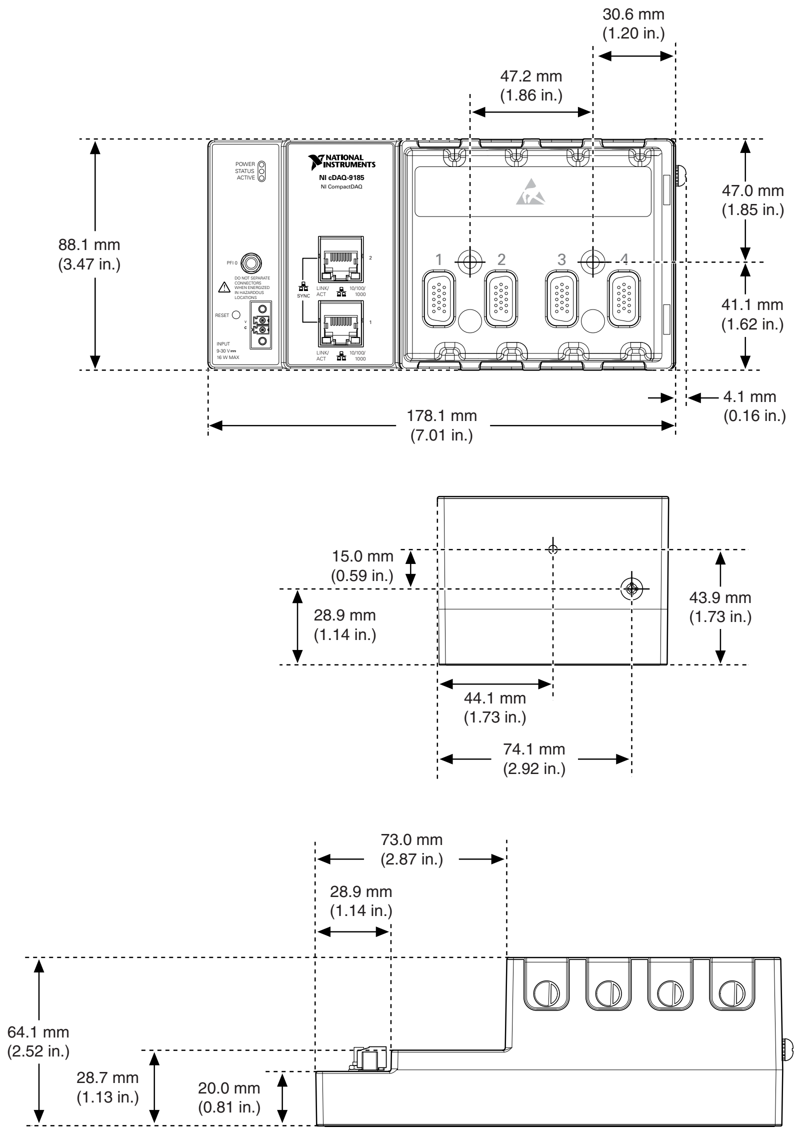
Weight (unloaded)	660.5 g (23.3 oz)
Dimensions (unloaded)	178.1 mm × 88.1 mm × 64.1 mm (7.01 in. × 3.47 in. × 2.52 in.) Refer to the following figure.

[11] Includes maximum 1 W module load per slot across rated temperature and product variations.

Screw-terminal wiring	
Gauge	0.2 mm^2 to 2.1 mm^2 (24 AWG to 14 AWG) copper conductor wire
Wire strip length	6 mm (0.24 in.) of insulation stripped from the end
Temperature rating	85 °C
Torque for screw terminals	0.20 N · m to 0.25 N · m (1.8 lb · in. to 2.2 lb · in.)
Wires per screw terminal	One wire per screw terminal
Connector securement	
Securement type	Screw flanges provided
Torque for screw flanges	0.3 N · m to 0.4 N · m (2.7 lb · in. to 3.5 lb · in.)

If you need to clean the chassis, wipe it with a dry towel.

Figure 1. cDAQ-9185 Dimensions



Safety Voltages

Connect only voltages that are within these limits.

V terminal to C terminal	30 V maximum, Measurement Category I

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as MAINS voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do not connect the system to signals or use for measurements within Measurement Categories II, III, or IV.

Note Measurement Categories CAT I and CAT O (Other) are equivalent. These test and measurement circuits are not intended for direct connection to the MAINs building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Environmental

Operating temperature (IEC 60068-2-1 and IEC 60068-2-2)	-40 °C to 70 °C[12]

Note Failure to follow the mounting instructions in the *cDAQ-9185/9189 User Manual* can cause temperature derating.

Storage temperature (IEC 60068-2-1 and IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP 40
Operating humidity (IEC 60068-2-56)	10% to 90% RH, noncondensing
Storage humidity (IEC 60068-2-56)	5% to 95% RH, noncondensing
Pollution Degree (IEC 60664)	2
Maximum altitude	5,000 m

Indoor use only.[13]

[12] When operating the cDAQ-9185 in temperatures below 0 °C, you must use the PS-15 power supply or another power supply rated for below 0 °C.

[13] Use NI 9917 and NI 9918 industrial enclosures to protect the device in harsh, dirty, or wet environments.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4 Gc
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Ex nA IIC T4 Gc
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc

Shock and Vibration

To meet these specifications, you must direct mount the cDAQ-9185 system and affix ferrules to the ends of the terminal lines.

Operating vibration	
Random (IEC 60068-2-64)	5 g RMS, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz to 500 Hz
Operating shock (IEC 60068-2-27)	30 g, 11 ms half sine, 50 g, 3 ms half sine, 18 shocks at 6 orientations

Safety and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA C22.2 No. 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 6, UL 60079-15; Ed 4
- CSA C22.2 No. 60079-0, CSA C22.2 No. 60079-15

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- EN 55022 (CISPR 22): Class A emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, and additional information, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2014/34/EU; Potentially Explosive Atmospheres (ATEX)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

376606A-01 May 11, 2017

Inspiron 3268

Setup and Specifications

Computer Model: Inspiron 3268
Regulatory Model: D13S
Regulatory Type: D13S002

Notes, cautions, and warnings

NOTE: A NOTE indicates important information that helps you make better use of your product.

CAUTION: A CAUTION indicates either potential damage to hardware or loss of data and tells you how to avoid the problem.

WARNING: A WARNING indicates a potential for property damage, personal injury, or death.

2016 - 12

Rev. A00

Contents

Set up your computer

1 Connect the keyboard and mouse.

See the documentation that shipped with the keyboard and mouse.

2 Connect the network cable — optional.

3 Connect the display.

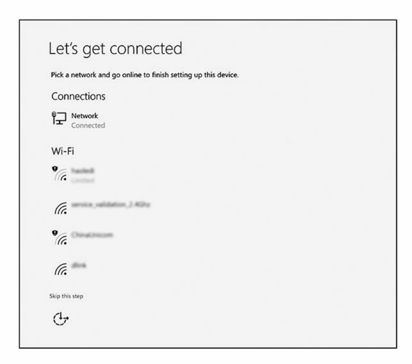
4 Connect the power cable.

5 Press the power button.

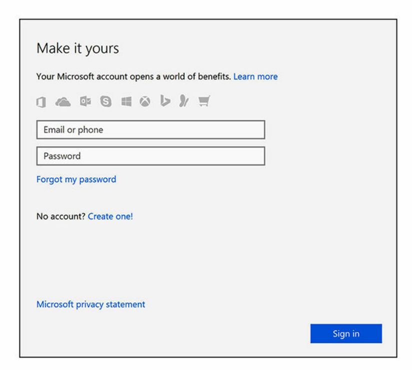
6 Finish operating system setup.

For Windows:

a) Connect to a network.



b) Sign-in to your Microsoft account or create a new account.

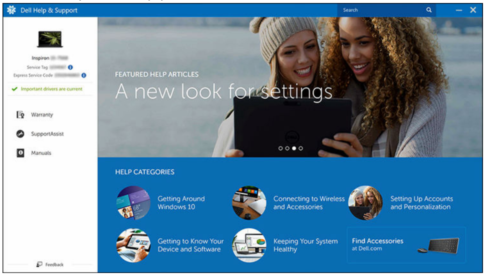


For Ubuntu:

Follow the instructions on the screen to finish setup.

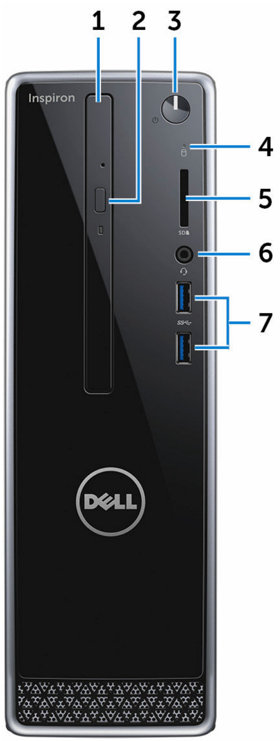
7 Locate Dell apps in Windows.

Table 1. Locate Dell apps

	Register your computer
	Dell Help & Support 
	SupportAssist—Check and update your computer

Views

Front



1 **Optical drive (optional)**

Reads from and writes to CDs and DVDs.

2 **Optical-drive eject button**

Press to open or close the optical drive tray.

3 **Power button**

Press to turn on the computer if it is turned off, in sleep state, or in hibernate state.

Press to put the computer in sleep state if it is turned on.

Press and hold for 4 seconds to force shut-down the computer.

NOTE: You can customize the power-button behavior in Power Options. For more information, see *Me and My Dell* at www.dell.com/support/manuals.

4 **Hard-drive activity light**

Turns on when the computer reads from or writes to the hard drive.

5 **Media-card reader**

Reads from and writes to media cards.

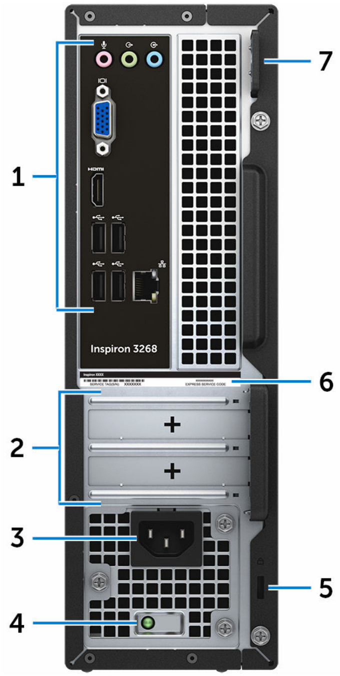
6 **Headset port**

Connect a headphone or a headset (headphone and microphone combo).

7 **USB 3.0 ports (2)**

Connect peripherals such as storage devices and printers. Provides data transfer speeds up to 5 Gbps.

Back



1 **Back panel**

Connect USB, audio, video, and other devices.

2 **Expansion-card slots**

Provide access to ports on any installed PCI Express cards.

3 **Power port**

Connect a power cable to provide power to your computer.

4 **Power-supply diagnostic light**

Indicates the power-supply state.

5 **Security-cable slot**

Connect a security cable to prevent unauthorized movement of your computer.

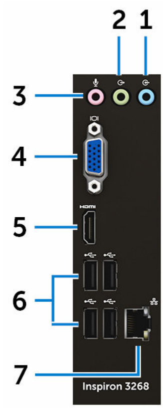
6 **Service Tag label**

The Service Tag is a unique alphanumeric identifier that enables Dell service technicians to identify the hardware components in your computer and access warranty information.

7 **Padlock rings**

Attach a standard padlock to prevent unauthorized access to the interior of your computer.

Back panel



1 **Line-in port**

Connect recording or playback devices such as a microphone or CD player.

2 **Line-out port**

Connect speakers.

3 **Microphone port**

Connect an external microphone to provide sound input.

4 **VGA port**

Connect an external display or a projector.

5 **HDMI port**

Connect a TV or another HDMI-in enabled device. Provides video and audio output.

6 **USB 2.0 ports (4)**

Connectperipherals such as storage devices and printers. Provides data transferspeeds up to 480 Mbps.

7 **Network port (with lights)**

Connect an Ethernet (RJ45) cable from a router or a broadband modem for network or internet access.

The two lights next to the connector indicate the connectivity status and network activity.

Specifications

Dimensions and weight

Table 2. Dimensions and weight

Height	293.10 mm (11.54 in)
Width	92.60 mm (3.65 in)
Depth	314.50 mm (12.38 in)
Weight (approximate)	4.40 kg (9.70 lb)
	NOTE: The weight of your computer varies depending on the configuration ordered and the manufacturing variability.

System information

Table 3. System information

Computer model	Inspiron 3268
Processor	• Intel Core i3/i5/i7 • Intel Celeron • Intel Pentium
Chipset	Intel H110

Memory

Table 4. Memory specifications

Slots	Two U-DIMM slots
Type	DDR4
Speed	• 2133 MHz (Intel Celeron)

	• 2400 MHz (Intel Pentium and Intel Core i3/i5/i7)
Configurations supported	2 GB, 4 GB, 6GB, 8 GB, 10 GB, 12 GB, and 16 GB

Ports and connectors

Table 5. Ports and connectors

External:	
Network	One RJ45 port
USB	• Four USB 2.0 ports • Two USB 3.0 ports
Audio/Video	• One headset port • One microphone port • One line-out port • One line-in port • One VGA port • One HDMI port
Internal:	
M.2 card	One M.2 card slot for Wi-Fi and Bluetooth combo card
PCIe slots	• One PCIe x1 card slot • One PCIe x16 card slot

Media-card reader

Table 6. Media-card reader specifications

Type	One 5-in-1 slot
Cards supported	• SD card

- SD High Capacity (SDHC) card
- SD Extended Capacity (SDXC) card
- MultiMediaCard (MMC)
- MultiMediaCard Plus (MMC Plus)

Communications

Table 7. Supported Communications

Ethernet	10/100/1000 Mbps Ethernet controller integrated on system board
Wireless	• Up to Wi-Fi 802.11ac/n • Bluetooth 4.0

Audio

Table 8. Audio specifications

Controller	Realtek ALC3820
Type	Integrated 5.1 channel Intel High Definition Audio

Storage

Table 9. Storage specifications

Interface	• SATA 1.5 Gbps for optical drive • SATA 6 Gbps for hard drive
Hard drive	• One 2.5-inch hard drive • One 3.5-inch hard drive
Solid-state drive	One 2.5-inch solid-state drive
Optical drive	One 9.5-mm DVD+/-RW drive

Power ratings

Table 10. Power ratings

Input voltage	100 VAC to 240 VAC
Input frequency	50 Hz to 60 Hz
Input current (maximum)	3.0 A

Video

Table 11. Video specifications

	Integrated	Discrete
Controller	Intel HD Graphics	NVIDIA GeForce GT710LP
Memory	Shared system memory	2 GB DDR3

Computer environment

Airborne contaminant level: G2 or lower as defined by ISA-S71.04-1985

Relative humidity (maximum): 20% to 80% (non-condensing)

Table 12. Computer environment

	Operating	Storage
Temperature range	10°C to 35°C (50°F to 95°F)	–40°C to 65°C (–40°F to 149°F)
Vibration (maximum)*	0.25 GRMS	2.20 GRMS
Shock (maximum)	40 G for 2 ms with a change in velocity of 20 in/s (51 cm/s)†	50 G for 26 ms with a change in velocity of 320 in/s (813 cm/s)‡
Altitude (maximum)	–15.24 m to 3048 m (–50 ft to 10,000 ft)	–15.24 m to 10,668 m (–50 ft to 35,000 ft)

* Measured using a random vibration spectrum that simulates user environment.

† Measured using a 2 ms half-sine pulse when the hard drive is in use.

‡ Measured using a 2 ms half-sine pulse when the hard-drive head is in parked position.

Getting help and contacting Dell

Self-help resources

You can get information and help on Dell products and services using these self-help resources:

Table 13. Self-help resources

Information about Dell products and services	www.dell.com
Dell Help & Support app	
Get started app	
Accessing help	In Windows search, type `Help and Support`, and press Enter.
Online help for operating system	www.dell.com/support/windows www.dell.com/support/linux
Troubleshooting information, user manuals, setup instructions, product specifications, technical help blogs, drivers, software updates, and so on.	www.dell.com/support
Learn about your operating system, setting up and using your computer, data backup, diagnostics, and so on.	See *Me and My Dell* at www.dell.com/support/manuals.

Contacting Dell

To contact Dell for sales, technical support, or customer service issues, see www.dell.com/contactdell.

NOTE: Availability varies by country and product, and some services may not be available in your country.

NOTE: If you do not have an active internet connection, you can find contact information on your purchase invoice, packing slip, bill, or Dell product catalog.

114103-P1
Rev F, 4/09

MKS Type 690A Absolute and Type 698A Differential High Accuracy Pressure Transducers

Table of Contents

List of Figures and Tables

Figures

Tables

Pressure Transducer Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning

The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution

The CAUTION sign denotes a hazard to equipment. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

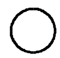
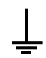
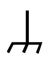
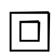
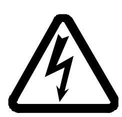
Definition of Symbols Found on the Unit			
 On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class ll equipment IEC 417, No.5172-a	 Three phase alternating current IEC 617-2 No.020206	
 Caution, refer to accompanying documents ISO 3864, No.B.3.1	 Caution, risk of electric shock ISO 3864, No.B.3.6	 Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

Observe the following general safety precautions during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not attempt component replacement and internal adjustments. Any service must be made by qualified service personnel only.

USE CAUTION WHEN OPERATING WITH HAZARDOUS MATERIALS

If hazardous materials are used, users must take responsibility to observe the proper safety precautions, completely purge the instrument when necessary, and ensure that the material used is compatible with the materials in this product, including any sealing materials.

PURGE THE INSTRUMENT

After installing the unit, or before removing it from a system, purge the unit completely with a clean, dry gas to eliminate all traces of the previously used flow material.

USE PROPER PROCEDURES WHEN PURGING

This instrument must be purged under a ventilation hood, and gloves must be worn for protection.

DO NOT OPERATE IN AN EXPLOSIVE ENVIRONMENT

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

USE PROPER FITTINGS AND TIGHTENING PROCEDURES

All instrument fittings must be consistent with instrument specifications, and compatible with the intended use of the instrument. Assemble and tighten fittings according to manufacturer's directions.

CHECK FOR LEAK-TIGHT FITTINGS

Carefully check all vacuum component connections to ensure leak-tight installation.

OPERATE AT SAFE INLET PRESSURES

Never operate at pressures higher than the rated maximum pressure (refer to the product specifications for the maximum allowable pressure).

INSTALL A SUITABLE BURST DISC

When operating from a pressurized gas source, install a suitable burst disc in the vacuum system to prevent system explosion should the system pressure rise.

KEEP THE UNIT FREE OF CONTAMINANTS

Do not allow contaminants to enter the unit before or during use. Contamination such as dust, dirt, lint, glass chips, and metal chips may permanently damage the unit or contaminate the process.

ALLOW PROPER WARM UP TIME FOR TEMPERATURE-CONTROLLED UNITS

Temperature-controlled units will only meet specifications when sufficient time is allowed for the unit to meet, and stabilize at, the designed operating temperature. Do not zero or calibrate the unit until the warm up is complete.

Sicherheitshinweise für den Druckmeßumformer

In dieser Betriebsanleitung vorkommende Symbole

Bedeutung der mit WARNUNG!, VORSICHT! und HINWEIS gekennzeichneten Absätze in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahr für das Bedienpersonal hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Verletzungen führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahr für das Gerät hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Gerätes oder von Teilen des Gerätes führen kann.

Hinweis

Das Symbol HINWEIS macht auf wichtige Informationen bezüglich eines Arbeitsablaufs, einer Arbeitsweise, eines Zustands oder einer sonstige Gegebenheit aufmerksam.

Erklärung der am Gerät angebrachten Symbole

Nachstehender Tabelle sind die Bedeutungen der Symbole zu entnehmen, die am Gerät angebracht sein können.

Bedeutung der am Gerät angebrachten Symbole			
Ein (Energie) IEC 417, No.5007	Aus (Energie) IEC 417, No.5008	Erdanschluß IEC 417, No.5017	Schutzleiteranschluß IEC 417, No.5019
Masseanschluß IEC 417, No.5020	Aquipotential- anschluß IEC 417, No.5021	Gleichstrom IEC 417, No.5031	Wechselstrom IEC 417, No.5032
Gleich- oder Wechselstrom IEC 417, No.5033-a	Durchgängige doppelte oder verstärkte Isolierung IEC 417, No.5172-a	3~ Dreileiter- Wechselstrom (Drehstrom) IEC 617-2, No.020206	
Warnung vor einer Gefahrenstelle (Achtung, Dokumen- tation beachten) ISO 3864, No.B.3.1	Warnung vor gefährlicher elektrischer Spannung ISO 3864, No.B.3.6	Höhere Temperatur an leicht zugänglichen Teilen IEC 417, No.5041	

Tabelle 2: Bedeutung der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Folgende allgemeine Sicherheitsvorschriften sind während allen Betriebsphasen dieses Gerätes zu befolgen. Eine Mißachtung der Sicherheitsvorschriften und sonstiger Warnhinweise in dieser Betriebsanleitung verletzt die für dieses Gerät und seine Bedienung geltenden Sicherheitsstandards, und kann die Schutzvorrichtungen an diesem Gerät wirkungslos machen. MKS Instruments, Inc. haftet nicht für Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Niemals Teile austauschen oder Änderungen am Gerät vornehmen!

Ersetzen Sie keine Teile mit baugleichen oder ähnlichen Teilen, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor. Schicken Sie das Gerät zwecks Wartung und Reparatur an den MKS-Kalibrierungs- und -Kundendienst ein. Nur so wird sichergestellt, daß alle Schutzvorrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Auswechseln von Komponenten und das Vornehmen von internen Einstellungen darf nur von qualifizierten Fachleuten durchgeführt werden, niemals vom Bedienpersonal.

Vorsicht beim Arbeiten mit gefährlichen Stoffen!

Wenn gefährliche Stoffe verwendet werden, muß der Bediener die entsprechenden Sicherheitsvorschriften genauestens einhalten, das Gerät, falls erforderlich, vollständig spülen, sowie sicherstellen, daß der Gefahrstoff die am Gerät verwendeten Materialien, insbesondere Dichtungen, nicht angreift.

Spülen des Gerätes mit Gas!

Nach dem Installieren oder vor dem Ausbau aus einem System muß das Gerät unter Einsatz eines reinen Trockengases vollständig gespült werden, um alle Rückstände des Vorgängermediums zu entfernen.

Anweisungen zum Spülen des Gerätes

Das Gerät darf nur unter einer Ablufthaube gespült werden. Schutzhandschuhe sind zu tragen.

Gerät nicht zusammen mit explosiven Stoffen, Gasen oder Dämpfen benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät niemals zusammen mit (oder in der Nähe von) explosiven Stoffen aller Art eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zugelassen ist.

Anweisungen zum Installieren der Armaturen!

Alle Anschlußstücke und Armaturenteile müssen mit der Gerätespezifikation übereinstimmen, und mit dem geplanten Einsatz des Gerätes kompatibel sein. Der Einbau, insbesondere das Anziehen und Abdichten, muß gemäß den Anweisungen des Herstellers vorgenommen werden.

Verbindungen auf Undichtigkeiten prüfen!

Überprüfen Sie sorgfältig alle Verbindungen der Vakuumkomponenten auf undichte Stellen.

Gerät nur unter zulässigen Anschlußdrücken betreiben!

Betreiben Sie das Gerät niemals unter Drücken, die den maximal zulässigen Druck (siehe Produktspezifikationen) übersteigen.

Geeignete Berstscheibe installieren!

Wenn mit einer unter Druck stehenden Gasquelle gearbeitet wird, sollte eine geeignete Berstscheibe in das Vakuumsystem installiert werden, um eine Explosionsgefahr aufgrund von steigendem Systemdruck zu vermeiden.

Verunreinigungen im Gerät vermeiden!

Stellen Sie sicher, daß Verunreinigungen jeglicher Art weder vor dem Einsatz noch während des Betriebs in das Instrumenteninnere gelangen können. Staub- und Schmutzpartikel, Glassplitter oder Metallspäne können das Gerät dauerhaft beschädigen oder Prozeß und Meßwerte verfälschen.

Bei Geräten mit Temperaturkontrolle korrekte Anwärmzeit einhalten!

Temperaturkontrollierte Geräte arbeiten nur dann gemäß ihrer Spezifikation, wenn genügend Zeit zum Erreichen und Stabilisieren der Betriebstemperatur eingeräumt wird. Kalibrierungen und Nulleinstellungen sollten daher nur nach Abschluß des Anwärmvorgangs durchgeführt werden.

Informations relatives à la sécurité pour le transducteur de pression

Symboles utilisés dans ce manuel d'utilisation

Définitions des indications AVERTISSEMENT, ATTENTION, et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger pour le personnel. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation présentant un risque d'accident pour le personnel, en cas d'exécution incorrecte ou de non respect des consignes.

Attention

L'indication ATTENTION signale un danger pour l'appareil. Elle attire l'attention sur une procédure d'exploitation, une pratique, ou toute autre situation, présentant un risque d'endommagement ou de destruction d'une partie ou de la totalité de l'appareil, en cas d'exécution incorrecte ou de non respect des consignes.

Remarque

L'indication REMARQUE signale une information importante. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation, présentant un intérêt particulier.

Symboles apparaissant sur l'unité

Le tableau suivant décrit les symboles pouvant apparaître sur l'unité.

Définition des symboles apparaissant sur l'unité			
Marche (sous tension) IEC 417, No.5007	Arrêt (hors tension) IEC 417, No.5008	Terre (masse) IEC 417, No.5017	Terre de protection (masse) IEC 417, No.5019
Masse IEC 417, No.5020	Equipotentialité IEC 417, No.5021	Courant continu IEC 417, No.5031	Courant alternatif IEC 417, No.5032
Courant continu et alternatif IEC 417, No.5033-a	Matériel de classe II IEC 417, No.5172-a	Courant alternatif triphasé IEC 617-2, No.020206	
Attention : se reporter à la documentation ISO 3864, No.B.3.1	Attention : risque de choc électrique ISO 3864, No.B.3.6	Attention : surface brûlante IEC 417, No.5041	

Tableau 3: Définition des symboles apparaissant sur l'unité

Mesures de sécurité et précautions

Prendre les précautions générales de sécurité suivantes pendant toutes les phases d'exploitation de cet appareil. Le non respect des ces précautions ou des avertissements contenus dans ce manuel constitue une violation des normes de sécurité relatives à l'utilisation de l'appareil et peut diminuer la protection fournie par l'appareil. MKS Instruments, Inc. n'assume aucune responsabilité concernant le non respect des consignes par les clients.

PAS DE SUBSTITUTION DE PIÈCES OU DE MODIFICATION DE L'APPAREIL

Ne pas installer des pièces de substitution ou effectuer des modifications non autorisées sur l'appareil. Renvoyer l'appareil à un centre de service et de calibrage MKS pour tout dépannage ou réparation afin de garantir le l'intégrité des dispositifs de sécurité.

DÉPANNAGE UNIQUEMENT PAR DU PERSONNEL QUALIFIÉ

Le personnel d'exploitation ne doit pas essayer de remplacer des composants ou de faire des réglages internes. Tout dépannage doit être uniquement effectué par du personnel qualifié.

PRÉCAUTION EN CAS D'UTILISATION AVEC DES PRODUITS DANGEREUX

Si des produits dangereux sont utilisés, l'utilisateur est responsable de la prise des mesures de précaution appropriées, de la purge complète de l'appareil quand cela est nécessaire, et de la garantie que les produits utilisés sont compatibles avec les composants de cet appareil, y compris les matériaux d'étanchéité.

PURGE DE L'APPAREIL

Après l'installation de l'unité, ou avant son enlèvement d'un système, purger l'unité complètement avec un gaz propre et sec afin d'éliminer toute trace du produit de flux utilisé précédemment.

UTILISATION DES PROCÉDURES APPROPRIÉES POUR LA PURGE

Cet appareil doit être purgé sous une hotte de ventilation, et il faut porter des gants de protection.

PAS D'EXPLOITATION DANS UN ENVIRONNEMENT EXPLOSIF

Pour éviter toute explosion, ne pas utiliser cet appareil dans un environnement explosif, sauf en cas d'homologation spécifique pour une telle exploitation.

UTILISATION D'ÉQUIPEMENTS APPROPRIÉS ET PROCÉDURES DE SERRAGE

Tous les équipements de l'appareil doivent être cohérents avec ses spécifications, et compatibles avec l'utilisation prévue de l'appareil. Assembler et serrer les équipements conformément aux directives du fabricant.

VÉRIFICATION DE L'ÉTANCHÉITÉ DES CONNEXIONS

Vérifier attentivement toutes les connexions des composants pour le vide afin de garantir l'étanchéité de l'installation.

EXPLOITATION AVEC DES PRESSIONS D'ENTRÉE NON DANGEREUSES

Ne jamais utiliser des pressions supérieures à la pression nominale maximum (se reporter aux spécifications de l'unité pour la pression maximum admissible).

INSTALLATION D'UN DISQUE D'ÉCHAPPEMENT ADAPTÉ

En cas d'exploitation avec une source de gaz pressurisé, installer un disque d'échappement adapté dans le système à vide, afin d'éviter une explosion du système en cas d'augmentation de la pression.

MAINTIEN DE L'UNITÉ À L'ABRI DES CONTAMINATIONS

Ne pas laisser des produits contaminants pénétrer dans l'unité avant ou pendant l'utilisation. Des produits contaminants tels que des poussières et des fragments de tissu, de glace et de métal peuvent endommager l'unité d'une manière permanente ou contaminer le processus.

RESPECT DU TEMPS D'ÉCHAUFFEMENT APPROPRIÉ POUR LES UNITÉS Á TEMPÉRATURE CONTRÔLÉE

Les unités à température contrôlée atteignent leurs spécifications uniquement quand on leur laisse un temps suffisant pour atteindre d'une manière stable la température d'exploitation. Ne pas remettre à zéro ou calibrer l'unité tant que l'échauffement n'est pas terminé.

Medidas de seguridad del transductor de presión

Símbolos usados en este manual de instrucciones

Definiciones de los mensajes de advertencia, precaución y de las notas usados en el manual.

Advertencia

El símbolo de advertencia indica la posibilidad de que se produzcan daños personales. Pone de relieve un procedimiento, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños personales.

Precaución

El símbolo de precaución indica la posibilidad de producir daños al equipo. Pone de relieve un procedimiento operativo, práctica, estado, etc. que en caso de no realizarse u observarse correctamente puede causar daños o la destrucción total o parcial del equipo.

Nota

El símbolo de notas indica información de importancia. Este símbolo pone de relieve un procedimiento, práctica o condición cuyo conocimiento es esencial destacar.

Símbolos hallados en la unidad

La tabla siguiente contiene los símbolos que puede hallar en la unidad.

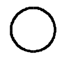
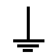
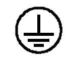
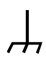
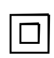
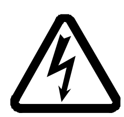
Definición de los símbolos hallados en la unidad			
Encendido (alimentación eléctrica) IEC 417, N° 5007	 Apagado (alimentación eléctrica) IEC 417, N° 5008	 Puesta a tierra IEC 417, N° 5017	 Protección a tierra IEC 417, N° 5019
 Caja o chasis IEC 417, N° 5020	 Equipotencialidad IEC 417, N° 5021	 Corriente continua IEC 417, N° 5031	 Corriente alterna IEC 417, N° 5032
 Corriente continua y alterna IEC 417, N° 5033-a	 Equipo de clase II IEC 417, N° 5172-a	 Corriente alterna trifásica IEC 617-2, N° 020206	
 Precaución. Consulte los documentos adjuntos ISO 3864, N° B.3.1	 Precaución. Riesgo de descarga eléctrica ISO 3864, N° B.3.6	 Precaución. Superficie caliente IEC 417, N° 5041	

Tabla 4: Definición de los símbolos hallados en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad descritas a continuación deben observarse durante todas las etapas de funcionamiento del instrumento. La falta de cumplimiento de dichas precauciones o de las advertencias específicas a las que se hace referencia en el manual, constituye una violación de las normas de seguridad establecidas para el uso previsto del instrumento y podría anular la protección proporcionada por el equipo. Si el cliente no cumple dichas precauciones y advertencias, MKS Instruments, Inc. no asume responsabilidad legal alguna.

NO UTILICE PIEZAS NO ORIGINALES O MODIFIQUE EL INSTRUMENTO

No instale piezas que no sean originales ni modifique el instrumento sin autorización. Para asegurar el correcto funcionamiento de todos los dispositivos de seguridad, envíe el instrumento al Centro de servicio y calibración de MKS toda vez que sea necesario repararlo o efectuar tareas de mantenimiento.

LAS REPARACIONES DEBEN SER EFECTUADAS ÚNICAMENTE POR TÉCNICOS AUTORIZADOS

Los operarios no deben intentar reemplazar los componentes o realizar tareas de ajuste en el interior del instrumento. Las tareas de mantenimiento o reparación deben ser realizadas únicamente por personal autorizado.

TENGA CUIDADO CUANDO TRABAJE CON MATERIALES TÓXICOS

Cuando se utilicen materiales tóxicos, es responsabilidad de los operarios tomar las medidas de seguridad correspondientes, purgar totalmente el instrumento cuando sea necesario y comprobar que el material utilizado sea compatible con los materiales del instrumento e inclusive, con todos los materiales de sellado.

PURGUE EL INSTRUMENTO

Una vez instalada la unidad o antes de retirarla del sistema, purgue completamente la unidad con gas limpio y seco para eliminar todo resto de la sustancia líquida empleada anteriormente.

USE PROCEDIMIENTOS ADECUADOS PARA REALIZAR LA PURGA

El instrumento debe purgarse debajo de una campana de ventilación y deben utilizarse guantes protectores.

NO HAGA FUNCIONAR EL INSTRUMENTO EN AMBIENTES CON RIESGO DE EXPLOSIÓN

Para evitar que se produzcan explosiones, no haga funcionar este instrumento en un ambiente con riesgo de explosiones, excepto cuando el mismo haya sido certificado específicamente para tal uso.

USE ACCESORIOS ADECUADOS Y REALICE CORRECTAMENTE LOS PROCEDIMIENTOS DE AJUSTE

Todos los accesorios del instrumento deben cumplir las especificaciones del mismo y ser compatibles con el uso que se debe dar al instrumento. Arme y ajuste los accesorios de acuerdo con las instrucciones del fabricante.

COMPRUEBE QUE LAS CONEXIONES SEAN A PRUEBA DE FUGAS

Inspeccione cuidadosamente las conexiones de los componentes de vacío para comprobar que hayan sido instalados a prueba de fugas.

HAGA FUNCIONAR EL INSTRUMENTO CON PRESIONES DE ENTRADA SEGURAS

No haga funcionar nunca el instrumento con presiones superiores a la máxima presión nominal (en las especificaciones del instrumento hallará la presión máxima permitida).

INSTALE UNA CÁPSULA DE SEGURIDAD ADECUADA

Cuando el instrumento funcione con una fuente de gas presurizado, instale una cápsula de seguridad adecuada en el sistema de vacío para evitar que se produzcan explosiones cuando suba la presión del sistema.

MANTENGA LA UNIDAD LIBRE DE CONTAMINANTES

No permita el ingreso de contaminantes en la unidad antes o durante su uso. Los productos contaminantes tales como polvo, suciedad, pelusa, lascas de vidrio o virutas de metal pueden dañar irreparablemente la unidad o contaminar el proceso.

CALIENTE ADECUADAMENTE LAS UNIDADES CONTROLADAS POR MEDIO DE TEMPERATURA

Las unidades controladas por medio de temperatura funcionarán de acuerdo con las especificaciones sólo cuando se las caliente durante el tiempo suficiente para permitir que lleguen y se estabilicen a la temperatura de operación indicada. No calibre la unidad y no la ponga en cero hasta que finalice el procedimiento de calentamiento.

This page intentionally left blank.

Chapter One: General Information

Introduction

This manual describes the MKS 690A Series (Absolute) and 698A Series (Differential) Baratron® Pressure Transducers.

These transducers, when used with their required MKS Type 670[1] Signal Conditioner/Readout, represent the best pressure measurement system (sensor/transducer, signal conditioner, digital readout) currently produced by MKS. For further information on the companion Signal Conditioner/Readout, please refer to the 670 instruction manuals.

These precision pressure measurement systems are available with high basic accuracies, wide dynamic range, and a typical Zero Coefficient of 1 to 2 ppm/ °C and a Span Coefficient of 10 to 15 ppm/°C (higher for the 100 mTorr range).

Figure 1: Type 690A Pressure Transducer

[1]The Type 670 Signal Conditioner/Readout is required for CE mark compliance.

How This Manual is Organized

This manual is designed to provide instructions on how to set up, install, and operate a Type 690A/698A unit.

Before installing your Type 690A/698A unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One, *General Information*, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two, *Installation*, explains the environmental requirements and describes how to mount the instrument in your system.

Chapter Three, *Overview*, gives a brief description of the instrument and its functionality.

Chapter Four, *Operation*, describes how to use the instrument and explains all the functions and features.

Chapter Five, *Maintenance and Troubleshooting*, lists any maintenance required to keep the instrument in good working condition, and provides a checklist for reference should the instrument malfunction.

Appendix A, *Product Specifications*, lists the specifications of the instrument.

Appendix B, *Model Code Explanation*, describes the instruments ordering code.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 690A/698A instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an RMA (Return Material Authorization) Number from the MKS Calibration and Service Center before shipping. The RMA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning

All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.

Chapter Two: Installation

How To Unpack the Type 690A/698A Unit

MKS has carefully packed the Type 690A/698A unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an RMA (Return Material Authorization) Number from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Caution **Only qualified individuals should perform the installation and any user adjustments. They must comply with all the necessary ESD and handling precautions while installing and adjusting the instrument. Proper handling is essential when working with all highly sensitive precision electronic instruments.**

Unpacking Checklist

Standard Equipment:

- Type 690A/698A Unit
- Type 690A/698A Instruction Manual (this book)

Optional Equipment:

- Electrical Connector Accessories Kit
  690A-K1
  698A-K1
- Interface cables (refer to Table 4, page 22)
- Type HS-1 Transducer Simulator

Interface Cables

As of July 20, 2009, most products shipped to the European Community must comply with the EMC Directive 2004/108/EEC, which covers radio frequency emissions and immunity tests. In addition, as of January 1, 1997, some products shipped to the European Community must also comply with the Product Safety Directive 92/59/EEC and Low Voltage Directive 73/23/EEC, which cover general safety practices for design and workmanship. MKS products that meet these requirements are identified by application of the CE Mark.

To ensure compliance with EMC Directive 2004/108/EEC, an overall metal braided shielded cable, properly grounded at both ends, is required during use. No additional installation requirements are necessary to ensure compliance with Directives 92/59/EEC and 73/23/EEC.

Note

1. Overall metal braided shielded cables, properly grounded at both ends, are required to meet CE specifications.
2. To order metal braided shielded cables, add an “S” after the cable type designation. For example, to order a standard cable to connect the 690A transducer to a 670 unit, use part number CB270-2-10; for a metal braided shielded cable, use part number CB270S-2-10.

System Interface Cables

System Interface Cables		
To Connect the 698A/698A Unit To...	**Use the MKS Cable...**	
	Standard	**Shielded**
670	CB270-2-10	CB270S-2-10
	CB270-2-20	CB270S-2-20
	CB270-2-40	CB270S-2-40

Table 5: System Interface Cables

Generic Shielded Cables

MKS offers a full line of cables for all MKS equipment. Should you choose to manufacture your own cables, follow the guidelines listed below:

1. The cable must have an overall metal *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding will be as effective; using either may nullify regulatory compliance.

2. The connectors must have a metal case which has direct contact to the cable's shield on the whole circumference of the cable. The inductance of a flying lead or wire from the shield to the connector will seriously degrade the shield's effectiveness. The shield should be grounded to the connector before its internal wires exit.

3. With very few exceptions, the connector(s) must make good contact to the device's case (ground). "Good contact" is about 0.01 ohms; and the ground should surround all wires. Contact to ground at just one point may not suffice.

4. For shielded cables with flying leads at one or both ends; it is important at each such end, to ground the shield *before* the wires exit. Make this ground with absolute minimum length. Refer to Figures 2 and 3, page 24. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in the instruction manual.

5. In selecting the appropriate type and wire size for cables, consider:

   A. The voltage ratings;

   B. The cumulative I^2R heating of all the conductors (keep them safely cool);

   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device;

   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables); and

   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Example 1: Preferred Method To Connect Cable
(shown on a transducer)

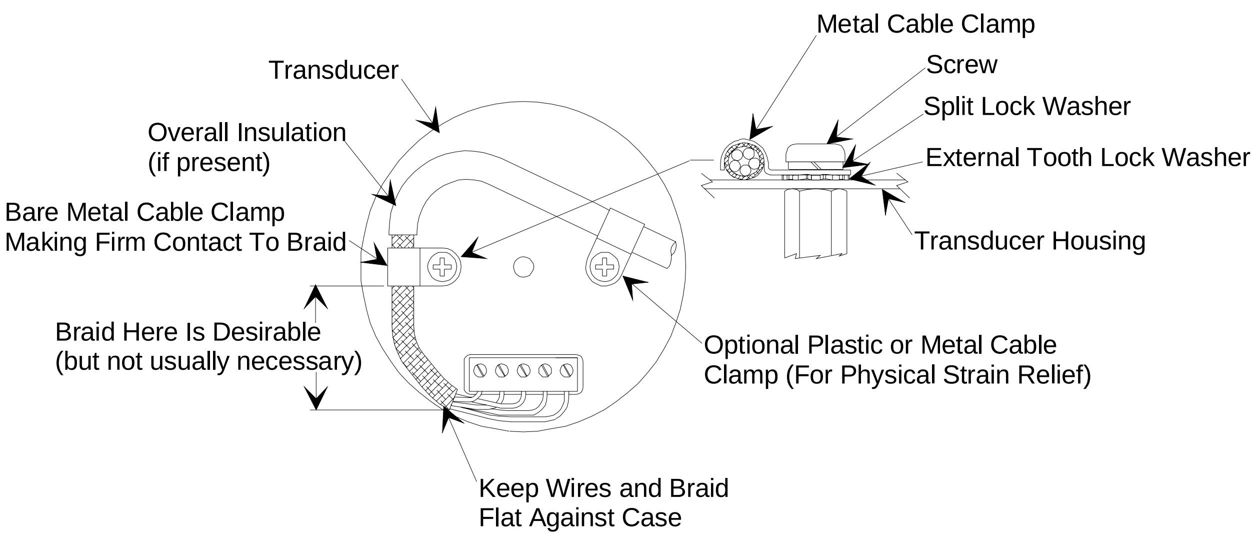


Figure 2: Preferred Method To Connect an Overall Metal Braided Shielded Cable

Example 2: Alternate Method To Connect Cable
(shown on a transducer)

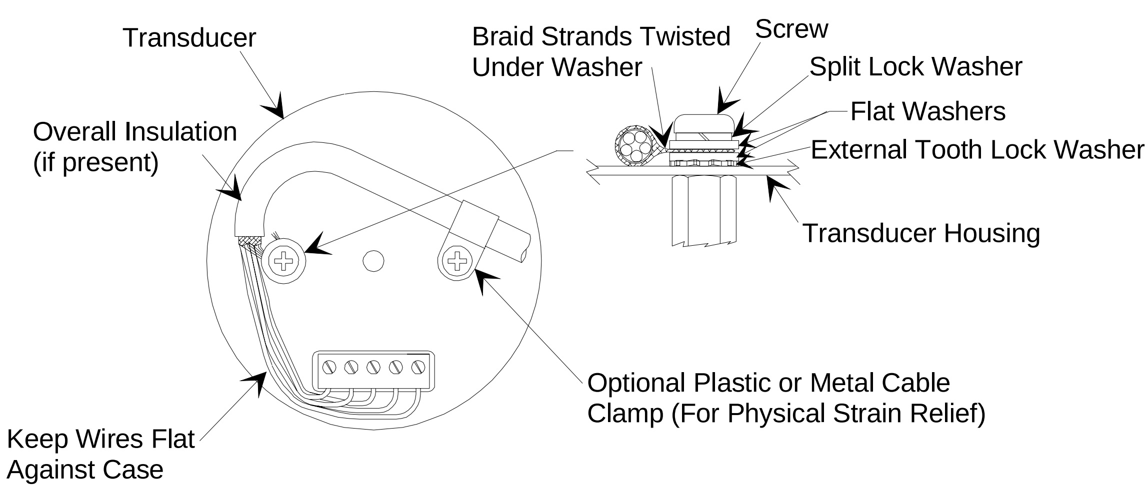


Figure 3: Alternate Method To Connect an Overall Metal Braided Shielded Cable
(Use this method when cable clamp is not available)

Setup

Dimensions

Note All dimensions are listed in inches.

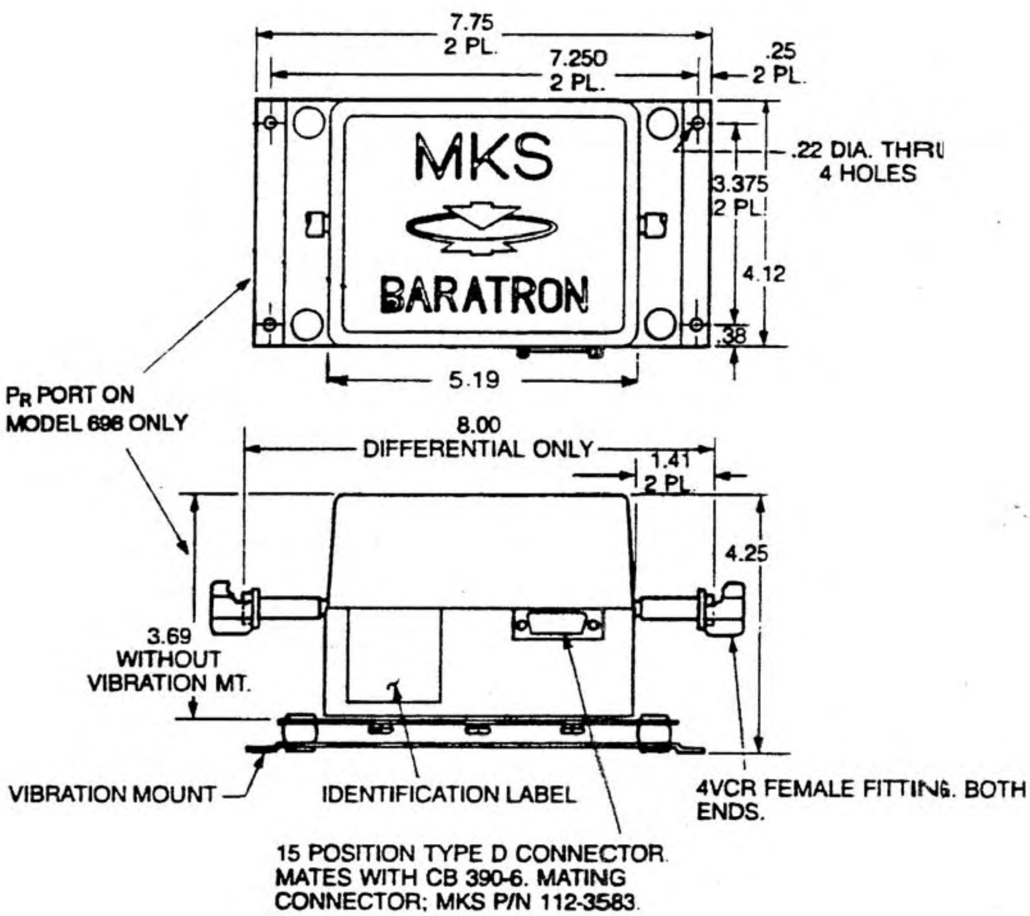


Figure 4: Dimensions of Type 690A and 698A Pressure Transducers

Mounting Instructions

The Type 690A/698A transducer must be mounted horizontally upon its vibration isolation base with the following points noted.

Warning

The unit *must* be mounted horizontally.

Do not mount the Type 690A/698A pressure transducer vertically or upside down. The vibration mount assembly is not designed to support the weight of the unit in either position.

A. All units are supplied with vibration isolators which should be used for maximum stability. A flexible bellows connection is suggested to minimize vibration. Furthermore, it is recommended that the sensor be mounted such that the sensor diaphragm plane is parallel to the major axis of vibration (diaphragm plane is perpendicular to port axis).

B. Ambient temperature around the 690A/698A transducer must not rise above 40° C as this will cause the 45° to 47° C control temperature to go out of regulation, thus destroying the system stability.

C. Mount the transducer as far from RFI and EMI sources as possible. Field experience has shown that care in positioning the transducer initially will prevent future difficulties. The MKS system is internally protected against RFI and EMI. However, in a system where several ground potentials are possible, a noisy environment may cause output to be unstable. When this happens, we have found the only solution has been an examination and correction of the source of RFI/EMI.

   Example:

   An SCR supply used in some systems should have the power-carrying wires that run to the chamber twisted to cancel high frequency magnetic fields. Never run the 690A transducer to Signal Conditioner cable in the same wiring bundle as RF or SCR signals.

D. The system interface cables are listed in Table 4, page 22.

E. *The vibration mount assembly is shipped from MKS with two shipping screws in place.* For noise-free operation, these screws must be removed. However, when this Baratron is subsequently reshipped on a piece of equipment, these screws ***must be reinstalled*** as the rubber feet will withstand no more than 3 g's force in transit.

F. When installing a 698A differential transducer, allow for a cross-porting manifold; that is, connecting the two ports together. In order to properly set the zero of any differential sensor, there must be equal pressure on both sides of the sensor.

G. Vacuum Connections: The sensor should be connected to the vacuum system via an appropriate isolation valve and bellows tubing.

a. To maximize the life and zero repeatability of the sensor, an isolation valve should be used. Set its closing point at or slightly above the transducer's full scale range.

An isolation valve serves to protect the sensor in two ways:

First: From overpressure in excess of the sensor's specifications, which is common in processing systems.

690A Absolute:	125% of FS or 45 psia (whichever is greater)
698A Differential:	125% of FS or 45 psia (whichever is greater) (lower for 100 mTorr Range)

Second: From contamination by moisture, which is present when a process system is vented to atmosphere. Moisture can often combine with residue on the sensor and/or system surfaces, and form acids such as HCl when chlorine - based processes are used.

Any high-quality electric, or air-operated valve, can be used for isolation.

b. The sensor inlet should be connected to the isolation valve via an appropriate length of stainless steel bellows tubing with welded mating fittings. Both VCR fittings and flexible tubing are products of the Swagelok Company.

The use of a flexible bellows completes vibration isolation to the sensor, allowing it to function independently of significant system vibration or stress that could be induced during operation or shipment.

Caution

Hard coupling of the sensor inlet tube so that the transducer is suspended by this tube is not recommended as the weight of the entire assembly will cause stress on the sensor.

c. 698A Differential Sensors: The P_X port must be connected to the high side of any system whose differential pressure is to be measured. The P_R side will then be connected to the low pressure side. If connections are reversed, the instrument will output a negative signal whose accuracy is not specified. A 698A differential sensor may be used to make an absolute measurement, by continually pumping the P_R port to a pressure below that of the resolution of the sensor. (Example: 1mm Hg FS x 10^{-6} = $<10^{-6}$ mm Hg).

Caution

Do not attempt to change the inlet tube fitting by cutting or welding. If a different fitting is desired, make up an adaptor, or consult MKS for a quotation on a special-version sensor.

For your convenience, MKS makes available several lengths of these bellows assemblies, including the mating VCR fittings welded to the bellows tubing. To order, specify P/N 6BL 4VCR for a 6” length, or P/N 12BL 4VCR for a 12” length.

Chapter Three: Overview

Functional Description

The 690A/698A Baratron is composed of four (4) sub-sections assembled within a precision die-cast housing. These are: 1) an Inconel® variable capacitance diaphragm sensor; 2) an electronic preamplifier and bridge circuits; 3) an inner temperature control housing; 4) a PC Board. The all-Inconel sensor, together with its high impedance bridge circuit and preamp, is mounted within a thick-walled, temperature controlled aluminum housing. This miniature "environmental chamber" reduces the ambient temperature effects upon the sensor and bridge circuit by more than a factor of 50.

The main PC board mounted outside the temperature-controlled housing consists of those circuits necessary to convert a low level 10 KHz signal to a precise ¼ V/V output that is linearly proportional to pressure. Also, that circuit necessary to maintain the housing temperature is located on this board. All gain-controlling components are selected for maximum stability (wire-wound resistor, NPO capacitor, etc.). A "system check" circuit is used which will point out any gain change experienced at any point in the electrical system.

The 690A Baratron is able to make a reliable absolute pressure measurement by virtue of its own built-in "zero" pressure reference cavity. During production, the low pressure side (P_R) of the sensor is pumped to less than 1 x 10^{-7} Torr, outgassed thoroughly, chemically gettered, and permanently sealed. The extremely low gas loads and active gettering material in the reference cavity assure the user of many years of useful service.

The 698A Baratron is unique, in that the entire differential sensor is surrounded by an Inconel case. Ambient line pressure (P_R) appears between the sensor and this case, thus eliminating sensitivity changes due to line pressure induced stress variations within the sensor structure. Careful deadweight testing has shown a variation of less than 0.01% of reading as the line pressure varies from 1 to 15 psia.

Transducer Simulator

The Type HS-1 Transducer Simulator is used as a test box for checkout and set-up of a precision pressure measurement system (690A/698A, and 670 signal conditioner). The simulator provides the following functions:

1. A dummy load for, and LED visual signal of, the heater supply power.
2. A visual signal of the ±15 VDC power supply function.
3. The generation of a zero, 50% FS, and 100% FS signal.
4. Test points for the measurement of the 6 VRMS excitation signal.

Through its use, one may accomplish the following:

1. Identify a faulty transducer.
2. Identify a faulty cable.
3. Check some of the fundamental functions of the signal conditioner/readout unit.
4. Adjust for transducer-to-signal conditioner cable length.

Chapter Four: Operation

General Information

Note It is important to remember that all diaphragm-variable capacitance pressure transducers require you to set "zero" with the signal conditioner, after suitable warm-up and pumping have been accomplished.

The following procedure is presented as an optimum guide to achieving the full design potential of the precision 690A/698A pressure measurement system.

1. (690A, 698A): After the sensor has been installed on the system whose pressure is to be measured, it should be connected to its Electronics Unit via the appropriate cable (refer to *Interface Cables*, page 22), and power applied.

2. (690A, 698A): A minimum of four (4) hours, and preferably overnight, should be allowed for the heater in the sensor package to thermally stabilize the sensor at control temperature.

3. (690A): While waiting for the sensor to reach stable thermal equilibrium, the appropriate vacuum pump(s) in the Processing System should be engaged, so as to pump down the sensor below its minimum usable resolution.

   (698A): While waiting for the sensor to reach stable thermal equilibrium, the appropriate vacuum pump(s) in the Processing System should be engaged, in such manner as to provide equal pressure on both sides of the sensor. (This can also be accomplished by cross-porting; that is, connecting the two ports together).

4. (690A, 698A): After the above warm-up time and pumping requirements have been met, the zero can be properly set.

Each full scale range has different pumping criteria. The following chart summarizes the basic pressures needed prior to setting the Zero.

Maximum Pressures For Proper Zero Adjustment			
Sensor Model Number	**Range Full Scale**	**Highest Pressure for Proper Zero Adjust**	**Warm-Up Time Before Adjusting Zero**
690A.1Txx	100 mTorr	$< 1 \times 10^{-7}$ Torr	4 Hours Minimum*
690A01Txx	1 Torr	$< 1 \times 10^{-6}$ Torr	"
690A11Txx	10 Torr	$< 1 \times 10^{-5}$ Torr	"
690A12Txx	100 Torr	$< 1 \times 10^{-4}$ Torr	"
690A13Txx	1000 Torr	$< 1 \times 10^{-3}$ Torr	"
698A14Txx	10000 Torr	$< 1 \times 10^{-2}$ Torr	"
** It is recommended that all temp-controlled transducers be powered continuously.*			

Table 6: Maximum Pressures for Proper Zero Adjustment

How To Zero the Transducer

How To Zero the Transducer Using the Zero Pot

The best method of zeroing the transducer system is:

1. Center the fine pot in the Electronics Unit.

   This is accomplished by turning the pot to either extreme, noting the voltages at each extreme, and then setting the pot at the half way point.

2. Adjust the zero using the coarse zero pot on the electronics unit.

Note The sensor zero pot is factory set during calibration, and should ***never*** be adjusted by the user unless there are suitable transfer or primary standards available to aid in recalibration.

3. Fine-trim the output, using the zero controls on the Electronics Unit.

   The measurement system is now ready to use.

   For reference, the frequency of setting the zero will depend on use, variations in ambient temperature, and your application. You will, with experience, gain a feeling for the frequency with which the zero adjustment must be made. For extremely critical measurement of very low pressures, checking the zero more often and making minor adjustments will ensure the most accurate measurements attainable with this MKS Baratron transducer system.

Note

1. The span of the sensor is factory set during the calibration, and should ***never*** be adjusted by the user unless there are suitable transfer or primary standards available to aid in recalibration.
2. If the Zero or Span potentiometers in the sensor head preamplifier are mistakenly adjusted, please contact your nearest MKS Service Center for assistance, and possible instructions to return the instrument to MKS for recalibration.

A 0.1 Torr 690A or 698A transducer operates within specifications if the range of the signal conditioner is set to either X1 or X.1. A 0.1 Torr 690A/698A transducer ***should not*** be set to the X.01 range. Operation of a 0.1 Torr transducer in the X.01 signal conditioner range may create electrical noise to the point of excessively distorting the pressure signal which, in turn, causes both linearity and zero errors.

If use of the Sensor Zero Coarse and Fine controls on the signal conditioner does not provide enough range, zero adjustment of a 0.1 Torr 690A or 698A transducer can be performed using the Zero control on the transducer. The Zero control is located at the top of the transducer within the lower loop of the letter B (in the word *Baratron*).

How To Zero The Transducer using the Zero Control

To zero a 0.1 Torr 690A/698A transducer using the Zero control:

1. Pump the transducer down, with the heater on, to less than 5×10^{-7} Torr and let itstabilize for a minimum of 16 hours.

2. Center both the Sensor Zero Coarse and Fine controls on the signal conditioner by first turning the controls completely counter-clockwise and then turning them 15 complete turns clockwise.

3. Follow the instructions below and adjust the Zero control on the 690A/698A unit until the output displayed on the signal conditioner reads nearly zero.

   a. The Zero control on the 690A/698A transducer is a wire-wound potentiometer with approximately 100 turns or positions (wires). It is essentially a 100-position switch with 200 to 1000 ppm FS per position.

   b. The stability of the setting is maintained if the Zero control shaft is adjusted to center the wiper on an individual wire. If the wiper is not well centered on the wire, it may move either with time or due to vibration or temperature changes and cause large shifts in the zero.

   c. Locating the center of a wire is complicated by the variable backlash between the zero control shaft and the wiper. Therefore, MKS does ***not recommend*** using the technique of turning the pot to either extreme, noting the voltage at each end, and positioning the pot midway.

How To Properly Adjust the Zero Control

To properly adjust the Zero control on a 0.1 Torr 690A/698A transducer:

1. Verify that there are four distinct and stable steps for each revolution of the Zero control shaft as evidenced by the output displayed on the signal conditioner.

   A step is considered to be stable if the output does not change while the shaft is turned $^1/_8$ of a turn further in the same direction.

2. Turn the Zero control in either direction to adjust it to the *stable* step nearest zero, and record the output displayed on the signal conditioner.

   It is generally not possible to achieve a precise zero due to the resolution of this control. Turn the Zero control an extra ½ turn in the *same* direction.

3. Turn the zero control back slowly in the *opposite* direction until the output first achieved in step 5 occurs. Then, carefully turn the Zero control an additional $^1/_8$ turn in this *same* direction.

   Performing this last $^1/_8$ turn centers the pot in the middle of a step to achieve maximum stability.

4. Use both the sensor Zero Coarse and Fine controls on the signal conditioner to adjust the output displayed to precisely zero.

   When using the Fine control, it may be necessary to adjust the range of the signal conditioner to X.1 (do not use X.01) for the final setting.

How To Perform a System Check

The System Check circuit generates a span calibration signal whose precision depends upon the position of the head's zero pot.

To perform a system check:

1. Disconnect the head cable from the transducer and connect it to the HS-1 simulator.

   The red lamp should be ON, indicating that the proper preamp voltage is present at the end of the cable.

2. Place the switch in the zero position.

   A zero signal is developed across the signal input lines. In this position it should be possible to adjust the electronics unit for a stable zero on all ranges.

3. Place the switch in the +10 V position.

   The simulator will produce a signal sufficient to produce a stable +10 V (full scale) reading on the X1 range.

The HS-1 simulator also contains a resistor to simulate the heater in the sensor. When the heater switch is placed in the REG. position, the heater lamps on the electronics unit will come ON if the supply is working properly. This lamp will not display the same brilliance as it does when attached to a heater due to the higher value of the simulator resistor.

How To Recalibrate the Electronics Unit

1. Connect a high accuracy AC meter to the jacks on the top of the simulator and measure the amplitude of the oscillator.

   The proper level is 6.000 VRMS.

2. Place the simulator switch in the zero position.

3. Adjust the Null and Full Scale on the indicator and then the zero on all ranges.

4. Place the range multiplier in the X1 position and the simulator switch in the +10 V position.

5. Adjust the full scale pot on the front of the electronics unit for a reading of +10.00 Volts at the output of the electronics unit.

6. Place the simulator switch in the +5 V position to check linearity at the 50% point.

   This should be within 5 mV of 5.00 Volts.

How To Optimize Long Cable Operation

When long transducer cables are used in a system, frequently it is necessary to adjust the system gain to optimize system performance which might be degraded due to the cable length. When the simulator is installed on the end of the transducer cable, the system gain is adjusted by using the procedures described in *How To Perform a System Check*, and *How To Recalibrate the Electronics Unit*, page 36. Note that on occasion, the Electronics Unit span adjust may have to be adjusted if the full scale adjustment is insufficient to set full scale.

This page intentionally left blank

Chapter Five: Maintenance and Troubleshooting

General Information

If the 690A/698A instrument fails to operate properly upon receipt, check for shipping damages, and check the cables for continuity. Any damage should be reported to the carrier and MKS Instruments immediately. If it is necessary to return the unit to MKS, obtain an ERA number (Equipment Return Authorization Number) from a MKS Service Center before shipping. Please refer to the inside back cover of this manual for a list of MKS Calibration and Service Centers.

Maintenance

Periodically check for wear on the cables and inspect the enclosure for visible signs of damage. Generally, nothing needs to be done to maintain the transducer, other than its proper installation and operation.

How To Clean the Unit

Periodically wipe down the unit with a damp cloth.

Troubleshooting

After extended use, the following situations may occur:

1. Measurement goes slowly negative with time.

   A reference leak may cause the zero adjustment to run out. This requires a new sensor replacement.

2. Measurement goes slowly positive with time.

   Overpressure, and/or a build-up of contamination in the P_X cavity will push the diaphragm toward the electrode, causing the zero adjustment to run out. Generally, this requires a new sensor replacement.

3. Overrange positive, or negative, signal.

   This is generally caused by a shorted sensor, or a damaged interconnect cable (sensor to electronics module).

Note If the "zero" output from the transducer is unstable, this is usually caused by the ambient temperature around the sensor or electronics module being too high. The ambient temperature around the sensor must be no higher than 40° C. The ambient temperature around the electronics unit must not exceed 50 °C.

Troubleshooting Chart		
Symptom	**Cause**	**Remedy**
CANNOT ZERO		
a. With absolute head	Pressure not below the reading resolution	Pump down P_X side
b. When power first applied	Head not at operating temperature	Allow time for stabilization (4 hours minimum)
c. On most sensitive ranges	Amplifier overload or system noise	Go back to less sensitive range until on scale and try again and/or try better vibration isolation.
ZERO SHIFT		
a. After applying power	Sensor temperature shift	Allow 4 to 6 hours for sensor stabilization (16 hours for optimum stability).
b. When changing from atmosheric to vacuum operation	Different outgassing rates from P_X and P_R at vacuum	Allow time for outgassing completion
c. When either raising or lowering line	Leaks in vacuum system	Check pressure connections at head and other fittings
d. Upon turn on of RF power in, for example, a sputtering system. Sudden “negative direction” pressure reading.	Pick up in sensor preamplifier	Replace standard sensor head cable with shielded version or relocate sensor on system or try better grounding
SYSTEM CHECK		
a. System check voltage different	Electronics gain has changed	Check calibration of transducer

Table 7: Troubleshooting Chart

This page intentionally left blank.

Appendix A: Product Specifications

Ambient Operating Temperature	15° to 40° C (59° to 104° F)
Accuracy 690A Standard Optional All ranges 1, 10, 100, and 1000 Torr units only 698A Standard Optional All ranges 1, 10, 100, and 1000 Torr units only	 0.12% of reading ±zero/span coeff. 0.08% of reading ±zero/span coeff. 0.05% of reading ±zero/span coeff. 0.12% of reading ±zero/span coeff. 0.08% of reading ±zero/span coeff. 0.15% of reading ±zero/span coeff. 0.2% of reading ±zero/span coeff. 0.05 of reading ±zero/span coeff.
CE Mark Compliance[2]	EMC Directive 2004/108/EEC
Full Scale Pressure Ranges (Torr) 690A 698A	 0.1, 1, 10, 100, 1K, 5K, 10K, 15K, 20K, 25K 0.1, 1, 10, 100, 1K Torr
Inlet Tube Fitting(s)	Swagelok® 4-VCR® (female)
Line Pressure Effects on Span 690A 698A	 N/A <0.010% / 15 psi[3]
Maximum Line Pressure 690A 698A	 N/A 150 psig
Measurement Side (P_X) Media Compatibility	Any gas compatible with Inconel®, 304 SS

[2] An overall metal braided shielded cable, properly grounded at both ends, is required during use. The Type 690A/698A units are only CE compliant when used with the Type 670 Signal Conditioner/Readout.

[3] For 100 mTorr units only.

P_X Overpressure 100 mTorr (0.1 T) Units All other ranges	 125% FS or 40 psia (whichever is greater) 125% FS or 45 psia (whichever is greater)
Reference Side (P_R) Media Compatibility 690A 698A	 N/A Any dry gas compatible with Inconel®, 304/306 SS, Fosterite, Palladium
Reference Side Volume 690A 698A	 N/A 25 cc
Resolution (of FS)	1 x 10^{-6}
Sensor Temperature	Regulated at 45° C
Sensor Type	Single sided, dual electrode
Temperature Effects on Span 100 mTorr (0.1 T) Units All other ranges	 <0.010% R / °C (100 ppm) <0.002% R / °C (20 ppm)
Temperature Effects on Zero 100 mTorr (0.1 T) Units All other ranges at 0.05% or 0.08% of Rdg accuracy at 0.12% of Rdg accuracy	 <30 PPM, F.S./ °C <4 PPM, F.S./ °C <15 PPM, F.S./ °C
Time Constant with Signal Conditioner in: Fast Position Std Position Slow Position	 > 25 ms 40 ms 400 ms
Type of Measurement 690A 698A	 Absolute Differential, Gage
Useable Resolution	5 decades
Volume (P_X) 690A ≥ 1000 T Units 5K to 25 K Units 698A	 2.5 cc 14 cc 3.5 cc

Due to continuing research and development activities, these product specifications are subject to change without notice.

Appendix B: Model Code Explanation

Model Code

The options for your transducer are identified in the model code when you order the unit. The model code is identified as follows:

XXX Y Z

where:

Type Number (####)

The type number – 690A or 698A – designates the model number of the instrument.

Full Scale Range (XXX)

The full scale range is indicated by a two digit / one letter code.

Full Scale Range in mmHg (Torr)	Ordering Code
0.1	0.1T
1	01T
10	11T
100	12T
1,000	13T
5,000*	53T
10,000*	14T
15,000*	RBT
20,000*	24T
25,000*	RCT

**Available with 690A unit only.*

Fittings (YY)

One type of fitting is available, designated by a single letter code.

Fittings	Ordering Code
Swagelok 4-VCR female	R

Accuracy (Z)

The accuracy is designated by a single letter code.

Accuracy	Ordering Code
Unidirectional Calibration (690A and 698A)	
Standard: ±0.12% of Reading	C
Optional: ±0.08% of Reading	B
Optional: ±0.05% of Reading*	A
Bidirectional Calibration (698A only)	
Standard: ±0.25% of Reading*	E
Optional: ±0.15% of Reading*	D

** Available in 1, 10, 100, and 1000 mmHg ranges only.*

Index

120466-P1
Rev B, 1/98
Instruction Manual

MKS Type 670B
High Accuracy
Signal Conditioner

Six Shattuck Road
Andover, MA 01810-2449
(800) 227-8766 or (978) 975-2350

Fax: (978) 975-0093
E-mail: mks@mksinst.com
Web site: http://www.mksinst.com

WARRANTY

Type 670B Equipment

MKS Instruments, Inc. (**MKS**) warrants that the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship for a period of one year from date of shipment and will for a period of two years from the date of shipment, correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

For the period commencing with the date of shipment of this equipment and ending one year later in the case of defects in materials and workmanship, but two years later in the case of failure to comply with the date-related operations warranty, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship or with respect to the date-related operations warranty without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS** home office in Andover, Massachusetts, USA.

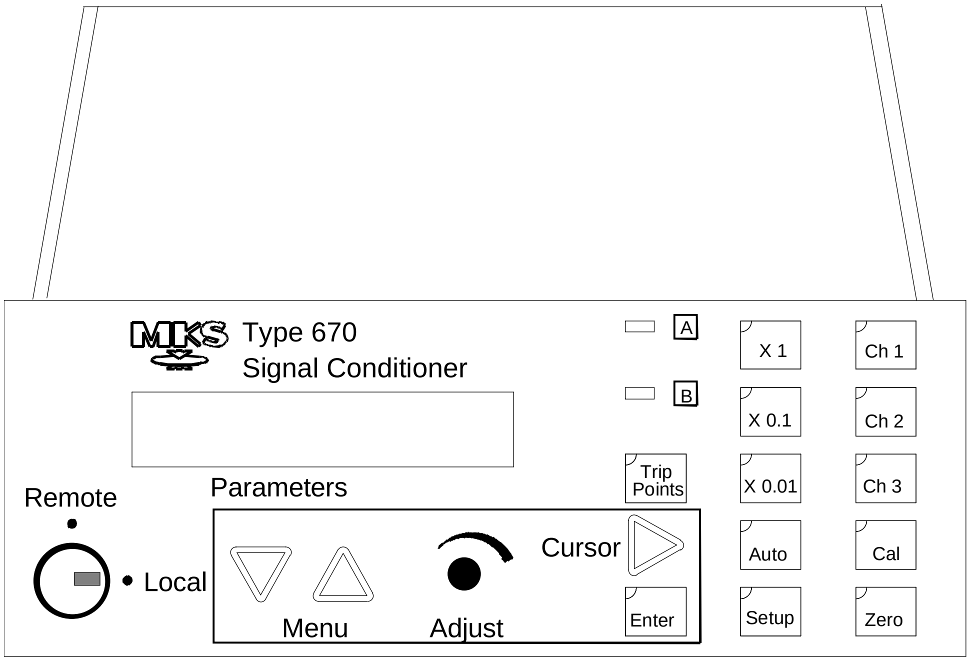
This warranty does not apply to any equipment which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

MKS recommends that all **MKS** pressure and flow products be calibrated periodically (typically every 6 to 12 months) to ensure accurate readings. When a product is returned to **MKS** for this periodic re-calibration it is considered normal preventative maintenance not covered by any warranty.

THIS WARRANTY IS IN LIEU OF ALL OTHER RELEVANT WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTY AGAINST INFRINGEMENT OF ANY PATENT.

120466-P1
Rev B, 1/98

MKS Type 670B
High Accuracy
Signal Conditioner



Printed in the United States of America

This manual is for firmware/software version 1.1x

Table of Contents

List of Figures

List of Tables

Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

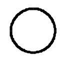
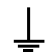
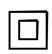
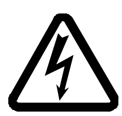
Definition of Symbols Found on the Unit			
 On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class II equipment IEC 417, No.5172-a	 Three phase alternating current IEC 617-2 No.020206	
 Caution, refer to accompanying documents ISO 3864, No.B.3.1	 Caution, risk of electric shock ISO 3864, No.B.3.6	 Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

GROUNDING THE PRODUCT

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting it to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electrical shock.

GROUND AND USE PROPER ELECTRICAL FITTINGS

Dangerous voltages are contained within this instrument. All electrical fittings and cables must be of the type specified, and in good condition. All electrical fittings must be properly connected and grounded.

USE THE PROPER POWER CORD

Use only a power cord that is in good condition and which meets the input power requirements specified in the manual.

Use only a detachable cord set with conductors that have a cross-sectional area equal to or greater than 0.75 mm^2. The power cable should be approved by a qualified agency such as VDE, Semko, or SEV.

USE THE PROPER POWER SOURCE

This product is intended to operate from a power source that does not apply more voltage between the supply conductors, or between either of the supply conductors and ground, than that specified in the manual.

USE THE PROPER FUSE

Use only a fuse of the correct type, voltage rating, and current rating, as specified for your product.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

HIGH VOLTAGE DANGER

High voltage is present in the cable, and in the sensor when the controller is turned on.

Sicherheitshinweise

In dieser Betriebsanleitung vorkommende Symbole

Definition der mit WARNUNG!, VORSICHT! und HINWEIS überschriebenen Abschnitte in dieser Betriebsanleitung.

Warnung!

Das Symbol WARNUNG! weist auf eine Gefahrenquelle hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Körperverletzung führen kann.

Vorsicht!

Das Symbol VORSICHT! weist auf eine Gefahrenquelle hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. Ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Produkts oder von Teilen des Produkts führen kann.

Hinweis

Das Symbol HINWEIS weist auf eine wichtige Mitteilung hin, die auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit von besonderer Wichtigkeit aufmerksam macht.

Am Gerät angebrachte Symbole

Der untenstehenden Tabelle sind die Bedeutungen der Symbole zu entnehmen, die an dem Gerät angebracht sind.

Definitionen der am Gerät angebrachten Symbole			
Ein (Netz) IEC 417, Nr. 5007	Aus (Netz) IEC 417, Nr. 5008	Erde IEC 417, Nr. 5017	Schutzleiter IEC 417, Nr. 5019
Rahmen oder Chassis IEC 417, Nr. 5020	Äquipotentialanschluß IEC 417, Nr. 5021	Gleichstrom IEC 417, Nr. 5031	Wechselstrom IEC 417, Nr. 5032
Wechselstrom und Gleichstrom IEC 417, Nr. 5033-a	Geräteklasse II IEC 417, Nr. 5172-a	3~ Drehstrom IEC 617-2 Nr. 020206	
Vorsicht! Bitte Begleitdokumente lesen! ISO 3864, Nr. B.3.1	Vorsicht! Stromschlaggefahr! ISO 3864, Nr. B.3.6	Vorsicht! Heiße Fläche! IEC 417, Nr. 5041	

Tabelle 2: Definitionen der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Die untenstehenden allgemeinen Sicherheitsvorschriften sind bei allen Betriebs-phasen dieses Instruments zu befolgen. Jede Mißachtung dieser Sicherheits-vorschriften oder sonstiger spezifischer Warnhinweise in dieser Betriebsanleitung stellt eine Zuwiderhandlung der für dieses Instrument geltenden Sicherheits-standards dar und kann die an diesem Instrument vorgesehenen Schutzvor-richtungen unwirksam machen. MKS Instruments, Inc. haftet nicht für eine Mißachtung dieser Sicherheitsvorschriften seitens des Kunden.

Keine Teile austauschen und keine Veränderungen vornehmen!

Bauen Sie in das Instrument keine Ersatzteile ein, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor! Schicken Sie das Instrument zu Wartungs- und Reparatur-zwecken an einen MKS-Kalibrierungs- und -Kundendienst ein! Dadurch wird sicher-gestellt, daß alle Sicherheitseinrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!

Das Gehäuse des Instruments darf vom Bedienpersonal nicht geöffnet werden. Das Auswechseln von Bauteilen und das Vornehmen von internen Einstellungen ist nur von qualifizierten Fachleuten durchzuführen.

Produkt erden!

Dieses Produkt ist mit einer Erdleitung und einem Schutzkontakt am Netzstecker versehen. Um der Gefahr eines elektrischen Schlages vorzubeugen, ist das Netzkabel an einer vorschriftsmäßig geerdeten Schutzkontaktsteckdose anzuschließen, bevor es an den Eingangs- bzw. Ausgangsklemmen des Produkts angeschlossen wird. Das Instrument kann nur sicher betrieben werden, wenn es über den Erdleiter des Netzkabels und einen Schutzkontakt geerdet wird.

Gefährdung durch Verlust der Schutzerdung!

Geht die Verbindung zum Schutzleiter verloren, besteht an sämtlichen zugänglichen Teilen aus stromleitendem Material die Gefahr eines elektrischen Schlages. Dies gilt auch für Knöpfe und andere Bedienelemente, die dem Anschein nach isoliert sind.

Erdung und Verwendung geeigneter elektrischer Armaturen!

In diesem Instrument liegen gefährliche Spannungen an. Alle verwendeten elektrischen Armaturen und Kabel müssen dem angegebenen Typ entsprechen und sich in einwand-freiem Zustand befinden. Alle elektrischen Armaturen sind vorschriftsmäßig anzubringen und zu erden.

Richtiges Netzkabel verwenden!

Das verwendete Netzkabel muß sich in einwandfreiem Zustand befinden und den in der Betriebsanleitung enthaltenen Anschlußwerten entsprechen.

Das Netzkabel muß abnehmbar sein. Der Querschnitt der einzelnen Leiter darf nicht weniger als 0,75 mm^2 betragen. Das Netzkabel sollte einen Prüfvermerk einer zuständigen Prüfstelle tragen, z.B. VDE, Semko oder SEV.

Richtige Stromquelle verwenden!

Dieses Produkt ist für eine Stromquelle vorgesehen, bei der die zwischen den Leitern bzw. zwischen jedem der Leiter und dem Masseleiter anliegende Spannung den in dieser Betriebsanleitung angegebenen Wert nicht überschreitet.

Richtige Sicherung benutzen!

Es ist eine Sicherung zu verwenden, deren Typ, Nennspannung und Nennstromstärke den Angaben für dieses Produkt entsprechen.

Gerät nicht in explosiver Atmosphäre benutzen!

Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät nicht in der Nähe explosiver Stoffe eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zertifiziert worden ist.

Hochspannungsgefahr!

Bei eingeschaltetem Steuerteil liegt im Kabel und im Sensor Hochspannung an.

Informations relatives à la sécurité

Symboles utilisés dans ce manuel d'utilisation

Définition des indications AVERTISSEMENT, ATTENTION et REMARQUE utilisées dans ce manuel.

Avertissement

L'indication AVERTISSEMENT signale un danger potentiel. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un risque de blessure en cas d'exécution incorrecte ou de non-respect des consignes.

Attention

L'indication ATTENTION signale un danger potentiel. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un risque d'endommagement ou de dégât d'une partie ou de la totalité de l'appareil en cas d'exécution incorrecte ou de non-respect des consignes.

Remarque

L'indication REMARQUE signale des informations importantes. Elle est destinée à attirer l'attention sur une procédure, une utilisation, une situation ou toute autre chose présentant un intérêt particulier.

Symboles apparaissant sur l'appareil

Le tableau suivant décrit les symboles apparaissant sur l'appareil.

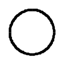
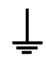
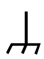
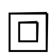
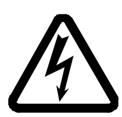
Définition des symboles apparaissant sur l'appareil			
 Marche (sous tension) IEC 417, No. 5007	 Arrêt (hors tension) IEC 417, No. 5008	 Terre (masse) IEC 417, No. 5017	 Terre de protection (masse) IEC 417, No. 5019
 Masse IEC 417, No. 5020	 Equipotentialité IEC 417, No. 5021	 Courant continu IEC 417, No. 5031	 Courant alternatif IEC 417, No. 5032
 Courant continu et alternatif IEC 417, No. 5033-a	 Matériel de classe II IEC 417, No. 5172-a	3 Courant alternatif triphasé IEC 617-2 No. 020206	
 Attention : se reporter à la documentation ISO 3864, No. B.3.1	 Attention : risque de secousse électrique ISO 3864, No. B.3.6	 Attention : surface brûlante IEC 417, No. 5041	

Tableau 3 : Définition des symboles apparaissant sur l'appareil

Mesures de sécurité et mises en garde

Prendre toutes les précautions générales suivantes pendant toutes les phases d'utilisation de cet appareil. Le non-respect de ces précautions ou des avertissements contenus dans ce manuel entraîne une violation des normes de sécurité relatives à l'utilisation de l'appareil et le risque de réduire le niveau de protection fourni par l'appareil. MKS Instruments, Inc. ne prend aucune responsabilité pour les conséquences de tout non-respect des consignes de la part de ses clients.

NE PAS SUBSTITUER DES PIÈCES OU MODIFIER L'APPAREIL

Ne pas utiliser de pièces détachées autres que celles vendues par MKS Instruments, Inc. ou modifier l'appareil sans l'autorisation préalable de MKS Instruments, Inc. Renvoyer l'appareil à un centre d'étalonnage et de dépannage MKS pour tout dépannage ou réparation afin de s'assurer que tous les dispositifs de sécurité sont maintenus.

DÉPANNAGE EFFECTUÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ

L'opérateur de l'appareil ne doit pas enlever le capot de l'appareil. Le remplacement des composants et les réglages internes doivent être effectués uniquement par un personnel d'entretien qualifié.

MISE À LA TERRE DE L'APPAREIL

Cet appareil est mis à la terre à l'aide du fil de terre du cordon d'alimentation. Pour éviter tout risque de secousse électrique, brancher le cordon d'alimentation sur une prise de courant correctement câblée avant de le brancher sur les bornes d'entrée ou de sortie de l'appareil. Une mise à la terre de protection à l'aide du fil de terre du cordon d'alimentation est indispensable pour une utilisation sans danger de l'appareil.

DANGER LIÉ À UN DÉFAUT DE TERRE

En cas de défaut de terre, toutes les pièces conductrices accessibles (y compris les boutons de commande ou de réglage qui semblent être isolés) peuvent être source d'une secousse électrique.

MISE À LA TERRE ET UTILISATION CORRECTE D'ACCESSOIRES ÉLECTRIQUES

Des tensions dangereuses existent à l'intérieur de l'appareil. Tous les accessoires et les câbles électriques doivent être conformes au type spécifié et être en bon état. Tous les accessoires électriques doivent être correctement connectés et mis à la terre.

UTILISATION D'UN CORDON D'ALIMENTATION APPROPRIÉ

Utiliser uniquement un cordon d'alimentation en bon état et conforme aux exigences de puissance d'entrée spécifiées dans le manuel.

Utiliser uniquement un cordon d'alimentation amovible avec des conducteurs dont la section est égale ou supérieure à 0,75 mm^2. Le cordon d'alimentation doit être approuvé par un organisme compétent tel que VDE, Semko ou SEV.

UTILISATION D'UNE ALIMENTATION APPROPRIÉE

Cet appareil est conçu pour fonctionner en s'alimentant sur une source de courant électrique n'appliquant pas une tension entre les conducteurs d'alimentation, ou entre les conducteurs d'alimentation et le conducteur de terre, supérieure à celle spécifiée dans le manuel.

UTILISATION D'UN FUSIBLE APPROPRIÉ

Utiliser uniquement un fusible conforme au type, à la tension nominale et au courant nominal spécifiés pour l'appareil.

NE PAS UTILISER DANS UNE ATMOSPHÈRE EXPLOSIVE

Pour éviter tout risque d'explosion, ne pas utiliser l'appareil dans une atmosphère explosive à moins qu'il n'ait été approuvé pour une telle utilisation.

DANGER DE HAUTE TENSION

Une haute tension est présente dans le câble et dans le capteur lorsque le contrôleur est sous tension.

Información sobre seguridad

Símbolos usados en el manual de instrucciones

Definiciones de los mensajes de ADVERTENCIA, PRECAUCIÓN Y OBSERVACIÓN usados en el manual.

Advertencia

El símbolo de ADVERTENCIA indica un riesgo. Pone de relieve un procedimiento, práctica, condición, etc., que, de no realizarse u observarse correctamente, podría causar lesiones a los empleados.

Precaución

El símbolo de PRECAUCIÓN indica un riesgo. Pone de relieve un procedimiento, práctica, etc., de tipo operativo que, de no realizarse u observarse correctamente, podría causar desperfectos al instrumento, o llegar incluso a causar su destrucción total o parcial.

Observación

El símbolo de OBSERVACIÓN indica información de importancia. Pone de relieve un procedimiento, práctica, condición, etc., cuyo conocimiento resulta esencial.

Símbolos que aparecen en la unidad

En la tabla que figura a continuación se indican los símbolos que aparecen en la unidad.

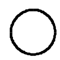
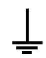
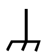
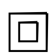
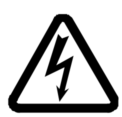
<table>
<tr><th colspan="4">Definición de los símbolos que aparecen en la unidad</th></tr>
<tr>
<td>
Encendido
(alimentación eléctrica)
IEC 417, N.° 5007</td>
<td>
Apagado
(alimentación eléctrica)
IEC 417, N.° 5008</td>
<td>
Puesta a tierra
IEC 417, N.° 5017</td>
<td>
Protección a tierra
IEC 417, N.° 5019</td>
</tr>
<tr>
<td>
Caja o chasis
IEC 417, N.° 5020</td>
<td>
Equipotencialidad
IEC 417, N.° 5021</td>
<td>
Corriente continua
IEC 417, N.° 5031</td>
<td>
Corriente alterna
IEC 417, N.° 5032</td>
</tr>
<tr>
<td>
Corriente continua y alterna
IEC 417, N.° 5033-a</td>
<td>
Equipo de clase II
IEC 417, N.° 5172-a</td>
<td>
Corriente alterna trifásica
IEC 617-2 N.° 020206</td>
<td></td>
</tr>
<tr>
<td>
Precaución. Consultar los documentos adjuntos
ISO 3864, N.° B.3.1</td>
<td>
Precaución. Riesgo de descarga eléctrica
ISO 3864, N.° B.3.6</td>
<td>
Precaución. Superficie caliente
IEC 417, N.° 5041</td>
<td></td>
</tr>
</table>

Tabla 4 : Definición de los símbolos que aparecen en la unidad

Procedimientos y precauciones de seguridad

Las precauciones generales de seguridad que figuran a continuación deben observarse durante todas las fases de funcionamiento del presente instrumento. La no observancia de dichas precauciones, o de las advertencias específicas a las que se hace referencia en el manual, contraviene las normas de seguridad referentes al uso previsto del instrumento y podría impedir la protección que proporciona el instrumento. MKS Instruments, Inc., no asume responsabilidad alguna en caso de que el cliente haga caso omiso de estos requerimientos.

NO UTILIZAR PIEZAS NO ORIGINALES NI MODIFICAR EL INSTRUMENTO

No se debe instalar piezas que no sean originales ni modificar el instrumento sin autorización. Para garantizar que las prestaciones de seguridad se observen en todo momento, enviar el instrumento al Centro de servicio y calibración de MKS cuando sea necesaria su reparación y servicio de mantenimiento.

REPARACIONES EFECTUADAS ÚNICAMENTE POR TÉCNICOS ESPECIALIZADOS

Los operarios no deben retirar las cubiertas del instrumento. El cambio de piezas y los reajustes internos deben efectuarlos únicamente técnicos especializados.

PUESTA A TIERRA DEL INSTRUMENTO

Este instrumento está puesto a tierra por medio del conductor de tierra del cable eléctrico. Para evitar descargas eléctricas, enchufar el cable eléctrico en una toma debidamente instalada, antes de conectarlo a las terminales de entrada o salida del instrumento. Para garantizar el uso sin riesgos del instrumento resulta esencial que se encuentre puesto a tierra por medio del conductor de tierra del cable eléctrico.

PELIGRO POR PÉRDIDA DE LA PUESTA A TIERRA

Si se pierde la conexión protectora de puesta a tierra, todas las piezas conductoras a las que se tiene acceso (incluidos los botones y mandos que pudieran parecer estar aislados) podrían producir descargar eléctricas.

PUESTA A TIERRA Y USO DE ACCESORIOS ELÉCTRICOS ADECUADOS

Este instrumento funciona con voltajes peligrosos. Todos los accesorios y cables eléctricos deben ser del tipo especificado y mantenerse en buenas condiciones. Todos los accesorios eléctricos deben estar conectados y puestos a tierra del modo adecuado.

USAR EL CABLE ELÉCTRICO ADECUADO

Usar únicamente un cable eléctrico que se encuentre en buenas condiciones y que cumpla los requisitos de alimentación de entrada indicados en el manual.

Usar únicamente un cable desmontable instalado con conductores que tengan un área de sección transversal equivalente o superior a 0,75mm². El cable eléctrico debe estar aprobado por una entidad autorizada como, por ejemplo, VDE, Semko o SEV.

USAR LA FUENTE DE ALIMENTACIÓN ELÉCTRICA ADECUADA

Este instrumento debe funcionar a partir de una fuente de alimentación eléctrica que no aplique más voltaje entre los conductores de suministro, o entre uno de los conductores de suministro y la puesta a tierra, que el que se especifica en el manual.

USAR EL FUSIBLE ADECUADO

Usar únicamente un fusible del tipo, clase de voltaje y de corriente adecuados, según lo que se especifica para el instrumento.

EVITAR SU USO EN ENTORNOS EXPLOSIVOS

Para evitar el riesgo de explosión, no usar este instrumento o en un entorno explosivo, a no ser que haya sido certificado para tal uso.

PELIGRO POR ALTO VOLTAJE

Cuando el controlador está encendido, se registra alto voltaje en el cable y en el sensor.

Chapter One: General Information

Introduction

The MKS Type 670B High Accuracy Signal Conditioner is designed to work with the MKS 300 and 600 Series Baratron® high accuracy pressure transducers. The 670 instrument consists of the power supplies, heater control, and oscillator necessary to interface with the compatible MKS pressure transducers. When combined with the Type 274 multiplexer, the 670 instrument can measure the pressure from up to three pressure transducers (from either the 300 or 600 Series, or a combination of both). The front panel includes three channel selector keys, each with a light in the upper left hand corner that illuminates when the channel is selected to visually indicate the active channel. The display screen can list the pressure reading as a 3½, 4½ or 5½ digit number. The unit is designed to fit in the standard ½ rack mount.

You can control the 670 instrument remotely, using either RS-232C or IEEE-488 (IEEE-488.2) communications. Both methods of remote communication allow you to perform virtually all the functions available through the front panel. While operating in the REMOTE mode, the instrument expects to receive commands through the RS-232 port, the IEEE-488 bus, or the rear panel connectors, so it locks out any commands entered through the front panel. This eliminates the possibility of accidental command entries. In LOCAL mode the instrument accepts commands issued by using the front panel only. During LOCAL mode operation, the RS-232 port and the IEEE-488 bus can be used to report status information. Remote communication commands to change operating parameters will not be accepted while in LOCAL mode.

The 670 instrument contains two alarm trip points. The high and low values for each trip point define a “normal” operating range for the pressure signal. If the pressure signal deviates from the range defined by the trip points, a trip point becomes activated and causes a relay to change state. The adjustable hysteresis feature prevents any “relay chatter” because it defines a deadband around each trip point. This deadband provides a “margin of error” since the relay does not change state until the pressure signal exceeds, or drops below, the trip point setting *plus* the hysteresis value. Therefore, an alarm condition does not occur if the pressure signal hovers around the trip point. In addition, you define the normal state for each relay as either energized or de-energized.

The averaging feature of the 670 instrument reduces fluctuation in the pressure reading by averaging multiple readings. This is especially useful in systems where the pressure is unstable. Instead of displaying every data point, the 670 instrument can average incoming data points with a specified number of data points collected previously. The display shows the averaged value, rather than the actual new data point. This averaging acts to smooth out the pressure readings. The number of points to average can range from 1 and 99, inclusive.

How This Manual is Organized

This manual provides instructions on how to set up, install, and operate a 670 unit.

Before installing your Type 670 unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One, *General Information*, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two, *Installation*, explains the environmental requirements and describes how to mount the instrument in your system.

Chapter Three, *Hardware Overview*, gives a brief description of the instrument and its functionality.

Chapter Four, *Functional Overview*, outlines the software features and functions.

Chapter Five, *Operation*, describes how to use the Type 670 instrument and explains all its functions and features.

Chapter Six, *RS-232 Communications Option*, discusses the optional RS-232C communications.

Chapter Seven, *IEEE-488 Communications Option*, describes the optional IEEE-488 syntax and messages.

Chapter Eight, *Maintenance and Troubleshooting*, provides a checklist for reference in the event your instrument malfunctions.

Appendix A, *Product Specifications*, lists the specifications for the instrument.

Appendix B, *Initial Settings*, lists the initial settings for the instrument.

Appendix C, *Sample BASIC Programs*, provides several short BASIC programs written for the IEEE-488 communications option.

Appendix D, *Interface Cables for a Type 274 Multiplexer*, lists the pinout of the Y-cable.

Manual Conventions

The following conventions apply throughout this manual:

$\overline{\text{XXXXXX}}$ *For inputs:*	Indicates that the line must be pulled low to activate the function.
$\overline{\text{XXXXXX}}$ *For outputs:*	Indicates that the output is active low.
670 Front Panel Keys:	Keys on the front panel of the 670 instrument appear in square brackets with leading spaces, for example, Press the [ENTER] key.
Operating Mode	The operating mode appears in small capital letters, such as LOCAL mode
Knobs or Switches on the 274:	Knobs and switches on the 274 multiplexer appear in small capital letters with leading spaces, for example: Set the CHANNEL SELECT switch in the REM position.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 670 instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an ERA Number (Equipment Return Authorization Number) from the MKS Calibration and Service Center before shipping. The ERA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

Your 670 instrument can be calibrated with or without the pressure transducer. If you are using your 670 instrument with a high accuracy pressure transducer, and the units require calibration, you may wish to return both units to MKS. Calibrating the units together ensures the best possible accuracy.

Chapter Two: Installation

How To Unpack the Type 670 Unit

MKS has carefully packed the Type 670 unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an ERA Number (Equipment Return Authorization Number) from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Unpacking Checklist

Caution **Only qualified individuals should perform the installation and any user adjustments. They must comply with all the necessary ESD and handling precautions while installing and adjusting the instrument. Proper handling is essential when working with all highly sensitive precision electronic instruments.**

The Type 670 unit includes the following standard parts plus any optional accessories ordered.

Standard Equipment

- The Type 670 instrument with either RS-232 or IEEE-488 remote communications
- A power cord
- Type 670 Instruction Manual (this book)
- Key for the Key Lock switch on the front panel

Optional Equipment

- 670B-K1 Electrical Connector Accessories Kit (includes mating connectors for all the electrical connectors)
- CB270-2-x (where x is the cable length in ft.) cable to connect the pressure transducer to the 670 instrument
- Serial Interface Cable to communicate with a computer equipped with RS-232 software

  Refer to Table 6, page 24, for a description of RS-232 cables.
- IEEE-488 cable to connect the 670 unit to a computer equipped with IEEE-488 software

  Refer to Table 6, page 24, for a description of IEEE-488 cables available.
- RM-6 Rack Mount to mount the 670 unit in a full 19” rack

Cabling for use with a 274 multiplexer

- Additional CB270-2-x (where x is the cable length in ft.) cables for each transducer (plus one to connect the 670 to the 274 unit)
- CB670-1 or CB670-2 cable to connect the 670 instrument to a 274 multiplexer (use the CB670-2 if you need to access the trip point relays and latching, remote zero, or remote range select)

600 Series High Accuracy Baratron transducers:

- 698 Differential Transducer (regulated at 45° C)
- 690 Absolute Transducer (regulated at 45° C)
- 617 Bakeable Absolute Transducer
- 616 Bakeable Differential Transducer
- 615 Bakeable Absolute Transducer
- 590 Absolute Transducer (regulated at 70° C)

300 Series High Accuracy Baratron transducers:

- 398 Differential Transducer
- 391 Differential Transducer
- 390 Absolute Transducer
- 370 Absolute or Differential Transducer
- 317 Bakeable Absolute Transducer
- 315 Bakeable Absolute or Differential Transducer
- 310 Absolute or Differential Transducer

The full scale range of the pressure transducers can vary from 0.1 to 25K Torr.

Interface Cables

As of January 1, 1996, most products shipped to the European Community must comply with the EMC Directive 89/336/EEC, which covers radio frequency emissions and immunity tests. In addition, as of January 1, 1997, most products shipped to the European Community must also comply with the Product Safety Directive 92/59/EEC and the Low-Voltage Directive 73/23/EEC, which cover general safety practices for design and workmanship. MKS products that meet these requirements are identified by application of the CE Mark.

This MKS product meets CE requirements, per EMC Directive 89/336/EEC. To ensure compliance when installed, an overall metal braided shielded cable, grounded at both ends, is required during use. No additional installation requirements exist to ensure compliance with Directives 92/59/EEC and 73/23/EEC.

Note

1. An overall metal braided shielded cable, properly grounded at both ends, is required during use to meet CE specifications.
2. To order a metal braided shielded cable, add an “S” after the cable type designation. For example, to order a standard connection cable, for a 690 transducer, use part number CB270-2 for a metal, braided, shielded cable use part number CB270S-2.

System Interface Cables

The system interface cables include cables to connect the 670 unit to a transducer or to a Type 274 multiplexer unit which, in turn, can connect to a maximum of three transducers.

System Interface Cables	
To Connect the 670 Unit To . . .	**Use the MKS Cable . . .**
615, 616 or 617 transducer	CB270S-1-*x* or CB270-1-*x*
590, 690, or 698 transducer	or CB270S-2-*x* CB270-2-*x*
274 multiplexer	either a CB670-1/CB670S-1 or CB670-2/CB670S-2 (if you need to access the trip point relays and latching, remote zero, or remote range select)
274 to transducer(s)	CB270-2-*x*
x indicates the cable length in feet	

Table 5: System Interface Cables

Remote Communications Interface Cables

Table 6 lists the cables to connect your 670 unit to either an RS-232 or IEEE-488 device.

Interface Cables for Remote Communications		
Communication	**Cable**	**Description**
RS-232	CB146-2-10	IBM compatible (9-pin female to 9-pin female), 10 ft
	CB146-4	25-pin adapter (25-pin female to 9-pin male)
IEEE-488	CB288-4-3	IEEE-488 cable, 1 meter length
	CB288-4-7	IEEE-488 cable, 2 meter length
	CB288-4-10	IEEE-488 cable, 3 meter length
	CB288-4-13	IEEE-488 cable, 4 meter length

Table 6: Interface Cables for Remote Communications

Generic Shielded Cable Description

MKS offers a full line of cables for all MKS equipment. Should you choose to manufacture your own cables, follow the guidelines listed below:

1. The cable must have a *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding will be as effective; using either may nullify regulatory compliance.

2. The connectors must have a metal case which has direct contact to the cable's shield on the whole circumference of the cable. The inductance of a flying lead or wire from the shield to the connector will seriously degrade the shield's effectiveness. The shield should be grounded to the connector before its internal wires exit.

3. With very few exceptions, the connector(s) must make good contact to the device's case (ground). "Good contact" is about 0.01 ohms; and the ground should surround all wires. Contact to ground at just one point may not suffice.

4. For shielded cables with flying leads at one or both ends; it is important at each such end, to ground the shield *before* the wires exit. Make this ground with absolute minimum length. Refer to Figures 1 and 2, page 26. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the instruction manual.

5. In selecting the appropriate type and wire size for cables, consider:

   A. The voltage ratings.

   B. The cumulative I^2R heating of all the conductors (keep them safely cool).

   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device.

   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables).

   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Example 1: Preferred Method To Connect Cable

(shown on a transducer)

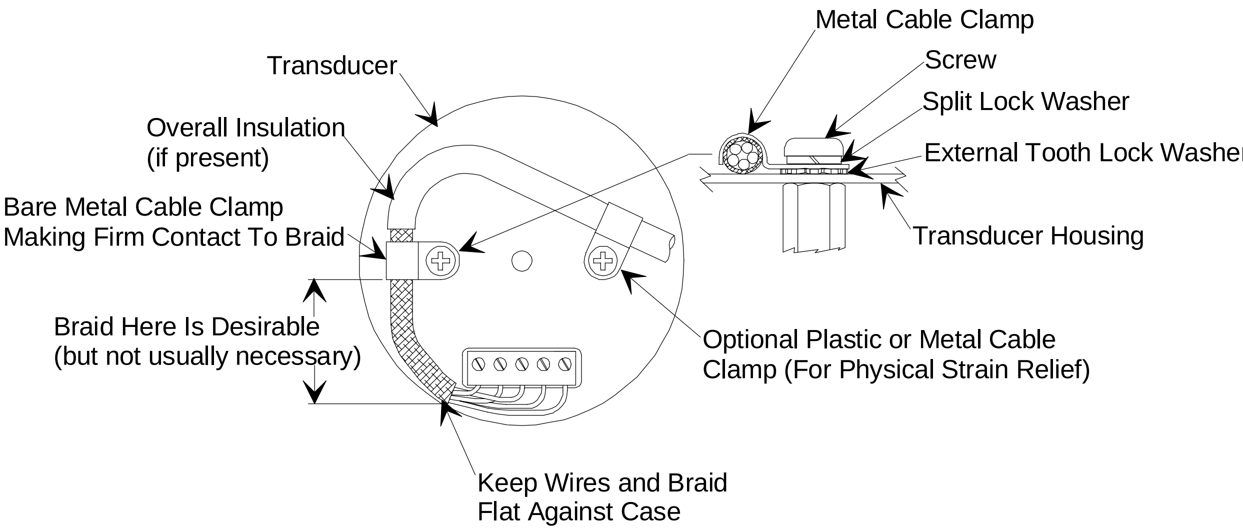


Figure 1: Preferred Method

Example 2: Alternate Method To Connect Cable

(shown on a transducer)

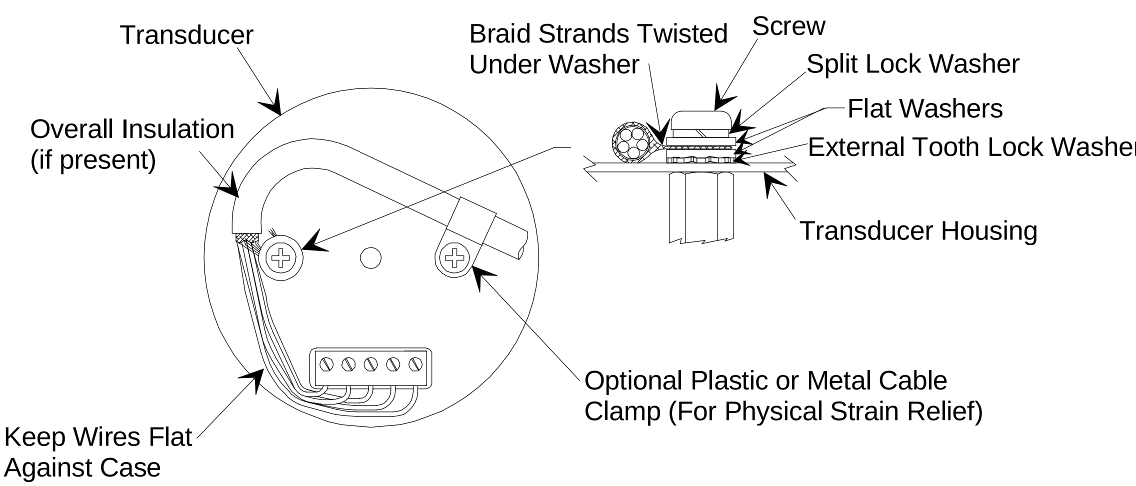


Figure 2: Alternate Method To Use When Cable Clamp is Not Available

Product Location and Requirements

The Type 670 unit meets the following criteria:

- POLLUTION DEGREE 2 in accordance with IEC 664
- Transient overvoltages according to INSTALLATION CATEGORY II

Operating Environmental Requirements

- Ambient Operating Temperature: 15° to 40° C (59° to 104° F)
- Main supply voltage fluctuations must not exceed ±10% of the nominal voltage
- Connect the power cord into a grounded outlet
- Ventilation requirements include sufficient air circulation

Caution **Position the 670 instrument in a location with sufficient air circulation. Insufficient air circulation could damage the instrument.**

Safety Conditions

The 670 unit poses no safety risk under the following environmental conditions.

- Altitude: up to 2000 m
- Maximum relative humidity: 80% for temperatures up to 31 °C, decreasing linearly to 50% at 40 °C

The 670 instrument fits in a standard ½ rack mount and can be placed on a work bench or mounted in an instrument panel. The optional RM-6 Rack Mount is necessary to mount the controller in a panel cutout or a 19” rack.

Electrical Requirements

- Power: 100 to 120 VAC nominal (for the 115 V line voltage setting) or 200 to 240 VAC nominal (for the 230 V line voltage setting) @ 50/60 Hz, 40 Watts (21 Watts with transducer heater off)

Caution **Plug the 670 unit into a grounded electrical outlet to ensure proper grounding.**

Dimensions

Note All dimensions are listed in inches with millimeters referenced in parentheses.

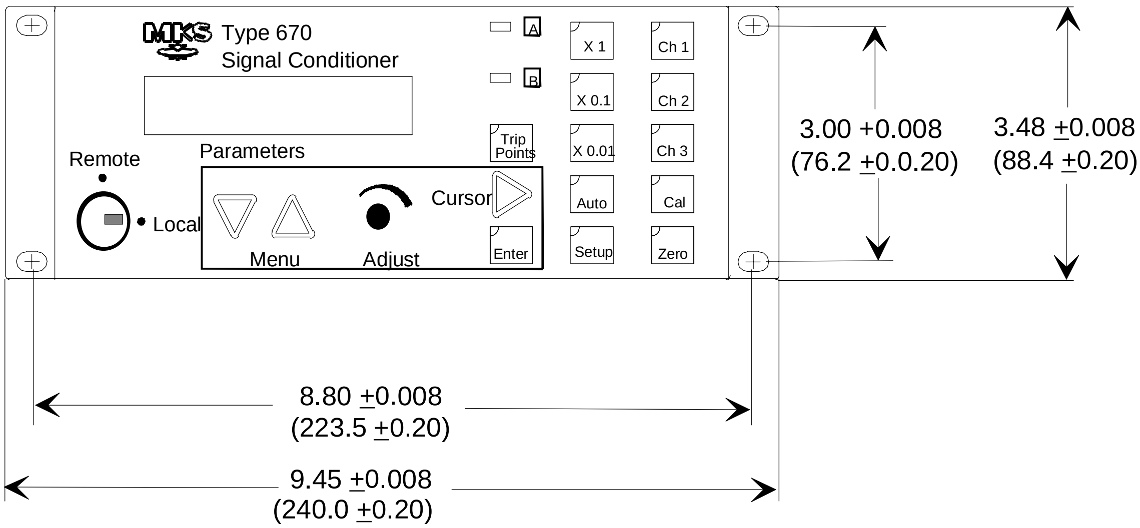


Figure 3: Front View Dimensions

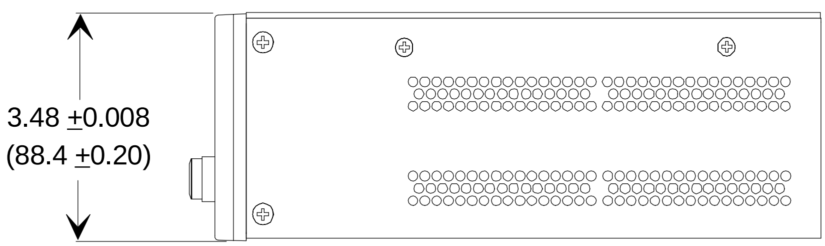


Figure 4: Side View Dimensions

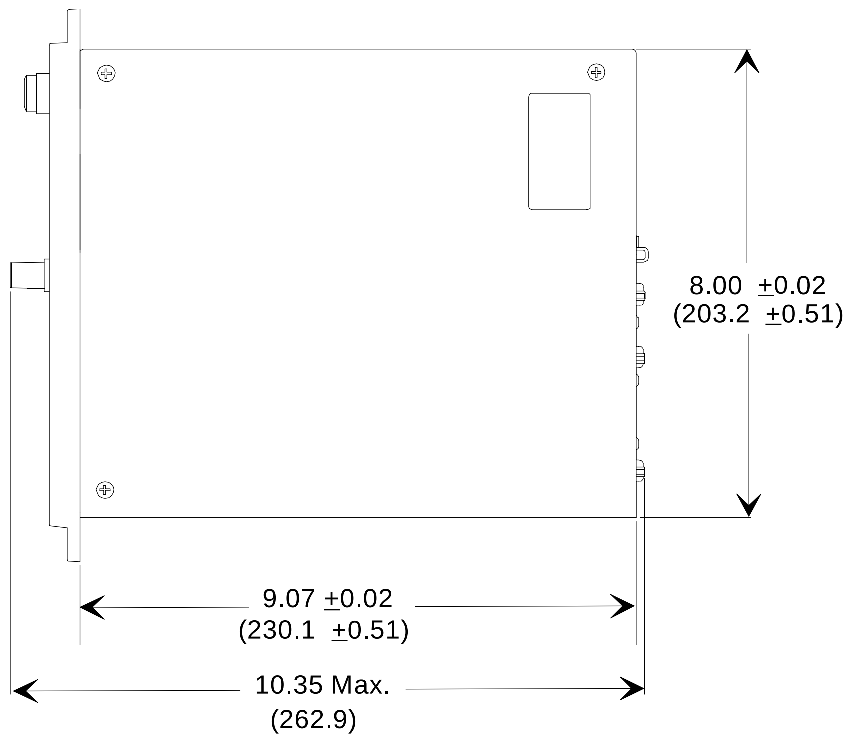


Figure 5: Top View Dimensions

This page intentionally left blank.

Chapter Three: Hardware Overview

Front Panel

Figure 6 shows the front panel of the 670 instrument. *Chapter Four: Functional Overview*, page 43, discusses the operation of the 670 instrument.

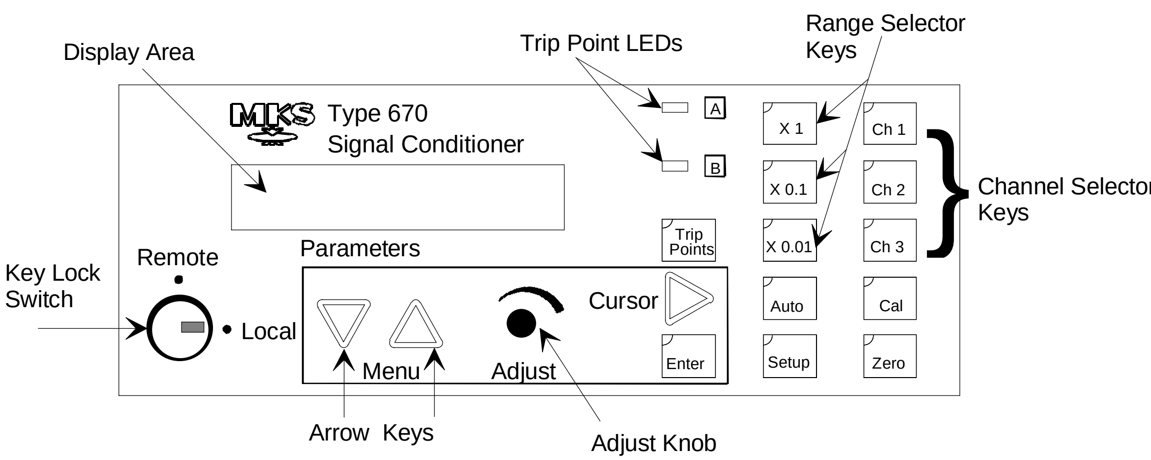


Figure 6: The Front Panel

Key Lock Switch

The position of the Key Lock switch determines whether the 670 instrument operates under front panel (Local) or remote communications (either RS-232 or IEEE-488; and TTL logic) control. When the Key Lock switch is in the LOCAL position, the 670 instrument responds to commands entered through the front panel. It will respond to status requests only, not commands, sent through remote communications. Additionally, it will not accept TTL commands issued to the rear panel connectors. When the Key Lock switch is in the REMOTE position, the 670 instrument responds to commands sent to it through the serial port, the IEEE-488 bus, or the rear panel connectors. The front panel can display status information only — it cannot be used to enter commands. The front panel controls are locked as a safety measure to prevent accidental command entries.

The key can be removed from the unit when positioned in the REMOTE position. It cannot be removed when positioned in the LOCAL position.

Display Area

The display area displays the pressure reading. It can also display the software version and the percentage of power supplied to a transducer heater. Additionally, when you press a mode key ([SETUP] [CAL] or [ZERO]) or the [TRIP POINTS] key, the display area changes to list the menu entries.

Trip Point LEDs

The trip point LEDs illuminate when the pressure reading deviates from the region defined by the trip point high and low entries. The LEDs are extinguished when the pressure reading is within the boundaries defined by the trip points.

Range Selector Keys

The 670 instrument uses the following ranges: x1, x0.1, x0.01, or autoranging. (This selection effects the displayed value, the value reported by remote communications, and the pressure output signal.) A small green light in the upper left-hand corner of the range key illuminates to indicate the active range. Both the AUTO key and the active range key illuminate while operating in the autoranging mode.

For more information, refer *The [AUTO] and Range Key*, page 64.

Channel Selector Lights

The channel selector lights illuminate to indicate the selected channel. When the 670 instrument is connected to a single transducer, “Ch 1” is always illuminated, and neither front nor rear panel commands to change the channel will be accepted. When the 670 instrument is connected to a 274 multiplexer, data from up to three channels can be displayed individually. Simply push the appropriate channel key to select the active channel.

Cursor Key

The [CURSOR] key is only active in menus that require you to enter a numeric value. Pressing the [CURSOR] key moves the blinking cursor from left to right on the screen. Once the blinking cursor reaches the rightmost digit and you press the [CURSOR] again, the blinking cursor will return to the leftmost digit.

Adjust Knob

The Adjust knob is only active in menus where you must select the entry from a list of choices. Turning the Adjust knob scrolls through any options available for entries that contain lists, or it scrolls through numbers for numeric entries.

Arrow Keys

The arrow keys ([△] and [▽]) allow you to scroll through the menu screens. The arrow keys have no function when the 670 instrument is not in a menu.

Rear Panel

Figure 7 shows the rear panel of the 670 instrument.

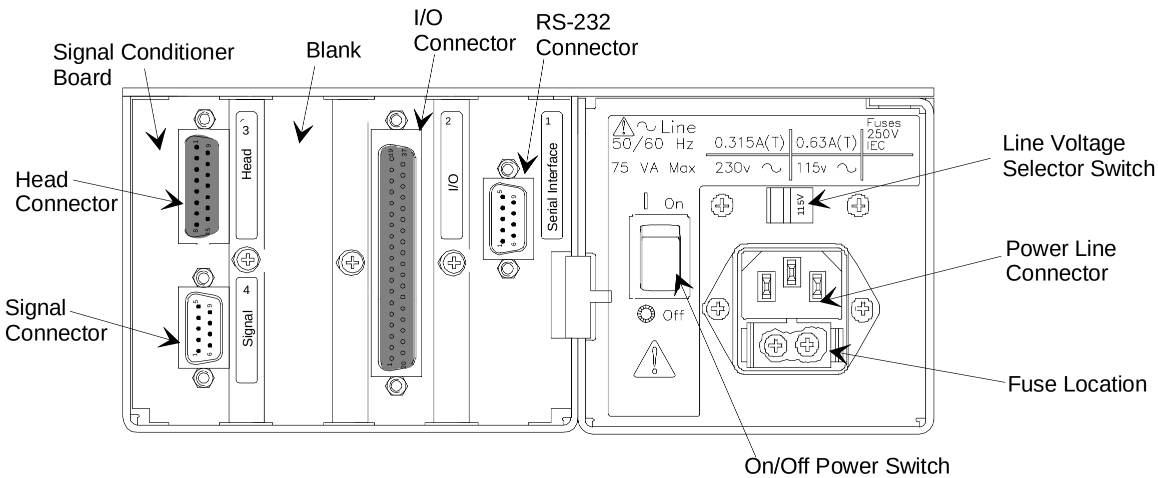


Figure 7: The Rear Panel with RS-232 Communications

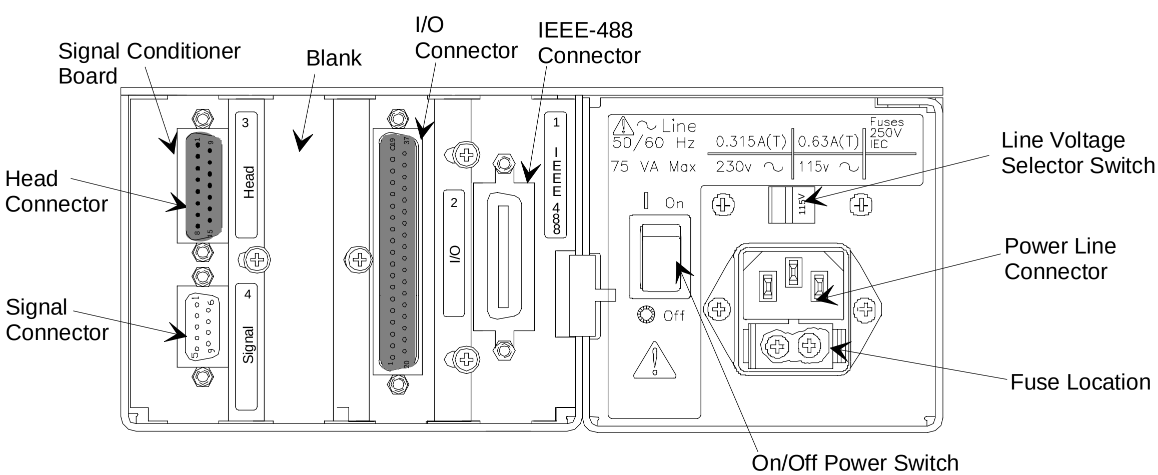


Figure 8: The Rear Panel with IEEE-488 Communications

Serial Interface or IEEE-488 Connector

Slot 1 will contain either the Serial Interface or the IEEE-488 board, depending on which remote communications option you ordered. The remote communications feature allows the 670 instrument to communicate with, and be controlled by, a computer equipped with the appropriate communications software. To use a computer to control the 670 instrument, place the Key Lock switch on the front panel of the 670 instrument in the REMOTE position.

Serial Interface (RS-232) Connector

The Serial Interface connector is a 9-pin male Type "D" connector. The pinout of the connector is listed in Table 7.

Pinout of the Serial Interface Connector	
Pin Number	**Assignment**
1	No Connection
2	Transmit Data
3	Receive Data
4	No Connection
5	Digital Ground
6	No Connection
7	No Connection
8	No Connection
9	No Connection

Table 7: Pinout of the Serial Interface Connector

Note There is no internal connection on pins assigned a "No Connection" function.

IEEE Connector

The IEEE-488 connector is a 24-pin General Purpose Interface Bus (GPIB) connector. The pin assignments, listed in Table 8, comply with the IEEE-488.1 specification.

Pinout of the IEEE-488 Connector		
Pin Number	**Abbreviation**	**Description**
1	DIO1	Data Input Output 1
2	DIO2	Data Input Output 2
3	DIO3	Data Input Output 3
4	DIO4	Data Input Output 4
5	EOI	End or Identify (return on pin 24)
6	DAV	Data Valid
7	NRFD	Not Ready for Data
8	NDAC	No Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Shield
13	DIO5	Data Input Output 5
14	DIO6	Data Input Output 6
15	DIO7	Data Input Output 7
16	DIO8	Data Input Output 8
17	REN	Return (return on pin 24)
18	Gnd (6)	Ground (for pin 6)
19	Gnd (7)	Ground (for pin 7)
20	Gnd (8)	Ground (for pin 8)
21	Gnd (9)	Ground (for pin 9)
22	Gnd (10)	Ground (for pin 10)
23	Gnd (11)	Ground (for pin 11)
24	Gnd (LOGIC)	Ground (LOGIC)

Table 8: Pinout of the IEEE-488 Connector

I/O Connector

The I/O connector provides the following features:

- Interface to a Type 274 multiplexer
- Relay closures for trip points
- ±15 Volt output signals
- Remote access of the range select, remote zero function, and trip point latch functions
- Pressure output signal

Note The Key Lock switch must be in the REMOTE position for the remote range selection, remote zero, and remote trip point latch functions to function.

The I/O connector contains one 37-pin female Type "D" connector. The pinout is listed in Table 9, page 37.

Interfacing the Type 670 Instrument to a Type 274 Multiplexer

Use the 670 instrument to configure the channels on the 274 multiplexer. Refer to *How To Interface to the Type 274 Multiplexer*, page 69, for instructions.

Note The 670 instrument *cannot* control the heater power on the 274 multiplexer.

Use either a CB670-1 or CB670-2 cable to connect the I/O connector to the 274 multiplexer. Refer to *How To Interface to the Type 274 Multiplexer*, page 69, for a description of the cables.

Pressure Output Signal

The analog pressure output signal, available on pin 36 of the I/O connector and pin 1 on the Signal connector on the Signal Conditioner board, is a 0 to 10 VDC signal (on each range). Refer to Table 9, page 37, for the complete pinout of the I/O connector. A 10 Volt signal corresponds to a full scale pressure signal; a 1 Volt signal corresponds to a 10% of full scale pressure signal. The pressure output signal is independent of the pressure units.

Use pin 1 on the Signal connector to access the pressure output signal if your 670 instrument is connected to a 274 multiplexer. The CB670-1 or CB670-2 cable occupies the I/O connector when the 670 instrument is connected to the 274 unit.

Pinout of the I/O Connector Pinout			
Pin Number	**Assignment**	**Pin Number**	**Assignment**
1	Trip Point A NC	20	Trip Point A Common
2	Trip Point A NO	21	Trip Point B Common
3	Trip Point B NC	22	Trip Point B NO
4	Digital Ground	23	$\overline{\text{x1 Range ID}}$
5	$\overline{\text{x0.1 Select}}$	24	$\overline{\text{x0.01 Select}}$
6	$\overline{\text{Special}}$	25	$\overline{\text{1}}$
7	$\overline{\text{10}}$	26	$\overline{\text{100}}$
8	$\overline{\text{1K}}$	27	$\overline{\text{10K}}$
9	$\overline{\text{Latch TP B}}$	28	$\overline{\text{Select Channel 2}}$ *
10	$\overline{\text{Latch TP A}}$	29	$\overline{\text{Select Channel 1}}$ *
11	Reserved	30	+15 V
12	$\overline{\text{Remote Zero}}$	31	-15 V
13	Reserved	32	Power Ground
14	$\overline{\text{Channel 3 ID}}$	33	Reserved
15	$\overline{\text{Channel 2 ID}}$	34	Reserved
16	$\overline{\text{Channel 1 ID}}$	35	Analog Ground
17	Reserved	36	Pressure Output
18	$\overline{\text{x0.01 Range ID}}$	37	Reserved
19	$\overline{\text{x0.1 Range ID}}$	*NC = Normally Closed NO = Normally Open*	
** The 274 multiplexer uses these pins select the active channel. Both pins 28 and 29 high when Channel 3 is the active channel.*			

Table 9: Pinout of the I/O Connector

Signal Conditioner Board

The Signal Conditioner board provides the interface between the 670 instrument and the pressure transducer. The board contains two connectors: an upper connector labeled “Head,” and lower connector labeled “Signal.”

Head (Upper) Connector

The Head connector is a 15-pin female Type “D” connector that enables the 670 instrument to connect to a pressure transducer. Refer to Table 10 for the pin assignments.

Pinout of the Head Connector Pinout (on the Signal Conditioner Board)	
Pin Number	**Assignment**
1	Chassis Ground
2	Analog Common
3	Heater Return (-38 V)
4	Mux Input
5	No Connection
6	Signal Return
7	Signal Input
8	Heater (+38 V)
9	-13 V
10	+13 V
11	No Connection
12	Reserved
13	Preamp (+12 V)
14	System Check
15	Oscillator (6 VAC)

Table 10: Pinout of the Head Connector on the Signal Conditioner Board

Note

1. A “No Connection” pin assignment refers to a pin with no internal connection. A “Reserved” pin assignment means that the pin has an internal connection and may be assigned a function in the future.
2. Use pin 1 to access the pressure output signal if your 670 instrument is connected to a 274 multiplexer.

Signal (Lower) Connector

This 9-pin male Type “D” connector allows an external device to access the range selection circuits. The three ranges (x1, x0.1, x0.01), along with a 0 to 10 VDC output on each range, are available through this connector. Table 11 lists the pin assignments.

Pinout of the Signal Connector Pinout (on the Signal Conditioner Board)	
Pin Number	**Assignment**
1	Pressure Output
2	No Connection
3	$\overline{\text{Select x0.1 Range}}$ *
4	$\overline{\text{Select x0.01 Range}}$ *
5	Digital Ground
6	Chassis Ground
7	No Connection
8	Output Return
9	No Connection
** To select the x1 range, leave both pins 3 and 4 high (open)*	

Table 11: Pinout of the Signal Connector on the Signal Conditioner Board

Note

1. The Key Lock switch must be in the REMOTE position for the remote range selection function to be accessed from this connector.
2. A “No Connection” pin assignment refers to pins with no internal connection.

Power Entry Module

The Power Entry module contains:

- Line voltage selector
- IEC power line connector
- Power line fuses (2)
- RFI power line filter

For information on the line voltage selector, refer to *How To Change the Line Voltage Selection*, page 82. *Maintenance*, page 128, discusses the types of fuses used, and how to replace them.

Labels

The rear panel of the 670 unit carries labels to identify each board, alert the user to read the manual for more information, designate alternating current power, and show the international symbols for “on” and “off” positions on the power switch.

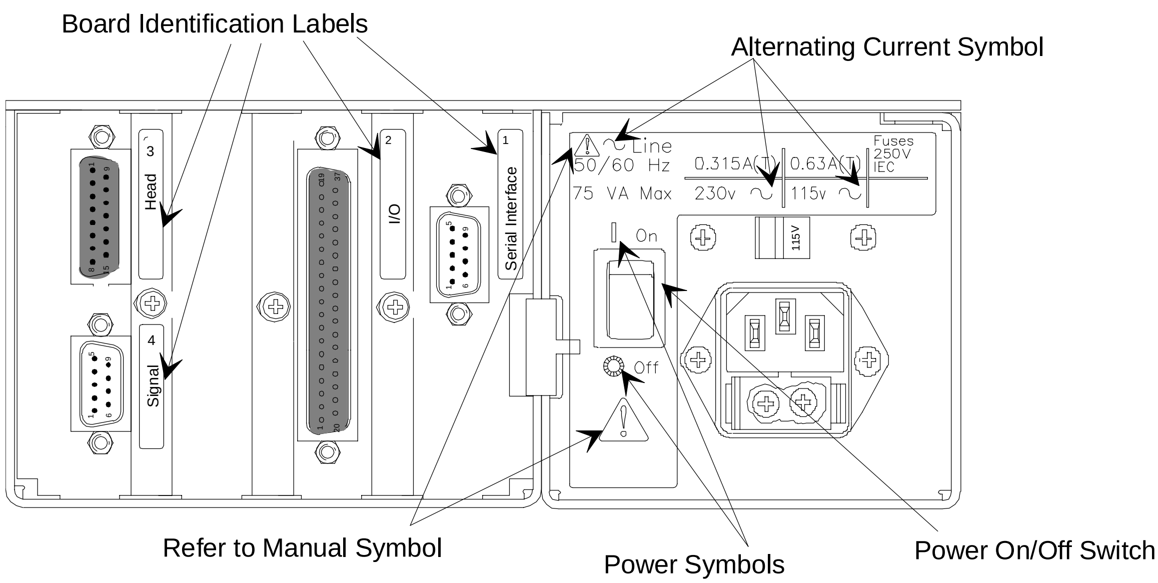


Figure 9: Labels on the Rear Panel

Serial Number Label

The serial number label, affixed to the side of the unit, lists the model code of the unit.

Figure 10: Serial Number Label

This page intentionally left blank.

Chapter Four: Functional Overview

General Information

This chapter presents a global view of the 670 functionality. For detailed instructions on how to perform a specific task, refer to *Chapter Five: Operation*, page 67.

Note To operate the 670 instrument from the front panel, place the Key Lock switch in the LOCAL position. Refer to *Key Lock Switch*, page 31, for more information on this switch.

Color Coded Keys

The front panel keys are color-coded to indicate functional associations, as listed in Table 12.

Color Coding of Front Panel Keys		
Function	**Keys**	**Color**
Channel selection	[Ch 1] [Ch 2] [Ch 3]	Green
Range selection	[x1] [x0.1] [0.01] [AUTO]	Blue
Configuration	[CAL] [ZERO] and [SETUP]	Black
Trip Points	[TRIP POINTS] LEDs A and B	Red

Table 12: Color Coding of Front Panel Keys

To select a function, press the key and a small green indicator light, in the upper left-hand corner of the key, will illuminate. In this chapter, the functions and submenus associated with each key on the front panel display are discussed.

Scrolling

To scroll through the screens associated with each key, press either arrow key ([△] or [▽]). The light on the key will remain illuminated as you scroll through its menus. To return to the pressure display screen, press the key again, and the green light will turn off as you exit the menu.

How To Change Entries

The menus consist of two types of entries; those you choose from a list of options, and those that require you to enter a value. To choose an entry from a list of options, use the Adjust knob to scroll through the options. For entries that require you to enter a value, use the [CURSOR] key to move the cursor from left to right, and the Adjust knob to change the value of each digit. Initially, the cursor is positioned at the first digit on the left, normally a ± sign. Press the cursor key to move the cursor one place to the right. Once the cursor is positioned on the last digit and you press the [CURSOR] key again, it returns to the first digit. To enter a value, press the [ENTER] key or any mode key.

When multiple entries appear on the screen, use an arrow key, ([△] or [▽]), to select each entry. The cursor indicates the active entry. Set the entry to the appropriate value in the manner described above. Once you have scrolled through all the entries on the screen, press an arrow key to advance the display to the next screen.

Note Press any configuration key to return to the pressure display screen after you have entered or changed an entry. Otherwise, you may change the parameter by inadvertently moving the Adjust knob.

Invalid Entries

The 670 instrument will not accept an invalid entry in any of the menu screens. If you enter an invalid entry and attempt to leave the screen by pressing an arrow key, the screen changes the entry to the last valid number entered. You must press an arrow key again to leave the screen. If you attempt to exit the screen by pressing a mode key, the pressure display screen appears, however, the screen entry reverts to the last valid number entered. The change is not visible until you re-enter the menu screen.

Display Screen

The main pressure display screen shows the active channel number on the left and the pressure reading on the right. The pressure display screen below shows Channel 1 as the active channel, reading atmospheric pressure:

```
Ch 1        760 Torr
```

The pressure display screen can also display the heater current power consumption and software version number. For more information, refer to *How To Display the Heater Current with the Pressure Reading,* and *How To Display the Software Version Number,* both on page 81.

How To Change Channels

If you are using the 670 instrument with a single pressure transducer, the active channel will always be Channel 1. Pressing the other channel number keys will have no effect.

Channel Selection Using the 274 Multiplexer

If you are using the 670 instrument with a 274 multiplexer, you can display data from Channels 1 through 3, individually. To select the active channel, press the appropriate channel selector key on the front panel. Be sure that the CHANNEL SELECT switch on the 274 multiplexer is in the REM position.

The [SETUP] Key

The [SETUP] key enables you to configure the operational parameters of the 670 instrument.

Display Size

Ch 1 760 Torr
Display Size 5½

The 670 instrument displays the pressure reading as a 3½, 4½, or 5½ digit number. To set the display size, turn the Adjust knob to toggle through the three options. This entry effects the data format used to report data by the remote communication options.

Response

```
Ch 1          760 T
Response  400 mSec.
```

The response can be set to 1, 40, or 400 milliseconds. The response entry selects the filter used to reduce noise in the pressure signal *before* it goes to the analog-to-digital (A/D) converter. This entry affects the displayed value, the value reported by the remote communications, and the pressure output signal. Setting the response too low may cause a noisy signal. Use the Adjust knob to toggle through the three options.

Note The response entry does not affect the sampling period of the A/D converter or the display update rate. The A/D converter samples every 0.1 seconds (ten times per second). The pressure reading in the display is updated every 0.25 seconds (four times per second).

Instrument Response Settings	
Milliseconds	**≈3 db Frequency (Hz)**
1	165
40	4
400	0.4

Table 13: Instrument Response Settings

Averaging, page 51, discusses the relationship between the response and averaging entries.

Heater

Ch 1	Heater OFF

This entry allows you to select whether the 670 instrument supplies power to a heated pressure transducer. The Adjust knob toggles between ON and OFF. The purpose of displaying the heater current is to indicate when the transducer has reached thermal equilibrium. The most accurate readings are attained when the transducer is thermally stable.

You can configure the main pressure display screen to list the amount of power used when the heater is turned ON. Refer to *How To Display the Heater Current with the Pressure Reading*, page 81, to display the heater current along with the pressure reading in the main pressure display screen. The amount of power is expressed as a percentage and ranges from 0 to 100%. When the heater goes from OFF to ON, the percentage of power used is very high, close or equal to 100%. Only a small percentage of power is used to maintain the desired temperature once the transducer is warmed up. The maintenance value will vary with ambient temperature, and from one transducer to another.

Note

Set the Heater entry OFF if:

1. You are not using a heated transducer.
2. You are using a 274 multiplexer. The 274 multiplexer supplies the power to heat the transducers.
3. There is no transducer connected to the 670 unit.

For more information, refer to *How To Display the Heater Current with the Pressure Reading,* page 81.

Pressure Units

Ch 1 760 Torr
Pressure Unit: Torr

The 670 instrument can display the pressure reading in Torr, mmHg, mbar, Pa, kPa, psi, inHg, inH_2O, cmH_2O, % Full Scale, ppm, and mTorr. Use the Adjust knob to scroll through the pressure units. This entry determines the units used for the pressure reading shown on the display and reported through remote communications.

Note If your pressure transducer is calibrated in units other than Torr, you must select the pressure unit used to calibrate the transducer *before* you select the sensor range and calibrate the full scale voltage. Once the full scale voltage is calibrated, you can change the pressure unit entry to display the reading in any unit.

For more information, refer to *How To Set the Sensor Full Scale Entry*, page 71.

Sensor Range

Ch 1	Sensor Range
±1.00000E+3Torr	

The sensor range entry, used in conjunction with the pressure units entry, sets the full scale reading of the pressure transducer. Set this entry to the full scale value of the transducer. Use the [CURSOR] key and the Adjust knob to change the sensor range value.

The actual output of the pressure transducer does not vary when you change the sensor range entry. This entry only changes the scale applied to the signal when it is converted into a pressure reading. For example, if the full scale output was calibrated as a 100 Torr unit, set the sensor range entry to 1.00000E+2 Torr. A signal 50% of full scale would correspond to a 50 Torr reading. If you set the sensor range entry to 2 Torr, the same 50% of full scale signal would correspond to a 1 Torr pressure reading.

The Effect of Changing the Pressure Units

For example, assume that you have a 100 Torr pressure transducer that was calibrated in Torr, and the pressure units entry is set to Torr. The correct sensor range entry would be 1.00000E+2 Torr. To display the pressure reading in mbar, change the pressure units entry to mbar. The sensor range entry will then display 133.3 mbar as the full scale reading, because a pressure of 100 Torr is equivalent to 133.3 mbar. A full scale pressure signal would now correspond to a pressure of 133.3 mbar. To configure the full scale reading for sensors that have been calibrated in units other than Torr, refer to *How To Set the Sensor Full Scale Entry*, page 71.

The analog output pressure signal is always a 0 to 10 Volt signal, representing 0 to full scale pressure.

Using the 670 Unit with a 274 Multiplexer

When the HEAD RANGE IN TORR switch on the 274 multiplexer is set to the SP position, the 670 unit determines the sensor range based on this entry. When the HEAD RANGE IN TORR switch is set to any position other than the SP position, the 274 head range selection overrides the 670 sensor range entry. In this case, the 670 instrument updates the sensor range entry to match the 274 setting.

For more information, refer to *How To Set the Sensor Full Scale Entry*, page 71.

Temperature Compensation

Ch 1	Temperature
Compensation:	+500

This screen allows you to use the 670 instrument to set the temperature compensation of a bakeable transducer, such as the 315, 317, 615, 616, 617. The Types 310, 370, 390, 391, 398, 590, 690, 698 transducers do not need to have the temperature compensation changed. This function corrects for gain changes on pressure transducers with user selectable temperatures. Refer to your transducer manual for details.

The temperature compensation entry can range from 0 to 999. Use the [CURSOR] key and the Adjust knob to change the value of the temperature compensation. Set the temperature compensation entry to 500 if your transducer does not need the temperature compensation setting adjusted.

Note ***If you are using a Type 274 multiplexer:*** Place the TEMP COMP switch on the 274 unit to the OUT position for each channel. This allows the 670 instrument (rather than the 274 unit) to control the temperature compensation value. Refer to *How To Interface to the Type 274 Multiplexer*, page 69, for additional information.

Averaging

```
Ch 1          760 Torr
   Averaging: 20
```

This screen displays the averaging entry that defines number of readings the 670 instrument will average to establish the pressure reading. By averaging multiple data points, you can smooth the pressure signal from an unstable system.

> **Note** The averaging feature only effects the displayed pressure reading and the value reported by the remote communications. It does *not* effect the pressure output signal.

To utilize averaging for the remote communications, refer to *Chapter Six: RS-232 Communications Option,* page 85, for more information about RS-232 commands, or *Chapter Seven: IEEE-488 Communications Option,* page 103, for information on the IEEE-488 command.

How Averaging Works

The averaging feature employs a moving average, continually dropping the oldest data point and adding the latest data point. The sampling rate is fixed at 10 samples per second. Figure 11 shows how the 670 instrument computes an average of 5 data points.

Averaging with 5 Data Points

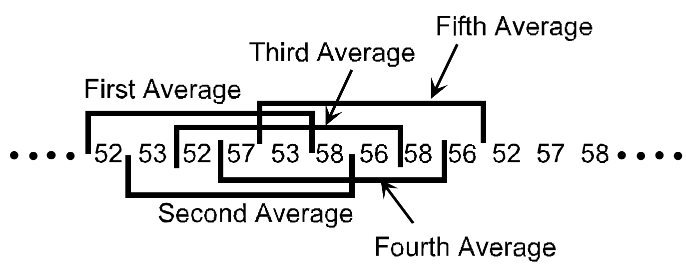


Figure 11: Averaging with 5 Data Points

A new data point is read every tenth of a second (a fixed sampling rate of 10 samples per second). The first average represents the average of the following 5 data points:

52
53
52
57
<u>53</u>

$267 \div 5 = 53.4$

The pressure reading is 53.4 at time T+0.5. At time T+0.6, the 670 instrument computes a new moving average, dropping the oldest value, 52 in the example above, and adding the reading collected at time T+0.6, in this case 58:

53
52
57
53
<u>58</u>

$273 \div 5 = 54.6$

The pressure reading changes from 53.4 to 54.6.

Use the averaging entry, in conjunction with the response entry, discussed on page 46, to achieve the best compromise between a quick response and minimal digit flickering. Refer to Table 14 for the optimal averaging and response entries.

Optimal Averaging and Response Entries	
Averaging Entry	**Response Entry**
1 - 3	1
4 - 9	40
10 - 100	400

Table 14: Optimal Averaging and Response Entries

In general, an averaging entry of 20 and a response entry of 400 milliseconds offers an acceptable response. If you are using the 670 instrument in a pressure control application, set the response entry to 1 millisecond.

The number of samples to average can range from 1 to 100, inclusive. The initial averaging value is 20.

Disabling Averaging

To disable averaging, set the averaging entry to 1. This causes the 670 instrument to report each pressure reading independent of the preceding value. In the previous example, the pressure reading would change from 53 to 58.

RS-232 Communication Parameters (Optional)

Note This screen only appears when the 670 instrument is equipped with the RS-232 remote communications option. It does not appear when the 670 instrument has the IEEE-488 communications option.

RS232:	9600 Baud
8 Bit	NO Parity

Select the RS-232 communications parameters using this screen. Use an arrow key ([△] or [▽]) to move through the entries. Use the Adjust knob to scroll through the options for each entry. The default settings are: 9600 Baud, 8 Data Bits, and No Parity.

Refer to *Chapter Six: RS-232 Communications Option*, page 85, for a complete description of the RS-232 communication parameters and protocol.

IEEE-488 Communication Parameters (Optional)

Note This screen only appears when the 670 instrument is equipped with the IEEE-488 remote communications option. It does not appear when the 670 instrument has the RS-232 communications option.

IEEE-488 Address: 8

Select the IEEE-488 device address using this screen. Valid addresses range from 1 to 30. Use the Adjust knob to scroll through the addresses.   The initial address is 8.

Refer to *Chapter Seven: IEEE-488 Communications Option*, page 103, for a complete description of the IEEE-488 communication features.

The [TRIP POINTS] Key

Use the [TRIP POINTS] key to configure the two trip points. Each trip point is defined by a high and low setting and controls a relay. In addition, you choose the initial state of the trip point relays; either energized or de-energized, and the trip point channel.

The 670 instrument contains two trip points; Trip Point A and Trip Point B. You set the high value, the low value, and the hysteresis for each trip point. The trip point entries define a "normal" operating range for the pressure signal. When the pressure signal deviates from this normal range, the relay changes state to indicate an alarm condition.

If the 670 instrument is connected to a 274 multiplexer, you must use the Y-cable, CB670-2, to access the trip point pins available on the I/O connector. Refer to *Appendix D: Interface Cables for a Type 274 Multiplexer*, page 145, for the pin assignments.

Trip Point Settings

The trip points can be set to any pressure within ±105% of transducer full scale. If you prefer to use a single pressure threshold as the alarm limit, disable one of the trip points. To disable a high trip point, select a pressure equal to or greater than +105% of full scale. To disable a low trip point, select a pressure equal to or less than -105% of full scale.

Table 15 summarizes the action of a trip point based on the pressure reading of the selected trip point channel.

Action of the Trip Points	
Pressure Value on the Trip Point Channel	**Action**
> trip point high value plus hysteresis value	Trip point relay is activated
Equal to or between the trip point high and trip point low values	Trip point relay is not activated
< trip point low value minus hysteresis value	Trip point relay is activated

Table 15: Action of the Trip Points

The trip point settings screens define the high and low settings for Trip Point A (TP A). The [CURSOR] key moves the cursor from left to right on the line, so you can change the trip point value. From the TP A HIGH screen press the down arrow key [▽] moves the cursor to the TP A LOW entry. Press the down arrow key [▽] again to configure the high and low values for Trip Point B.

Trip Point A Settings

TP A HIGH 7.80000E+2 Torr

TP A LOW 7.40000E+2 Torr

Trip Point B Settings

TP B HIGH 7.80000E+2 Torr

TP B LOW 7.40000E+2 Torr

These screens define the high and low settings for Trip Point B (TP B). Press the down arrow key [▽] once to scroll to the TP B LOW screen.

Hysteresis

Hysteresis is built into the operation of the two trip points to help compensate for the noise inherent in all systems. Without hysteresis, the noise may cause the relays to repeatedly switch states, a condition known as “relay chatter.” The amount of hysteresis can be adjusted separately for each trip point.

Setting the hysteresis too high will create a *deadband* around the trip point. The deadband prevents the trip point relay from responding to changes in the pressure signal around the trip point. Ideally, the hysteresis should be close to, but not less than, the peak-to-peak noise. This setting will provide maximum immunity from relay chatter while providing the best possible accuracy. It may take some trial and error efforts to determine the smallest hysteresis setting appropriate for your system to prevent relay chatter.

The hysteresis value is defined as a ±percent of the trip point value and can range from 0 to 10%. The 670 instrument adds the ± hysteresis value to the trip point value to create a hysteresis band around the trip point, as shown in Figure 12.

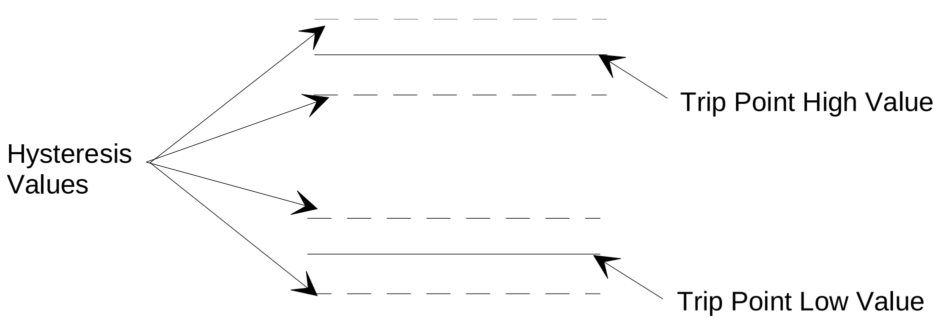


Figure 12: Hysteresis Bands Applied to the Trip Point Values

Example: Setting the trip point high value to 100, the trip point low value to 50, and the hysteresis entry to 1%, creates the hysteresis bands shown in Figure 13.

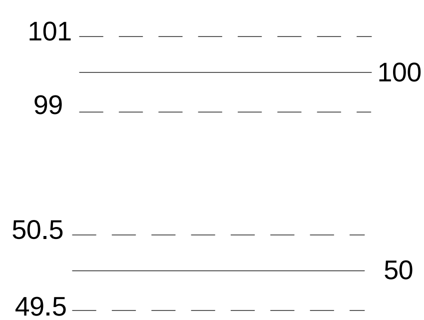


Figure 13: Hysteresis Bands and Trip Point Values

Therefore, the high trip point is activated when the pressure exceeds 101. It is deactivated when the pressure drops below 99. The low trip point is activated when the pressure drops below 49.5. It is deactivated when the pressure exceeds 50.5.

Hysteresis Screen

TP A	Hysters:	10.00%
TP B	Hysters:	-10.00%

The hysteresis feature, built into the operation of the two trip points, helps to compensate for the noise inherent in all systems. Excessive noise can cause the trip points to repeatedly switch states, a condition known as “relay chatter.”

The hysteresis value is defined as a ± percent of the trip point entry, on the selected range. The entry can range from 0 to 10 %. For example, if TP A HIGH is set to 70 and TP A LOW is set for 50, a hysteresis value to 1%, will create a hysteresis band from 63 to 77 around TP A HIGH, and a hysteresis band from 45 to 55 around TP A LOW.

Relay State

You select the state of the relays in the normal operating range, either energized or de-energized. The relay changes state when the pressure reading on the relay channel exceeds the trip point high value *plus* hysteresis value, or drops below the trip point low value minus hysteresis value. For example, if TP A is set as de-energized, it becomes energized when the pressure exceeds the range defined by the trip point values plus the hysteresis value. *Table 15: Action of the Trip Points*, on page 54, describes the action of the trip points based on the pressure reading of the trip point channel.

The relay state entry does not effect the function of the trip point LEDs. The LEDs always illuminate when the pressure reading deviates from the boundaries defined by the trip point high value plus hysteresis, and the trip point low value minus hysteresis. The LEDs are extinguished when the pressure reading is within the trip point boundaries.

Relay State Screen

TP A	ENERGIZED
TP B	DE-ENERGIZED

This screen determines the state of the trip points when the pressure is between the high and low trip point values. Set the state as either energized or de-energized. Use the Adjust knob to toggle between ENERGIZED and DE-ENERGIZED. Use the arrow keys to move from one trip point to the other.

The initial value is ENERGIZED for both trip points.

Channel Selection

Each trip point must be assigned to a channel. If you are using a single pressure transducer, set the trip point channel to Channel 1. If you are using a 274 multiplexer, the trip point channels assigned may differ from the *active* channel.

TP A Channel	#1
TP B Channel	#1

Use the Adjust knob to select the channel (1 through 3) for each trip point. Press the an arrow key to move to the other trip point field.

Note The Adjust knob scrolls through Channels 2 and 3 even when the 670 instrument is *not* connected to a 274 multiplexer. This enables you to configure the 670 instrument in one location and then insert it into a system with a 274 multiplexer, without modification.

Latching a Trip Point

The 670 instrument provides the ability to "latch" the trip points. Once the latch on a trip point is enabled, the next time the trip point value is crossed (either the pressure exceeds the high trip point, or drops below the low trip point) the relay will remain in that state as long as the latch is enabled, regardless of the pressure value. The trip point relay will return to its normal state only when the latch is either cleared or disabled, *and* the pressure value falls within the normal limits defined by the trip points. Pins on the I/O connector allow you to use an external signal to release the relay, yet maintain the latched mode. The next time that the trip point value is crossed, the relay will become latched again. Refer to *How To Clear a Latched Trip Point*, page 77. The latch feature is useful if you need to implement a manual acknowledgment of an alarm condition.

Note If the 670 instrument is connected to a 274 multiplexer, you must use the Y-cable, CB670-2, to access the trip point latch pins. Refer to *Appendix D: Interface Cables for a Type 274 Multiplexer*, page 145, for the pin assignments.

Latch Mode

TP A LATCH:	ENABLED
TP B LATCH:	DISABLED

Use the Adjust knob to select the state of the latch mode. Press the down arrow key [▽] to set the latch for Trip Point B.

The I/O connector provides the ability to clear latched trip points remotely. Once a trip point has been latched, you can clear the latch to release the trip point from the alarm condition, and maintain the latch enabled mode. The trip point will become latched again should the pressure cross a trip point.

For more information on trip points, refer to:

How To Configure the Trip Points, on page 75

How To Disable a Trip Point, on page 77

How To Clear a Latched Trip Point, on page 77

How To Adjust Hysteresis, on page 78

The [CAL] Key

The [CAL] key presents the calibration information and performs the calibration functions. The message "CALIBRATING" appears on the screen and the channel selector lights extinguish while the 670 instrument performs a calibration procedure. The current value of the entry is listed in the top portion of the screen.

The Null and Full Scale calibrations are performed independently of the pressure transducer. Perform the Null calibration procedure any time the value changes from 0.0000 Volts. Perform the Full Scale calibration procedure whenever the full scale value drifts from 10.000 Volts.

Note When the 670 instrument requires recalibration, run the Null procedure first, followed by the Full Scale procedure, if necessary. Both the Null and Full Scale values effect the output signal voltage.

Null

```
NULL        -0.0001 Volts
   Press ENTER to cal
```

This screen displays the null calibration value. The null calibration procedure eliminates any zero errors inherent in the 670 instrument. Press the [ENTER] key to perform the null calibration. The front panel will flash the message "CALIBRATING" while the instrument performs the calibration procedure. Press either of the arrow keys to change to another screen and avoid the calibration procedure.

The pressure transducer does not have to be connected to the 670 instrument for this procedure.

Full Scale

```
FS:          9.99998 Volts
   Press ENTER to cal
```

This screen displays the current full scale voltage value. This procedure eliminates any gain errors in the 670 instrument by calibrating the output span to an internal standard. To perform the full scale calibration, press the [ENTER] key. The front panel will flash the message "CALIBRATING" during the full scale calibration procedure. Press either of the arrow keys to change to another screen and avoid the calibration procedure.

The pressure transducer does not have to be connected to the 670 instrument to perform this procedure.

System Check Calibration

Ch 1 9.9998
SYSCHK

This screen displays the system check value. This value can be used as a diagnostic tool.

Note

Be sure that the system is at the correct pressure for the type of transducer, BEFORE using the SYSCHK function. Otherwise, the 670 unit may report erroneous values.

Absolute Transducers: Pump the system down to base pressure, that is, a pressure below the resolution of the transducer.

Differential Transducers: Equalize the pressure on both the reference (Pr) and measurement (Px) ports.

When you enter the SYSCHK screen, the 670 instrument sends out a digital signal to prompt the transducer to return a 10 Volt signal. The value displayed in this screen reflects the value returned by the pressure transducer. The system check value varies for each transducer, and can range from 9.5 to 10.5 Volts. Refer to *Troubleshooting*, page 130, if your SYSCHK value does not fall within this range.

For more information on calibrating the 670 unit, refer to *How To Calibrate the 670 Instrument*, page 72.

The [ZERO] Key

The [ZERO] key allows you to zero the transducer from the 670 instrument. The 670 instrument performs the zero function on all three ranges (x1, x0.1, and x0.01).

Zero Enable

Ch 1 760 Torr
Zero Enable: ON

The zero enable entry must be ON for the 670 instrument to calibrate the zero. Use the Adjust knob to toggle between ON and OFF. With the zero enable set to ON, advance to the zero calibration screen to initiate the zero procedure. When the zero enable is set to OFF, no other screens are available.

When the zero enable is off the signal used to zero the transducer is turned off. This capability is useful in the situation that requires changing the transducer zero adjustment. Refer to your transducer manual for calibration procedures.

Note You *cannot* access the zero calibration screen when the zero enable entry is OFF.

Zero Calibration

Ch 1 2E-3 Torr
Press ENTER to zero

This screen is accessible only when the zero enable entry is set to ON. To start the zero procedure, press the [ENTER] key. The front panel will flash the message "CALIBRATING" during the zero procedure.

Note

1. Before you initiate the zero procedure, be sure that your system is pumped down to a base pressure *less than* the resolution of the transducer measuring the pressure of the system. Otherwise, the resultant zero setting will be incorrect.
2. The 670 instrument *cannot* correct for a transducer zero greater than ±2% of full scale.

The zero calibration applies a zero correction factor to assign the present voltage reading a pressure of 0.00 Torr (or to the base pressure reading appropriate for the units you are using). This correction factor accounts for any voltage offset caused by the transducer or the wiring between the transducer and the 670 instrument. When the zero enable is OFF, the 670 instrument does not apply any zero correction factor to the pressure signal. The 670 instrument sets the zero value as close to 0.00 Torr as possible. This allows you to remove any transducer zero without effecting the null calibration.

Note When using a Type 274 multiplexer, you must perform the zero calibration on *each* channel you intend to use.

Remote Zero Feature

The 670 instrument can be zeroed remotely through pins on the I/O connector, when the Key Lock switch is in the REMOTE position.

For more information on the zero feature, refer to:

How To Calibrate the 670 Instrument, on page 72

How To Use the Remote Zero Feature, on page 80

The [AUTO] and Range Keys

The [AUTO] key activates the autoranging feature. When the 670 instrument is configured for autoranging, the instrument switches the range automatically to optimize the pressure reading. Both the [AUTO] key and the active range key ([X1], [X0.1], or [X0.01]) are illuminated when the autoranging feature is active. Autoranging allows the 670 instrument to produce the most accurate pressure reading throughout the range of the pressure transducer. By changing the range, based on the magnitude of the pressure signal, the 670 instrument can increase the resolution for a low level signal, and decrease the resolution to track a high level signal. Autoranging is useful in situations that require maximum resolution for a system in which the pressure signal may change substantially. However, for pressure control applications, do not use autoranging since the range crossover will cause the analog output signal to change ranges.

Figure 14 demonstrates how autoranging works. In this example, the full scale voltage is set for 10 Volts and the full scale pressure reading is 100 Torr.

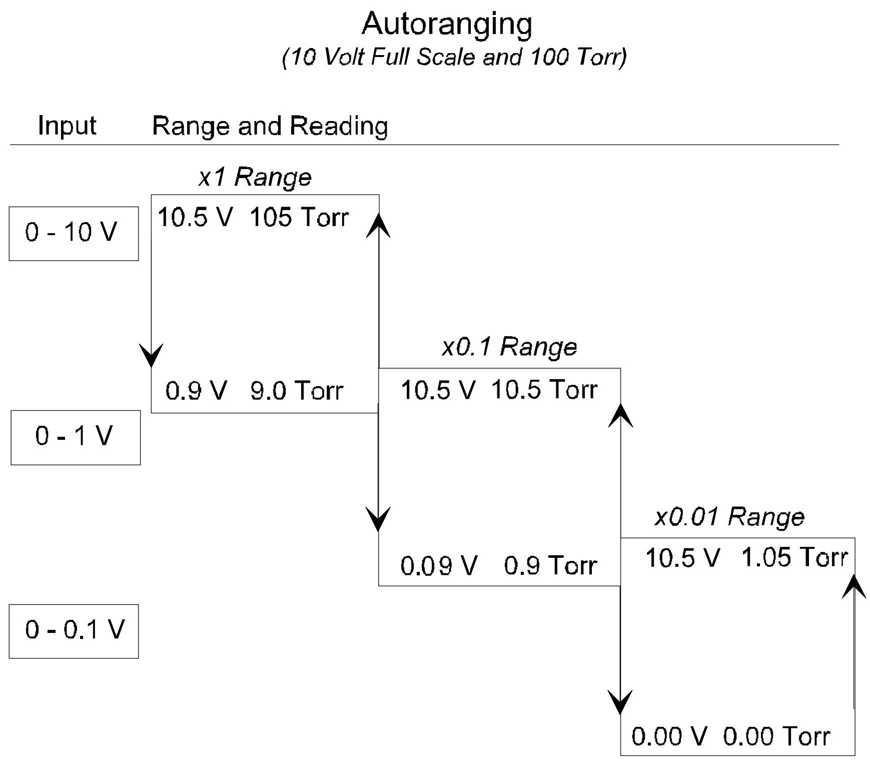


Figure 14: Autoranging on a 10 Volt Full Scale Signal

Following the example in Figure 14, the 670 instrument applies the x1 range to pressure readings between 105% F.S. (105 Torr) and 9% F.S. (9.0 Torr). When the pressure reading drops below 9% of F.S. (9.0 Torr), the 670 instrument applies the x0.1 range. This change adds another significant digit to the display. The full scale voltage on the x0.1 range is 10 Volts. The range remains at x0.1 for pressure readings between 105% of the *current* range (10.5 Torr) and 9% of the *current* range (0.9 Torr). Once the pressure reading drops below 9% of the voltage range (0.9 Torr), the 670 instrument applies the x0.01 range. The range remains at x0.01 for pressure readings between 105% of the *current* range (1.05 Torr) and zero (0.00 Torr). This range increases the number of significant digits by one.

A differential transducer may generate negative pressure readings. The autoranging sequence is repeated for negative pressure values, up to -105% F.S. Using the example system in Figure 14, page 64, the range remains at x0.01 when the pressure reading drops below zero to -105% of the *current* range (-1.05 Torr). When the pressure drops below -1.05 Torr, the range switches to x0.1. The 670 instrument holds the range at x0.1 for pressure readings between -9% of the *current* range (-0.9 Torr) and 105% of the *current* range (-10.5 Torr). Once the pressure reading drops below -105% of the x0.1 range (-10.5 Torr), the range switches to the x1. The range remains at x1 for pressure readings between -9% of full scale (-9 Torr) and -105% of full scale (-105 Torr).

The display reads UNDERRANGE when the pressure is less than -105% of full scale (105 Torr) and OVERRANGE when the pressure exceeds +105% of full scale (+105 Torr).

Note In the autoranging mode, the display may list UNDERRANGE or OVERRANGE while changing ranges since the 670 instrument uses all the previous data to calculate the new average. Once the previous data is replaced by new data, or the average value falls within the new range, the out-of-range condition will disappear. To avoid this, reduce the number of samples to average entry. For more information, refer to *Averaging* page 51.

De-Selecting the AUTO Operation

To de-select the AUTO operation, press either the [AUTO] key or a range selection key ([X1], [X0.1], or [X0.01]). The 670 instrument either maintains to the last range used while in the AUTO mode (if you press the [AUTO] key), or changes to the new range (if you press another range selection key). The light on the appropriate range selection key illuminates to indicate the active range.

For more information on range selection, refer to *How To Select the Range Setting Remotely*, page 79.

This page intentionally left blank.

Chapter Five: Operation

How To Configure the 670 Instrument

This section describes how to connect and configure the 670 instrument.

1. Power up the unit by pressing the On/Off switch to the On position.

   Refer to Figure 7, page 33, for the location of the On/Off switch.

2. Connect the 670 instrument to the pressure transducer.

   Figure 15 shows the connection between the 670 instrument and a single pressure transducer. If you are using a Type 274 multiplexer, refer to *How To Interface to the Type 274 Multiplexer*, page 69.

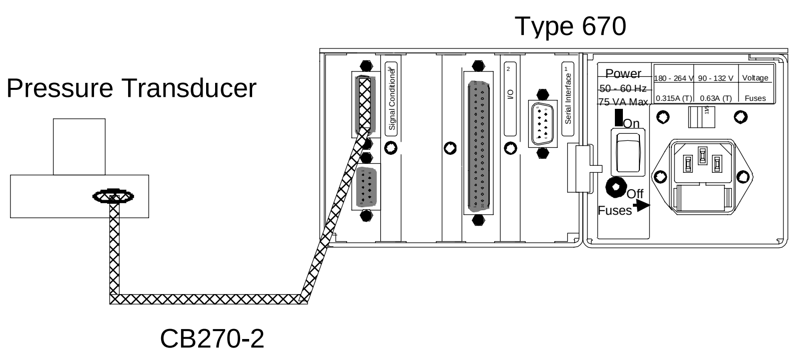


Figure 15: Connecting to a Single Pressure Transducer

3. Press the [SETUP] key.

   The system responds by displaying a configuration screen.

4. Use the arrow keys, ([△] or [▽]), to scroll through the screens. Change the configuration, if necessary.

   Refer to *Chapter Four: Functional Overview*, page 43, for information about the setup menu screens. If you need to change the sensor range, follow the directions in *How To Set the Sensor Full Scale Entry*, page 71. The *How To Calibrate the 670 Instrument*, page 72, describes how to calibrate the instrument.

5. Once the 670 instrument is fully configured, press the SETUP key to return to the pressure display screen.

6. Place the Key Lock switch in the desired position.

Refer to *Chapter Three: Hardware Overview*, page 31, for a description of the Key Lock switch. When the Key Lock switch is in the REMOTE position, you can remove the key. The key cannot be removed when the switch is in the LOCAL position.

How To Interface to the Type 274 Multiplexer

The 670 instrument can interface to the Type 274 multiplexer and display the pressure signal from up to three pressure transducers, individually. Figure 16, page 69, shows the 670 instrument connected to a 274 multiplexer.

Connecting the Cables

1. Disconnect the power cords from the 670 instrument and the 274 multiplexer.

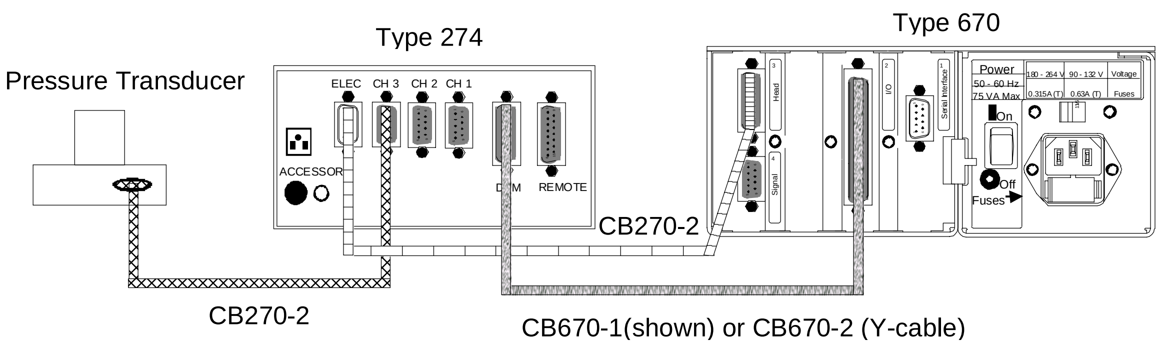


Figure 16: Connecting to a Type 274 Multiplexer

2. Use a CB670-X cable to connect the I/O connector on the 670 instrument to the DVM connector on the 274 multiplexer.

   The I/O connector is a 37-pin female connector; the DVM connector is a 25-pin female connector. The CB670-1 cable is a straight cable; the CB670-2 cable is a Y-cable that allows access to the trip point relays, and the remote functions (zero, range select, and trip point latching). Refer to *Appendix D: Interface Cables for a Type 274 Multiplexer,* page 145, for a description of the cables.

3. Use a CB270-2 cable(s) to connect the pressure transducer(s) to the “CH 1,” “CH 2,” or “CH 3,” connector(s) on the 274 multiplexer.

4. Use a CB270-2 cable to connect the Head connector on the 670 instrument to the ELEC connector on the 274 multiplexer.

   The Head connector (upper connector on the Signal Conditioner board) is a 15-pin female connector; the ELEC connector is a 15-pin male connector.

Configuring the 274 Multiplexer

1. Place the CHANNEL SELECT switch in the REM position.

This allows the 670 instrument to select the active channel.

2. Place the TEMP COMP switch (on the left-hand side), in the OUT position, for each channel.

This allows the 670 instrument to set the temperature compensation. Refer to the discussion of the temperature compensation screen, page 50, for details.

3. Turn the REG HEATER switch ON to control the heater power, if necessary. Set this switch for each channel on the 274 multiplexer.

The Heater screen in the [SETUP] menu allows the 670 instrument to provide power to the transducer heater. Refer to *Heater,* page 47, for a discussion of the heater function.

4. Place the HEAD RANGE IN TORR switch, for each channel, in the SP position.

This allows the 670 instrument to set the sensor range. Refer to *Sensor Range,* page 49, for a complete discussion.

5. Plug in the power cord on both the 670 instrument and the 274 multiplexer.

Configuring the 670 Instrument

To configure the 670 instrument, complete steps 3 through 6 in *How To Configure the 670 Instrument*, page 67.

Note If you are using heated transducers, turn the Heater entry OFF (in the Setup menu). The 274 multiplexer, rather than the 670 instrument, supplies power to heat the transducers.

If the 670 instrument has not been calibrated, complete the steps outlined in *How To Calibrate the 670 Instrument,* page 72. If the 670 instrument has been calibrated, you only need to zero each channel with a transducer connected. Steps 11 through 15 on page 73, describe the zero procedure.

Refer to *How To Set the Sensor Full Scale Entry,* page 71, if you need to change the full scale or pressure unit entries.

How To Set the Sensor Full Scale Entry

To configure the 670 instrument to work with a pressure transducer, you need to select the sensor range and pressure unit. You should check the label on your transducer to determine both the sensor range and pressure unit used to calibrate the transducer. Be sure that the pressure unit entry is set to the unit used to calibrate the transducer *before* you set the sensor range entry. Once the sensor range is set correctly, you may change the pressure unit entry at any time. The pressure unit entry effects the displayed reading as well as the reading reported by remote communications.

1. Press the [SETUP] key.

   The system responds by displaying a setup screen.

2. Repeatedly press either arrow key ([△] or [▽]) to scroll to the pressure unit screen.

   The system responds by scrolling through the setup screens.

Ch 1	760 Torr
Pressure Unit: Torr	

3. Use the Adjust knob to scroll through the various pressure units and select the unit used to calibrate the transducer full scale value.

   The label on your transducer should list the units used to calibrate the transducer.

4. Press the down arrow key ([▽]) to scroll to the sensor range screen.

   The system responds by scrolling to the sensor range screen.

Ch 1	Sensor Range
±1.00000E+3Torr	

5. Enter the correct sensor range by using the [CURSOR] key to position the cursor on each digit, and then turn the Adjust knob to vary the value of each digit.

   The system responds by accepting the new full scale value (if the selection has changed).

6. Press either arrow key ([△] or [▽]) to move to another screen.

   If you prefer to display the pressure reading in a unit other than the unit used to calibrate the transducer, select the pressure unit screen to change the pressure unit.

7. Once the 670 instrument is fully configured, press the [SETUP] key to return to the pressure display screen.

How To Calibrate the 670 Instrument

The 670 instrument displays the message "CALIBRATING" during any calibration procedure.

Note Complete the calibration procedure in the order listed below. Failure to do so may result in an invalid calibration.

To calibrate the 670 instrument:

1. Press the [SETUP] key to enter the setup menu.

   The system responds by displaying a setup screen.

2. Repeatedly press either arrow key ([△] or [▽]) to scroll to the response screen.

   The system responds by scrolling through the setup screens.

3. Use the Adjust knob to set the response entry to 400 milliseconds. Refer to *Response*, page 46, for a complete description of this entry.

Ch 1 760 Torr
Response: 400 mSec.

4. Repeatedly press the down arrow key ([▽]) to scroll to the averaging screen.

Ch 1 760 Torr
Averaging: 20

5. Use the Adjust knob to set the averaging entry to 20.

   An averaging entry of 20 is sufficient for the null and full scale calibration procedures. You may need to increase the averaging entry to establish a valid zero. Increasing the averaging entry and the response time will improve the accuracy, however, the instrument response will be slower and the calibration will take longer to complete. Table 16, page 73, lists the approximate time for each calibration function with various averaging entries.

Relationship Between Averaging Entry and Calibration Times					
Averaging Entry:	**20**	**40**	**60**	**80**	**100**
Null	17 sec.	24 sec.	32 sec.	40 sec.	49 sec.
F.S.	9 sec.	13 sec.	17 sec.	20 sec.	24 sec.
Zero	21 sec.	30 sec.	39 sec.	50 sec.	1 min.

Table 16: Relationship Between Averaging Entry and Calibration Times

Refer to *Averaging*, page 51, for more information.

6. Press the [CAL] key to enter the calibration menu.

7. Repeatedly press either arrow key ([△] or [▽]) to scroll to the null screen.

```
NULL        -0.0001 Volts
   Press ENTER to cal
```

8. Press the [ENTER] key to initiate the null calibration routine.

   This step may take several minutes to complete, depending upon the averaging entry. Refer to Table 16 for an approximate time. The message "CALIBRATING" will flash on the display until the calibration procedure is complete. The reading should go to 0.000 ±0.0005. If the reading does not approach 0.000, press the [ENTER] key again to repeat the null calibration routine.

9. Repeatedly press either arrow key ([△] or [▽]) to scroll to the full scale screen.

```
FS:          9.99998 Volts
   Press ENTER to cal
```

10. Press the [ENTER] key to initiate the full scale (FS) calibration routine.

    The message "CALIBRATING" will flash on the display during the calibration process. The reading should go to 10.000 ±0.0005. If the reading does not approach 10.000, press the [ENTER] key again to repeat the F.S. calibration routine.

11. Pump down the system to a pressure less than the resolution of the pressure transducer.

    To achieve a proper zero, the pressure of the system must be *less than* the resolution of the pressure transducer used to measure the system pressure. The transducer will not be zeroed if the output of the transducer is greater than 2% of the sensor full scale range. Refer to the pressure transducer instruction manual for the proper pressure for your transducer. It may take several hours to achieve an acceptable base pressure.

12. Press the [ZERO] key.

13. Use the Adjust knob to set the zero enable entry to ON.

Ch 1 2.14E-3 Torr
Zero Enable: ON

14. Press the down arrow key ([▽]) to scroll to the zero screen.

Ch 1 2.14E-3 Torr
Press ENTER to zero

This screen will not appear if the zero enable entry is set to OFF.

15. Press the [ENTER] key to initiate the zero procedure.

The message "CALIBRATING" will flash on the display until the calibration procedure is complete. The system responds by zeroing the pressure transducer.

If the 670 instrument is unable to establish an acceptable zero, you may need to increase the averaging entry. Repeat steps 4 and 5 and increase the averaging entry. Setting the averaging entry higher than 20 may increase the accuracy of the calibration, however, the calibration procedure will take longer to complete. You do *not* need to repeat the null and F.S. calibrations if you change the averaging entry.

16. Press the [ZERO] key to return to the pressure display screen.

17. If you prefer to use another value for the averaging entry, press the [SETUP] key, use the arrow keys to scroll to the averaging screen, and reset the averaging entry.

Additional Calibration for the Type 274 Multiplexer

To calibrate a 670 instrument connected to a 274 multiplexer, complete the procedure described above and repeat steps 11 through 17 for each channel. This configures the zero setting for each channel.

How To Configure the Trip Points

The 670 instrument has two trip points, and each trip point controls a relay. The relays provide 24 Volts AC/DC @1 Amp resistive (contact rating) power. You assign a channel number, an initial state, and high and low values for each trip point. Refer to *The [TRIP POINTS] Key,* page 54, for a complete description of trip points.

1. Connect the trip point relays, on the I/O connector, to your system.

   Table 9, page 37, lists the complete pinout for the I/O connector.

2. Press the [TRIP POINTS] key on the front panel of the 670 instrument.

   The system responds by displaying the screen below.

TP A HIGH
7.80000E+2 Torr

3. Use the [CURSOR] key and the Adjust knob to set the value for the TP A HIGH entry.

   The entry can vary from ±105% of full scale. The actual signal output depends on the range selection.

Note A +105% of full scale setting for the high entry or a -105% of full scale setting for a low entry, *disables* the trip point.

4. Press an arrow key to move the cursor the to TP B entry.

   The system responds by displaying the value of the TP A LOW entry.

5. Use the [CURSOR] key and the Adjust knob to set the value for the TP B HIGH entry.

   Refer to step 3 above for an explanation of the setting.

Note Switching the range may delay the response of the trip points to a change in pressure. Immediately after the range changes, the 670 unit waits until a stable pressure reading is achieved before activating the trip point.

6. Repeatedly press an arrow key ([△] or [▽]) to display the relay state screen.

   The system responds by displaying the relay state screen.

TP A	ENERGIZED
TP B	ENERGIZED

7. Use the Adjust knob to set the normal state for TP A.

   The Adjust knob alternates between ENERGIZED and DE-ENERGIZED.

8. Press an arrow key to move the cursor to the TP B entry.

   The system responds by moving the cursor to the TP B entry.

9. Use the Adjust knob to set the normal state for TP B.

10. Press the down arrow key ([▽]) once to display the channel selection screen.

    The system responds by displaying the channel selection screen.

TP A Channel	#1
TP B Channel	#1

11. Use the Adjust knob to assign a channel for TP A.

    The system responds by scrolling through Channels 1 through 3. Channel 1 is available on the 670 instrument itself; Channels 2 through 3 are available when the 670 unit is connected to a 274 multiplexer.

Note The Adjust knob scrolls through Channels 2 and 3 even when the 670 instrument is not connected to a 274 multiplexer. This enables you to configure the 670 instrument in one location and then insert it into a system with a 274 multiplexer, without modification.

12. Press an arrow key to move the cursor to the TP B entry.

    The system responds by moving the cursor to the TP B entry.

13. Use the Adjust knob to assign a channel for TP B.

    Refer to step 11 for instructions on selecting a trip point channel.

14. Press an arrow key to move to the TP Latch screen.

15. Use the Adjust knob to set the latch for each trip point.

16. Once the trip points are configured, press the [TRIP POINTS] key again to return to the pressure display screen.

How To Disable a Trip Point

Refer to *The [TRIP POINTS] Key,* page 54, for a complete description of trip points.

- Setting the trip point high entry to +105% of full scale disables the trip point
- Setting the trip point low entry to -105% of full scale disables the trip point

For example, if the sensor range is set to 1000 Torr, and you wish to disable the high trip point, set the trip point high entry to 1050 Torr. To disable the low trip point, set the trip point low entry to -1050 Torr.

How To Clear a Latched Trip Point

Refer to *The [TRIP POINTS] Key,* page 54, for an explanation of the trip points, and the latching feature.

A trip point latch can be enabled through the TRIP POINTS menu screen on the front panel, or through a remote communications command. Follow this procedure to release a latched trip point and maintain the latch as enabled. Once the latch is cleared, the trip point will become latched again should the pressure cross a trip point.

1. Place the Key Lock switch in the REMOTE position.
2. Connect the I/O connector pins, as described in Table 17, to clear a latched trip point(s).

Connections to Latch the Trip Points		
To Latch Trip Point:	**Connect Pin:**	**To Pin:**
A	10 (latch TP A)	4 (digital ground)
B	9 (latch TP B)	4 (digital ground)

Table 17: Connections to Clear a Latch on the Trip Points

Maintain this connection for at least 100 milliseconds to clear the latch on the appropriate trip point.

3. To release the clear signal, release the connection, so the pins float high.

   Refer to Table 9, page 37, for the complete list of pin assignments for the I/O connector.

How To Adjust Hysteresis

Refer to *The [TRIP POINTS] Key*, page 54, for a complete description of trip points and hysteresis.

1. Press the [TRIP POINTS] key.

   The system responds by displaying a trip points screen.

2. Repeatedly press an arrow key ([△] or [▽]) to scroll to the hysteresis screen:

TP A	Hyst:	1.00%
TP B	Hyst:	1.00%

   The system responds by displaying the screen with the cursor positioned at the entry for TP A if you pressed the down arrow [▽] key and TP B if you pressed the up arrow [△] key.

3. Use the [CURSOR] key and the Adjust knob to adjust the hysteresis value.

   The system responds by accepting the new hysteresis value for TP A.

4. Press the down arrow key ([▽]) to edit the hysteresis value for TP B.

   The system responds by moving the cursor to the entry for TP B.

5. Use the [CURSOR] key and the Adjust knob to adjust the value.

   The system responds by accepting the new hysteresis value for TP B.

6. Press the [TRIP POINTS] key to return to the pressure display screen.

How To Select the Range Setting Remotely

The Head connector on the Signal Conditioner board provides the ability to select the range setting remotely.

1. Place the Key Lock switch, located on the front panel, in the REMOTE position.

2. To select the desired range, apply the appropriate signal to pins 3 and 4 on the Head (lower) connector of the Signal Conditioner board.

   Table 18 lists the logic levels and the corresponding ranges.

Pin State for Remote Range Selection		
Range	Head (Lower) Connector on the Signal Conditioner Board	
	Pin 3	Pin 4
x1	HI	HI
x0.1	LO	HI
x0.01	HI	LO

Table 18: Pin State for Remote Range Selection

Refer to Table 11, page 39, for a complete list of the pin assignments for the Head connector on the Signal Conditioner board.

How To Use the Remote Zero Feature

The I/O connector provides the ability to zero the 670 instrument remotely. The 670 instrument uses an edge trigger to activate the remote zero function. Edge triggering requires that pins change from one state to another before the function will occur. The function will not be repeated until the *transition* occurs again. The pins on the I/O connector float high when open (disconnected). To activate the remote zero feature, pull the pins low (transition from high to low). Refer to *The [ZERO] Key,* page 62, for information on the zero function.

1. Check that the zero feature is enabled.

   If you are using remote communications, send the appropriate command to enable the zero. If you are in LOCAL operation, press the [ZERO] to check the state of the zero function. Adjust if necessary.

2. Place the Key Lock switch, located on the front panel, in the REMOTE position.

3. Pump down the system to a pressure less than the resolution of the pressure transducer.

   To achieve a proper zero, the pressure of the system must be *less than* the resolution of the pressure transducer used to measure the system pressure. The transducer will not be zeroed if the output of the transducer is greater than 2% of the sensor full scale range. Refer to the pressure transducer instruction manual for the proper pressure for your transducer. It may take several hours to achieve an acceptable base pressure.

4. Connect pin 12 (remote zero) to pin 4 (digital ground) on the I/O connector and hold the connection for at least 200 milliseconds.

   The remote zero function uses edge triggering so that the command is only executed once when the remote zero pin is brought low. If you need to repeat the zero procedure, you must release the connection for 200 milliseconds, to allow the line to float high. When you reestablish the connection, the line will be pulled low again, and the instrument will perform the zero function.

How To Display the Software Version Number

1. From the pressure display screen, press an arrow key ([△] or [▽]) until the software version number display screen appears.

   The version number is displayed below the pressure reading.

2. Press an arrow key ([△] or [▽]) to return to the pressure display screen.

   The instrument scrolls to the pressure display screen.

```
Ch1      760 Torr
V1.2   RS232C
```

or

```
Ch1      760 Torr
V1.2  IEEE-488
```

How To Display the Heater Current with the Pressure Reading

The 670 instrument can display the amount of power being supplied to a heated transducer, along with the pressure reading. Once you select this screen, it will appear every time you exit out of a menu. Once you power down, the normal pressure display screen (without the heater status) will reappear, however. Refer to *Heater*, page 47, for more information.

- From the normal pressure display screen, that appears upon power-up, press the down arrow key ([▽]).

  The instrument displays both the pressure reading and the heater current.

```
Ch 1      760 Torr
heater:   100%
```

The software version is also displayed briefly upon startup.

How To Change the Line Voltage Selection

The 670 instrument can use power from any of the following line voltages:

- 100 to 120 VAC nominal on the 115 V setting *(factory default setting)*
- 200 to 240 VAC nominal on the 230 V setting

To change the line voltage:

1. Disconnect the power cord from the 670 instrument.

Warning **To avoid an electrical shock, be sure to disconnect the power cord *before* proceeding.**

2. Disconnect all cables from the connectors located at the back of the unit.
3. Locate the Line Voltage selector switch on the rear panel of the 670 instrument.

   Refer to Figure 7, page 33, for the location of the Line Voltage selector switch.
4. Insert a small device, for example, a screwdriver, to slide the switch so the “115V” label is visible to operate in the 115 V range, or so the “230V” label is visible to operate in the 230 V range.

How To Use the SYSCHK Feature

Refer to *System Check Calibration*, page 61, for a description of the SYSCHK feature.

1. Verify that all vacuum fittings are tight.

2. For an absolute transducer, pump down the system to a base pressure less than the resolution of the transducer. For a differential transducer, equalize the pressure on both the reference port (Pr) and the measurement port (Px).

   Refer to the transducer manual for pump down instructions.

3. Press the [CAL] key to enter the calibration screen.

4. Press an arrow key, ([△] or [▽]), until the system check screen appears.

```
Ch 1                    9.8799 Volts
              SYSCHK
```

The SYSCHK reading should be between 9.5 and 10.5 Volts. A SYSCHK value outside this range, indicates a problem with the pressure transducer or its cable.

This page intentionally left blank.

Chapter Six: RS-232 Communications Option

General Information

Note The information in this chapter *only* applies if your 670 instrument is configured with the RS-232 Communications option. If your 670 instrument is configured with the IEEE-488 communication option, refer to *Chapter Seven, IEEE-488 Communications Option*, page 103, for remote communications information.

To configure the 670 instrument to accept commands issued through serial communications, place the Key Lock switch, located on the front panel, in the REMOTE position. While operating the 670 instrument in the REMOTE mode, the front panel controls are locked out and the display shows status information only. The 670 instrument expects to receive commands and instructions through the serial port or the rear panel connectors. When the Key Lock switch is in the LOCAL position, the 670 instrument behaves in the opposite manner — it accepts commands from the front panel only and ignores commands issued by serial communications. Only status information is available through serial communications.

Figure 6, page 31, shows the location of the Key Lock switch.

Communication Parameters

The RS-232 communication parameters are accessed from the [SETUP] key. Initially, the 670 instrument is configured at 9600 Baud, 8 Data Bits, and No Parity. Table 19 lists the setting for all the communication parameters.

RS-232 Communication Parameters		
Parameter	**Options**	**Page Reference**
Baud Rate*	300, 1200, 2400, 4800, 9600†	53
Number of Data Bits*	7, 8†	53
Parity*	Even, Odd, No†	53
Stop Bits	1	Cannot be changed
End-of-Line delimiter	CR	Cannot be changed
** denotes user selectable* *† indicates the initial setting*		

Table 19: RS-232 Communication Parameters

RS-232 Protocol

Messages sent to the 670 instrument are either *commands* that instruct the instrument to change an operating parameter, or *requests* that prompt the instrument to report information.

Responses sent by the 670 instrument either acknowledge a command issued by the host computer, or reply to a request sent by the host computer.

All messages must use a carriage return (CR) as the end-of-line delimiter. Use your communications software on the host computer to assign a CR to the ENTER key.

Message Syntax

The information presented in this section applies to all RS-232 messages. The RS-232 message syntax uses the following conventions:

bold	Messages that you must enter exactly as shown in the manual. Do not include any spaces in the message string.
italics	Placeholder that represents text or numeric values that you must supply.
`response`	Format of message sent from the 670 controller.
ENTER	Represents Carriage Return (CR) that must be configured as the end-of-line delimiter (in your communications software).

Commands

A *command* message sent to the 670 instrument instructs it to perform a task or change a setting. All commands sent to the 670 instrument must have the following format:

@parameter *id data* ENTER

where:	**parameter**	is two ASCII bytes representing the command parameter
	id	is a single ASCII byte identifying the specific channel or relay, or a ‘0’ if the command is neither a channel nor relay command
	data	is a variable length ASCII field representing the new value for the parameter

Refer to Table 21, page 90, Table 22, page 92, and Table 23, page 96, for a list of commands.

Requests

A *request* message sent to the 670 instrument causes it to send back information. All requests sent to the 670 instrument use the same basic format as commands:

@parameter *id ?* ENTER

where:	**parameter**	is two ASCII bytes representing the command parameter
	id	is a single ASCII byte identifying the specific channel or relay, or a 0 if the command is neither a channel nor relay command
	?	is a '?' to request the current setting of the parameter

Note The *data* entry is a ? to identify the message as a request rather than a command.

Responses

All RS-232 messages sent to the 670 instrument initiate a response.

Response to a Command

The response to a command will follow the format listed below:

```
status parameter id data <CR>
```

where:	`status`	'@' command accepted '>' parameter value is unrecognized '?' data field value invalid '=' command is inappropriate
	`parameter`	is identical to the parameter field of the command received
	`id`	is identical to the id field of the command received
	`data`	is identical to the data field of the command received

Note The *parameter*, id, and *data* fields in the response will be identical to the *parameter, id,* and *data* fields contained in the command received by the 670 instrument.

Table 20, page 88, shows the response and the cause for rejected commands.

Responses for Rejected Commands	
Response	**Cause**
`?parameter data`	Invalid data field
`>parameter data`	unrecognized *parameter* or identifier *id*
`=parameter data`	Command is inappropriate at this time

Table 20: Responses for Rejected Commands

The response to an accepted command will be identical to the command itself.

Response to a Request

The response to a request will follow the format listed below:

`status parameter id data <CR>`

where: `status`
‘@’ indicates valid data
‘>’ parameter value is unrecognized
‘?’ data field value invalid
‘=’ request is inappropriate

`parameter` is identical to the parameter field of the request received

`id` is identical to the id field of the request received

`data` contains the data requested

Example: Response to A Report Reading Request

The response to a request to report the pressure reading (02) will have the following format, if accepted:

`@020 status reading <CR>`

where: `status`
‘*space*’ where *space* represents one blank space if reading is valid

‘!’ if the 670 instrument is calibrating

‘"’ if the pressure reading is underranged

‘#’ if the pressure reading is overranged

Note The *parameter* and *id* fields in the response will be identical to the *parameter* and *id* fields contained in the request received by the 670 instrument. The *data* field in the response will contain the current value of the parameter or mode specified by the *parameter* field.

RS-232 Messages

The RS-232 messages are divided into the following groups:

Group I	requires no specific ID (*id* = ‘0’)
Group II	requires a channel ID (*id* = ‘0’ for channel 1, ‘1’ for channel 2, ‘2’ for channel 3)
Group III	requires a trip point ID (*id* = ‘0’ for Trip Point A, ‘1’ for Trip Point B)
Group IV	diagnostic information

Note To request the status of a parameter, enter the command for the parameter with a question mark inserted as the data field.

This section discusses the RS-232 commands used to implement features of the 670 instrument. Refer to *Chapter Four: Functional Overview,* page 43, for a complete description of the software features.

Global Messages

The Global messages, listed in Table 21, do not use the <id> entry, however you must enter a ‘0’ in the <id> entry field to complete the message string. The table lists the <data> entry for a command and a request.

@parameter 0 *data* [ENTER]

Global Messages			
Parameter Entry	**Action**	***Data* for a Command**	***Data* for a Request**
00	Active Channel	0 = Channel 1 1 = Channel 2 2 = Channel 3	‘?’
01	Mode	0 = Pressure 1 = Zero 2 = Null 3 = Full Scale 4 = System Check	‘?’
02	Report Reading	*Request Only*	‘?’
03	Calibrate Mode	None	*Command Only*
04	Enable RS-232 Averaging	0 = No 1 = Yes	‘?’

Table 21: RS-232 Global Messages

Example 1: How To Set the Active Channel

1. To set the active channel to Channel 2 (with a 274 multiplexer connected), send the command:

   @0001 [ENTER]

   The 670 instrument will return the same command to indicate that the command was accepted and implemented. In addition, it will illuminate the light in the [Ch 2] key.

Example 2: How To Request the Pressure Reading

1. Issue the following command to set the 670 instrument in the pressure reading mode:

   @0100 [ENTER]

2. To request the pressure reading issue the following query:

   @020? [ENTER]

If the transducer is open to the atmosphere and Torr is selected as the pressure units, the response will be:

@020   760 ENTER

Example 3: How To Calibrate the Null Value

Calibrating the 670 instrument involves two Global commands. First, use the set mode (01) command to select the calibration procedure. Second, issue the calibrate mode (03) command to actually perform the calibration procedure.

Note

1. The remote zero feature requires an additional step. Refer to page 95 for an example explaining how to use the remote zero feature.
2. The time required to complete a calibration procedure depends on the value of the averaging entry. Refer to Table 16, page 73, for more information.

1. Use the set mode command to select the null calibration procedure:

   @0102 ENTER

   The 670 instrument will return the same command to indicate that the command was accepted.

2. Send the calibrate mode (03) command to initiate the null calibration procedure:

   @030 ENTER

   The front panel will flash the message "CALIBRATING" during the null calibration procedure. The system will send back the same command to indicate that the command was accepted. It does *not* send notification when the calibration is complete.

3. Change the mode back to pressure by sending the command:

   @0100 ENTER

Channel-Specific Messages

The Channel-Specific messages, listed in Table 22, require the *id* entry to identify the channel:

@parameter *id data* ENTER

where	*id*	=	0 for Channel 1
		=	1 for Channel 2
		=	2 for Channel 3

Channel-Specific Messages			
Parameter Entry	**Action**	***Data* for a Command**	***Data* for a Request**
10	Display and Remote Reading Resolution	0 = 3.5 1 = 4.5 2 = 5.5	'?'
11	Response Time	0 = 1 msec 1 = 40 msec 2 = 400 msec	'?'
12	Enable Heater	0 = No (Off) 1 = Yes (On)	'?'
13	Pressure Unit	0 = Torr 1 = mmHg 2 = mbar 3 = Pa 4 = kPa 5 = psi 6 = inHg 7 = in H_2O 8 = cm H_2O 9 = % FS 10 = ppm 11 = mTorr	'?'
14	Temperature Compensation	ASCII number from 0 to 999 (500 disables the feature)	'?'
15	Sensor Full Scale	ASCII number	'?'
16	Number of Readings to Average	ASCII integer from 1 to 100	'?'

Table 22: RS-232 Channel-Specific Messages
(Continued on next page)

Channel-Specific Messages *(Continued)*			
Parameter Entry	**Action**	***Data* for a Command**	***Data* for a Request**
17	Gain Range Mode	0 = x1 1 = x0.1 2 = x0.01 3 = Auto	'?'
18	Enable Zero	0 = No (Off) 1 = Yes (On)	'?'
19	Heater Current	*Request Only*	'?'

Table 22: RS-232 Channel-Specific Messages

Example 1: How To Change the Pressure Units

To change the pressure units to psi on Channel 1, send the following command:

@1305 ENTER

The 670 instrument will return the same command to indicate that the command was accepted.

Example 2: How To Set the Display and Remote Reading Resolution

To set the display and remote reading resolution to 4.5 digits on Channel 1, send the command:

@1001 ENTER

The 670 instrument will return the same command to indicate that the command was accepted. The pressure reading, reported by the 020 command, will be in 4.5 digits.

Example 3: How To Set the Sensor Full Scale Value

Use the following command to set the sensor full scale to 0.1 Torr on Channel 2 (assuming that you have a 274 multiplexer connected to the 670 instrument):

@151.1 ENTER

The 670 instrument will return the same command to indicate that the command was accepted. The pressure reading will now reflect the new sensor full scale range.

Note

The 670 instrument will accept fractional entries with or without the leading zero. For example, you may enter either "@1510.1" or "@151.1" as the full scale value.

Example 4: How To Request the Heater Current

The enable heater (12) command allows you to toggle the transducer heater on or off. In addition, the 670 unit can report the percentage of power used. You cannot change the power consumption.

1. Issue the following command to turn on the transducer heater (assuming that you have a heated transducer connected to the 670 instrument) on Channel 1:

   @1201 ENTER

   The 670 instrument will return the same command to indicate that the command was accepted.

2. To determine the heater current send the command:

   @190? ENTER

   For example, if the heater current is at 55% of full power, the response will be:

   @19055 ENTER

Example 5: How To Use Averaging

The 670 instrument provides the capability to average multiple data points. You must issue the enable RS-232 averaging (04) command to use this feature for the RS-232 readings. Use the averaging period (16), to determine the number of points to average. Refer to *Averaging,* page 51, for a complete description of the averaging feature.

1. Issue the following command to enable RS-232 averaging on Channel 1:

   @0401 ENTER

2. To set the number of points to average to 10 on Channel 1, enter:

   @16010 ENTER

   The 670 instrument will return the same command to indicate that the command was accepted.

Note Be careful not to enter a decimal point in the number of points to average entry. The entry must be a *whole number*, from 1 to 100.

Example 6: How To Zero the 670 Instrument

Zeroing the 670 instrument involves two Group I commands and one Group II command. First, issue the enable remote zero (18) command to enable the zero operation. Second, use the set mode (01) command to select the calibration procedure. Third, send the calibrate mode (03) command to initiate the calibration procedure.

Note The time required to complete a calibration procedure depends on the value of the averaging entry. Refer to Table 16, page 73, for more information.

The following example will zero the transducer on Channel 1.

1. Issue the following command to enable the remote zero operation:

   @1801 ENTER

2. Use the set mode command to select the zero procedure:

   @0101 ENTER

   The 670 instrument will return the same command to indicate that the command was accepted and implemented.

3. Send the calibrate mode (03) command to initiate the zero procedure:

   @030 ENTER

   The front panel will flash the message "CALIBRATING" while the instrument performs the zero function. The system will send back the same command to indicate that the command was accepted. It does *not* send notification when the calibration is complete.

4. Change the mode back to pressure by sending the command:

   @0100 ENTER

Trip Point Messages

The Trip Point messages, listed in Table 23, require the <id> entry to identify the trip point:

@parameter *id data* ENTER

where: *id* = 0 for Trip Point A
= 1 for Trip Point B

Refer to *The [TRIP POINTS] Key,* page 54, for a complete description of the trip points.

Trip Point Messages			
Parameter Entry	**Action**	***Data* for a Command**	***Data* for a Request**
40	High Trip Point	ASCII number ranging from -105% to +105% of transducer full scale	‘?’
41	Low Trip Point	ASCII number ranging from -105% to +105% of transducer full scale	‘?’
42	Trip Point Hysteresis	ASCII number from 0 to 10 (used as a % of trip point value)	‘?’
43	Relay Normal Configuration	0 = De-energized 1 = Energized	‘?’
44	Trip Point Channel	0 = Channel 1 1 = Channel 2 2 = Channel 3	‘?’
45	Latch Mode	0 = Disabled 1 = Enabled	‘?’

Table 23: RS-232 Trip Point Messages

Example 1: How To Configure the Trip Point Values

1. To set the trip point high value for TP A to 900, issue the following command:

   @400900 ENTER

   The 670 instrument will return the same command to indicate that the command was accepted and implemented.

2. To set the trip point low value for TP A to 450, issue the following command:

   @410450 ENTER

Example 2: How To Set the Trip Point Hysteresis

The hysteresis value is defined as a ± percent of the trip point value and can range from 0 to 10%. Refer to *How To Adjust Hysteresis*, page 78, for a complete discussion of hysteresis.

To set the hysteresis value for TP B to 0.1%, enter:

@421.1 [ENTER]

The 670 instrument will return the same command to indicate that the command was accepted.

Note The 670 instrument will accept fractional entries with or without the leading zero. For example, you may enter either “@4210.1” or “@421.1” as the hysteresis value.

Example 3: How To Set the Trip Point Channel

To set the trip point channel for TP A to Channel 3 (assuming that you have a 274 multiplexer connected to the 670 instrument):

@4402 [ENTER]

The 670 instrument will return the same command to indicate that the command was accepted.

Note The 670 instrument allows you to select Channels 2 and 3 even if the 670 is *not* connected to a 274 multiplexer. This enables you to configure the 670 instrument in one location and then insert it into a system with a 274 multiplexer, without modification.

Diagnostic Messages

The Diagnostic messages, listed in Table 24, consist of one command (80) to provide diagnostic information. The <id> field identifies the diagnostic information requested.

Diagnostic Messages			
Parameter Entry	*Id*	*Data*	**Response**
80	0 = Request Answer Back	?	*U*U*U (produces an alternating bit pattern)
	1 = Request Version Number	?	Version number
	2 = I/O Connector Response	8-bit output image ?	Produces the 8-bit output image at the I/O connector 16-bit input image
	3 = Report Actual Gain Range	?	0 = x1 1 = x 0.1 2 = x 0.01

Table 24: RS-232 Diagnostic Messages

Example 1: How To Check the Version Number

To check the version number, send the following query:

@801? ENTER

The 670 instrument will respond with:

`@801X.X`

where `X.X` represents the actual version number.

Example 2: How To Test the Output Signals on the I/O Connector

This diagnostic test allows you to set the values of the output signals on the I/O connector. Use a voltmeter to read the value of the signals at the connector to detect any problem. This command controls the 8 outputs on the I/O connector. Table 25 lists the output bit number assignments and the bit values. To determine the connector value, add the bit values of the bits you wish to pull low. A value of 255 will set all the outputs low. Enter the connector value as the <data> field in the command string.

1. Calculate the connector value by adding the value of the bits you wish to pull low, in this case bits 3 (Channel 1 selected) and 5 (x1 range):

   4 + 16 = 20 ← Connector value

   Value of bit 3 Value of bit 5

2. Issue the following command:

   @80220 ENTER

3. Use a voltmeter to measure the output signals on pins 29 and 23 of the I/O connector. Each pin should be close to 0.00 V.

I/O Connector Output Bit Number Assignments			
Diagnostic Output Bit Number	**Bit Value**	**Function**	**I/O Pin Number**
1	1	Not Used	—
2	2	Not Used	—
3	4	$\overline{\text{Select Channel 1}}$ *	29
4	8	$\overline{\text{Select Channel 2}}$ *	28
5	16	$\overline{\text{x1 Range ID}}$	23
6	32	$\overline{\text{x0.1 Range ID}}$	19
7	64	$\overline{\text{x0.01 Range ID}}$	18
8	128	Reserved	17
* *The 274 multiplexer uses these pins select the active channel. Both pins 28 and 29 high when Channel 3 is the active channel.*			

Table 25: I/O Connector Output Bit Assignment

Example 3: How To Read the Input Signals on the I/O Connector

This diagnostic command (802) allows you to read the input signals on the I/O connector. To perform this diagnostic test you will need to configure each input so you know the bit value of the connector. The I/O connector has 16 inputs. Table 26, page 101, lists the input bit number assignments and the bit values. A value of 65535 indicates that all the inputs are high. To determine the connector value, add the bit values of the bits you wish to pull low, and subtract that value from 65535.

1. Connect bit 7 (I/O pin 24) and bit 15 (I/O pin 10) to digital ground (I/O pin 4) to pull the inputs low.

2. To determine the value of the inputs read by the 670 instrument, issue the query:

   @802?

3. The 670 instrument will respond with:

   `@80249087`

   To determine whether bits 7 and 15 are low, subtract the value of each bit from the total value of the connector:

   65535 - (64 + 16384) = 49087 ← Value returned by the 670 instrument

   Connector value when all bits are high

   Value of bit 7

   Value of bit 15

   The value returned by the 670 instrument indicates that bits 7 and 15 are low.

I/O Connector Input Bit Number Assignments			
Diagnostic Input Bit Number	**Bit Value**	**Function**	**I/O Pin Number**
1	1	$\overline{\text{10K}}$	27
2	2	$\overline{\text{1K}}$	8
3	4	$\overline{\text{100}}$	26
4	8	$\overline{\text{10}}$	7
5	16	$\overline{\text{1}}$	25
6	32	$\overline{\text{0.1}}$	6
7	64	$\overline{\text{x0.1 Select}}$	5
8	128	$\overline{\text{x0.01 Select}}$	24
9	256	$\overline{\text{Channel 1 ID}}$	16
10	512	$\overline{\text{Channel 2 ID}}$	15
11	1024	$\overline{\text{Channel 3 ID}}$	14
12	2048	Reserved	13
13	4096	$\overline{\text{Remote Zero}}$	12
14	8192	Reserved	11
15	16384	$\overline{\text{Latch TP A}}$	10
16	32768	$\overline{\text{Latch TP B}}$	9

Table 26: I/O Connector Input Bit Assignment

Example 4: How To Determine the Actual Range Used

This message enables you to query the 670 instrument for the actual range in use. This may be useful when the 670 instrument is configured for autoranging. (The Channel-Specific query for the range will simply return “Auto” when the instrument is in autoranging.) Additionally, the 670 instrument changes the range during some calibration procedures so the actual range may differ from the range you selected. Once the calibration procedure is complete, it will return to the range selected before the calibration procedure was initiated.

This example assumes that the active range is x0.1.

- To check the actual range, send the following query:

  @803? ENTER

  The 670 instrument will respond with:

  `@8031`

  to indicate an active range of x0.1.

Chapter Seven: IEEE-488 Communications Option

General Information

Note The information in this chapter only applies if your 670 instrument is configured with the IEEE-488 Communications option. If your 670 instrument is configured with the RS-232 communication option, refer to *Chapter Six, RS-232 Communications Option*, page 85, for remote communications information.

The IEEE-488 communications option complies with the ANSI/IEEE Standard 488.2 - 1992 (this standard encompasses the ANSI/IEEE Standard 488.1 - 1987).

Key Lock Switch

To configure the 670 instrument to accept commands issued through IEEE-488 communications, place the Key Lock switch, located on the front panel, in the REMOTE position. While operating the 670 instrument in the REMOTE mode, the front panel controls are locked out and the display shows status information only. The 670 instrument expects to receive commands and instructions through the IEEE-488 communications or through the rear panel connectors. When the Key Lock switch is in the LOCAL position, the 670 instrument behaves in the opposite manner — it accepts commands from the front panel only and ignores commands issued by IEEE-488 communications or the rear panel connectors. Only status information is available through IEEE-488 communications.

Figure 6, page 31, shows the location of the Key Lock switch.

IEEE-488 Device Compliance

Refer to Table 27 for a description of the IEEE-488 device compliant functions.

IEEE-488 Device Compliance		
Function	**Command**	**Compatibility**
Source Handshake	SH1	Complete
Acceptor Handshake	AH1	Complete
Talker	T6	Talker, serial poll and unaddress if my-listener-address (MLA)
Listener	L4	Listener and unaddress if my-talker-address (MTA)
Service Request	SR1	Can request (asynchronously) service from controller
Remote Local	RL0	No capability for lockout
Parallel Poll	PP0	No capability to send message without being addressed to talk
Device Clear	DC1	Complete
Device Trigger	DT0	No Capability
Controller	C0	Does not have the capability to send commands or addresses to other devices
Talker	TE0	Talker function with address extension not available
Listener	LE0	Listener function with address extension not available
Electrical Interface	E1	Open collector
All the functions listed in this table are bus functions		

Table 27: IEEE-488 Device Compliance

Buffer Length

The buffer length is fixed at 256 characters.

Address

Every device on the IEEE-488 bus must have an address assigned to it. To set the address of 670 instrument, scroll to the IEEE-488 configuration screen, under the [SETUP] key menu. The address entry ranges from 1 to 30. The 670 instrument is initially configured with the address set to 8.

Status Information

The 670 instrument uses two software registers (defined by IEEE-488.2) to provide status information. The registers are the Standard Event Status register and the Status Byte register. The relationship of the registers is shown in Figure 17.

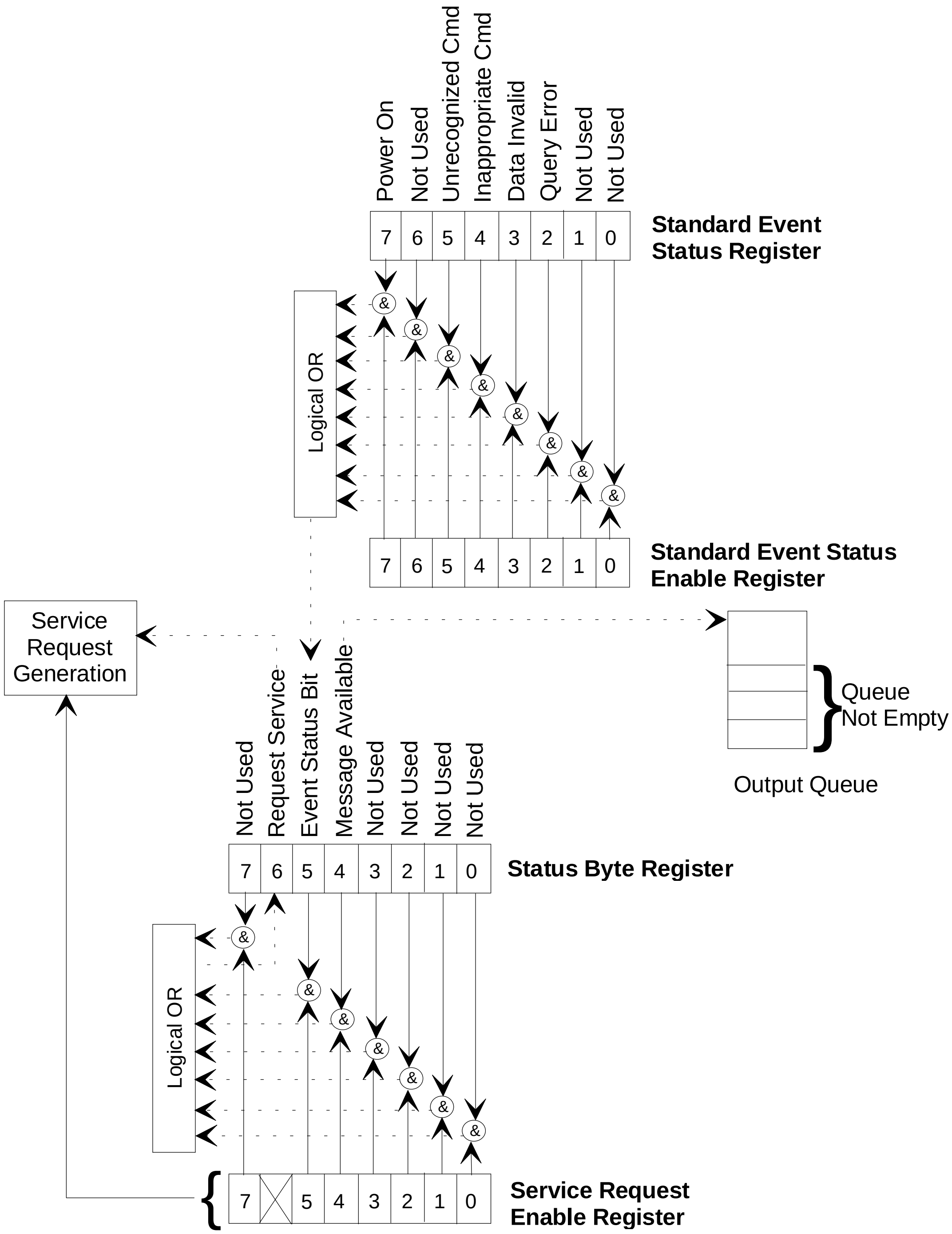


Figure 17: IEEE-488 Registers

Standard Event Status Register

This register contains status information on the last communication (command) sent to the controller. The 670 instrument updates this register each time it receives a command.

Table 28 describes the function of this register.

Standard Event Status Register	
Bit Number	**Function**
7	Power On *Always set (value of 1) when the 670 unit is powered on*
6	Not Used*
5	Unrecognized Command
4	Inappropriate Command
3	Data Invalid
2	Set when query received and previous query not read
1	Not Used*
0	Not Used*
** Will read as 0*	

Table 28: Standard Event Status Register

Standard Event Status Register Query (*ESR?)

Use this command to query the Standard Event Status register. If there is an error, this register may indicate what *type* of error has occurred.

Status Byte Register

The Status Byte register contains information on the status of the 670 instrument. Bits 6, 5, and 4 are defined by IEEE-488.2. The information is useful to check the status of the instrument. To read the Status Byte register, issue the "*STB?" command. Refer to Table 29 for a description of this register.

Status Byte Register	
Bit Number	**Function**
B7	Not Used*
B6	Master Summary Status bit. Set when service requested
B5	Set if Event Status Bit is set. Read Standard Event Status Register for status.
B4	Message available/Output Queue Not Empty
B3	Not Used*
B2	Not Used*
B1	Not Used*
B0	Not Used*
**Will read as 0*	

Table 29: Status Byte Register

*Read Status Byte Register Query (*STB?)*

This command queries the status of the Status Byte register and the Master Summary Status bit (bit 6). The value of this register is placed in the output queue of the 670 instrument.

Generating a Service Request

The 670 instrument can generate a Service Request (SRG) based on the status of the registers described above. A SRG alerts the host computer that the 670 instrument has encountered an error condition. To enable the 670 instrument to send a SRG, you must configure two enable registers: the Service Request Enable register (SRE) and the Standard Event Status Enable register (ESE). You can only read the status information of bits that have been enabled.

Commands for the Enable Registers		
Enable Register	**Command to Set the Value**	**Command to Query the Value**
Service Request Enable	"*SRE*data*"	"*SRE?"
Standard Event Status Enable	"*ESE*data*"	"*ESE?"

Table 30: Commands for the Enable Registers

To Set the Value the Service Request Enable Register

The "*SRE*data*" command sets the value of the Service Request Enable register. For all bits except bit 6, a 1 indicates an enabled condition, and a 0 indicates a disabled condition. Bit 6 is not active and will always be 0.

To Set the Value the Standard Event Status Enable Register

The "*ESE*data*" command sets the bits in the Standard Event Status Enable register. To clear the register, send the *ESE command with a data value of 0, or cycle the power to the 670 instrument. The bits in this register are "enable" or "mask" bits for the Standard Event Status register. Setting a bit allows that bit (or status) to set a bit in the Status Byte register, listed in Table 29, page 107 (provided that B5 is set in the Service Request Enable).

IEEE-488 Messages

The 670 instrument supports standard IEEE-488 messages, along with the MKS device dependent messages. The messages include both *commands* that instruct the 670 instrument to perform a task, and *queries* that request information from the 670 instrument.

Note The IEEE-488 messages are *not* case sensitive. You may enter the commands in either upper- or lowercase.

Clear Status Command (*CLS)

The CLS command clears all status data structures and/or registers. The registers are SESR, OPERation Status Register, QUEStionable Status Register, and Error/Event Queue.

Operation Complete Messages

The operation complete messages determine the status of an instrument, whether it is performing a task or idle.

*Operation Command (*OPC)*

The operation complete command is ignored since the 670 instrument executes only one command at a time.

*Operation Complete Query (*OPC?)*

Since the 670 instrument executes only one command at a time the response to an operation complete query is always complete and the query will return a value of 1.

Wait-to-Continue Command (*WAI)

The Wait-to-Continue command functions like a “no operation” command in the 670 instrument. The normal function of this command causes the instrument to stop executing commands until either the “no operation pending” state is true, or the 670 instrument is rebooted, or a Device Clear Active State (DCAS) message is received. Since the 670 instrument always processes messages sequentially, the “no operation pending” state is always true.

Identification Query (*IDN?)

The 670 instrument identifies itself in response to an identification query. The response includes the four fields listed in Table 31.

Identification Query Response		
Field	**Information**	**Contents**
1	Manufacturer	MKS Instruments
2	Model Number	MKS670BXXX
3	Reserved field	0
4	Firmware Level	x.x

Table 31: Identification Query Response

Example: How To Check the Version Number

- To check the version number, send the following command:

  ***IDN?** ENTER

  The 670 instrument will respond with:

  `MKS Instruments MKS670BXXX 0 1.1x`

  where XXX represents the model number, and the last field contains the actual version number, in this example, version 1.1x.

Reset Command (*RST)

The reset command initializes to the 670 instrument. The initialization procedure includes Bus initialization and Message Exchange initialization. The reset command does not change the IEEE-488 address.

Self-Test Query (*TST?)

The self-test query performs an internal self-test and places a response in the Output queue to indicate whether the 670 instrument detected any errors during the self-test. A value of 0 is placed in the output queue when the self-test is completed successfully. A value of 1 indicates that the self-test has failed.

MKS Device Dependent Messages

The IEEE-488 remote communications option allows you to operate the 670 instrument from an external IEEE-488 device, such as a computer equipped with a IEEE-488 communications board.

The messages are divided into *commands* that instruct the 670 instrument to perform a function or change a parameter, and *queries* that request information from the 670 instrument.

Responses sent by the 670 instrument reply to a query sent by the external IEEE-488 device. The 670 instrument does *not* send an acknowledgment message when it receives a command.

The device dependent commands are separated into four categories: global configuration commands, channel-specific configuration commands, trip point commands, and diagnostic commands.

Note

1. The MKS device dependent messages are *not* case sensitive. You may enter the messages in either upper- or lowercase.
2. The 670 instrument does not send an acknowledgment message when it receives a command. This differs from the RS-232 protocol.

Command Syntax

The commands and queries listed in this section use the following typographical conventions:

bold	Messages that you must enter exactly as shown in the manual. The 670 instrument ignores any spaces included in the message string.
italics	Placeholder that represents text of numeric values that you must supply.
`response`	Format of messages sent from the 670 instrument in response to a query.
ENTER	Represents the message termination character(s) that you may have to enter at the end of each message string. Normally, GPIB interface software programs expect a carriage return and line feed to indicate the end of a message. The GPIB message termination requirements are defined in the IEEE488.2 specification.

Note

In general, the format for a query is the same as the command to set the entry, except that the value is replaced by a "?".

Shortcut Commands and Queries

The 670 instrument message protocol adheres to the format defined by Standard Commands for Programmable Instruments (SCPI) protocol although the commands and queries may not specifically meet the standards. This format allows you to enter either the entire message string or a shortcut version of the string. The following tables show both the full and the shortcut message string.

Global Configuration Messages

The Global configuration messages include commands that define the operation of the 670 instrument and queries that request the status of a particular entry. These commands configure operating parameters that are used for all channels.

Global Messages	
Function	**Message**
Set the Active Channel	
Command Shortcut command	**:route:close(@** *chan #*) **:rout:clos(@** *chan #*)
	where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3
Query Shortcut query	**:route:close?** **:rout:clos?**
Set the Mode	
Command Shortcut command	:**sense:function** *mode* **:sens:func** *mode*
	mode equals (shortcut entry in parentheses): pressure (pres) zero syscheck (sysc) null fulscale (fuls)
Query Shortcut query	**:sense:function?** **:sens:func?**
Report Reading	
Command Shortcut command	:**measure:function** **:meas:func**
No query necessary	The 670 will report the reading in response to this command.

Table 32: IEEE-488 Global Messages

(Continued on next page)

Global Messages *(Continued)*	
Function	**Message**
Perform a Calibration Command Shortcut command	 **:calibrate:function** **:cali:func**

Table 32: IEEE-488 Global Messages

Example 1: How To Set the Active Channel

To set the active channel to Channel 2 (assuming you have a 274 multiplexer connected), send the command:

:route:close(@2) ENTER

Channel 2 will become the active channel and its front panel LED will illuminate.

Example 2: How To Request the Pressure Reading

When using the 670 unit with a single transducer, the response to the report reading command will report data from Channel 1. If you are using the 670 unit with a 274 multiplexer, the response to the report reading command will report data from the active channel. Be sure that the active channel is the channel whose data you want *before* sending the report reading command.

1. To read the pressure on Channel 1, you must first send a command to set the 670 instrument in the pressure reading mode:

   :sense:function pressure ENTER

2. To request the pressure reading, issue the following command:

   :measure:function ENTER

   If the transducer is open to the atmosphere and Torr is selected as the pressure units, the response will be:

```
measuring 760 <CR LF>
```

Example 3: How To Calibrate the Null Value

Calibrating the 670 instrument involves two steps. First, use the set mode command to select the calibration procedure. Second, issue the command to perform the calibration function to actually initiate the calibration procedure.

Note

1. The zero feature requires an additional step. Refer to *Channel-Specific Messages,* page 115, for an example explaining how to use the zero feature.
2. The time required to complete a calibration procedure depends on the value of the averaging entry. Refer to Table 16, page 73, for more information.

1. Use the set mode command to select the null calibration procedure:

   :sense:function null ENTER

2. Send the perform calibration command to initiate the null calibration procedure:

   :calibrate:function ENTER

   The front panel will flash the message "CALIBRATING" during the null calibration procedure. *Table 16: Relationship Between Averaging Entry and Calibration Times,* page 73, lists the approximate time for the null calibration.

3. Read the contents of the buffer to determine when the calibration is complete.

4. Change the mode back to pressure by sending the command:

   :sense:function pressure ENTER

Channel-Specific Messages

The Channel-Specific messages define the operation of a single channel on the 670 instrument. Channel 1 is always accessible. When the 670 instrument is connected to a 274 multiplexer, Channels 2 and 3 are accessible and should be configured. The queries cause the 670 instrument to report on the status of a particular entry.

In all the Channel-Specific messages, the channel number is shown as *chan #* . Enter the channel number as:

1 for Channel 1
2 for Channel 2
3 for Channel 3

Channel-Specific Messages	
Function	**Message**
Display and Remote Reading Resolution	
Command Shortcut command	**:sense:scan(@***chan #***):digit** *display resolution* **:sens:scan(@***chan #***):digi** *display resolution*
Query Shortcut query	**:sense:scan(@***chan #***):digit?** **:sens:scan(@***chan #***):digi?**
	where *chan #* equals 1, 2, or 3
	where *display resolution* equals: 3.5 for 3.5 digit display and reading response 4.5 for 4.5 digit display and reading response 5.5 for 5.5 digit display and reading response
Response Time	
Command Shortcut command	**:sense:scan(@***chan #***):filter** *response time* **:sens:scan(@***chan #***):filt** *response time*
Query Shortcut query	**:sense:scan(@***chan #***):filter?** **:sens:scan(@***chan #***):filt?**
	where *chan #* equals 1, 2, or 3
	where *response time* equals: 1MS for 1 millisecond 40MS for 40 millisecond 400MS for 400 millisecond

Table 33: IEEE-488 Channel-Specific Messages
(Continued on next page)

Channel-Specific Messages *(Continued)*	
Function	**Message**
Enable Heater Command Shortcut command Query Shortcut query	 **:route:control:heater(@***chan #***)** *State* **:rout:cont:heat(@***chan #***)** *State* **:route:control:heater(@***chan #***)?** **:rout:cont:heat(@***chan #***)?** where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3 where *State* equals: ON for On or enabled OFF for Off or disabled
Report Heater Current Command Shortcut command	 **:measure:heater (@***chan #***)** **:meas:heat (@***chan #***)** where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3 The 670 instrument will report the percentage of power used by the heater. (It does not require a query message.)
Temperature Compensation Command Shortcut command Query Shortcut query	 **:calculate:scan(@***chan #***):temcomp** *value* **:calc:scan(@***chan #***):temc** *value* **:calculate:scan(@***chan #***):temcomp?** **:calc:scan(@***chan #***):temc?** where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3 *value* is an ASCII number between 0 and 999, inclusive (value of 500 disables the feature)

Table 33: IEEE-488 Channel-Specific Messages
(Continued on next page)

Channel-Specific Messages *(Continued)*	
Function	**Message**
Zero Enable	
Command Shortcut command	**:sense:scan(@***chan #***):zero** *state* **:sens:scan(@***chan #***):zero** *state*
Query Shortcut query	**:sense:scan(@***chan #***):zero?** **:sens:scan(@***chan #***):zero?**
	where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3
	where *state* equals: ON (enabled) OFF (disabled)
Set Pressure Unit	
Command Shortcut command	**:sense:scan(@***chan #***):puni** *pressure unit* **:sens:scan(@***chan #***):puni** *pressure unit*
Query Shortcut query	**:sense:scan(@***chan #***):puni?** **:sens:scan(@***chan #***):puni?**
	where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3
	where *pressure unit* equals: TORR (for Torr) MMHG (for mmHg) MBAR (for mbar) PA (for Pa) KPA (for kPa) PSI (for psi) INHG (for inHg) INH2 (for inH_2O) CMH2 (for cmH_2O) PREC (for percent F.S.) PPMF (for ppm) MTOR (for mTorr)
	The response is in uppercase and contains the first four characters only. For example, inH_2O is reported as INH2.

Table 33: IEEE-488 Channel-Specific Messages
(Continued on next page)

Channel-Specific Messages *(Continued)*	
Function	**Message**
Sensor Full Scale	
Command Shortcut command	**:sense:scan(@***chan #***):range** *value* **:sens:scan(@***chan #***):rang** *value*
Query Shortcut query	**:sense:scan(@***chan #***):range?** **:sens:scan(@***chan #***):rang?**
	where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3
	where *value* is an ASCII number
Set Averaging	
Command Shortcut command	**:calculate:scan(@***chan #***):average** *value* **:calc:scan(@***chan #***):aver** *value*
Query Shortcut query	**:calculate:scan(@***chan #***):average?** **:calc:scan(@***chan #***):aver?**
	where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3
	where *value* is an ASCII number from 1 to 100, inclusive
	Note: An averaging entry of 1 effectively disables the averaging feature.

Table 33: IEEE-488 Channel-Specific Messages
(Continued on next page)

Channel-Specific Messages *(Continued)*	
Function	**Message**
Gain Range	
Command Shortcut command	**:sense:scan(@***chan#***):gain** *value* **:sens:scan(@***chan#***):gain** *value*
Query Shortcut query	**:sense:scan(@***chan#***):gain?** **:sens:scan(@***chan#***):gain?**
	where *chan #* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3
	where *value* equals X1, X0.1, X0.01, or Auto

Table 33: IEEE-488 Channel-Specific Messages

Example 1: How To Change the Pressure Units

To change the pressure units to psi on Channel 1, send the following command:

:sense:scan(@1):puni psi ENTER

Example 2: How To Set the Display and Remote Reading Resolution

To set the display and remote reading resolution to 4.5 digits on Channel 1, send the command:

:sense:scan(@1):digit 4.5 ENTER

The 670 instrument will return the same command to indicate that the command was accepted. The pressure reading, reported by the ":measure:function" command, will be in 4.5 digits.

Example 3: How To Set the Sensor Full Scale Value

Use the following command to set the sensor full scale to 0.1 Torr on Channel 2 (assuming that you have a 274 multiplexer connected to the 670 instrument):

:sense:scan(@2):range 0.1 ENTER

The pressure reading will now reflect the new sensor full scale range.

Note

The 670 instrument will accept fractional entries with or without the leading zero. For example, you may enter either "0.1" or ".1" to set the full scale range.

Example 4: How To Request the Heater Current

The enable heater command allows you to toggle the transducer heater on or off. In addition, it will report the percentage of power used (when enabled). You cannot change the value.

1. Issue the following command to enable the transducer heater (assuming that you have a heated transducer connected to the 670 instrument) on Channel 1:

   :route:control:heater(@1) on ENTER

2. To determine the heater current send the command:

   :measure:heater(@1) ENTER

   For example, if the heater current is at 55% of full power, the message will be:

   `55 <CR LF>`

Example 5: How To Zero the 670 Instrument

Zeroing the 670 instrument involves one channel-specific command and two global configuration commands. First, issue the channel-specific command to enable the zero operation. Second, use the global configuration command, set mode, to select the calibration procedure. Third, send the command to perform the calibration to initiate the calibration procedure.

Note The time required to complete a calibration procedure depends on the value of the averaging entry. The values are listed in Table 16, page 73.

The following example will zero the transducer on Channel 1.

1. Issue the zero enable command to enable the zero operation:

   :sense:scan(@1):zero on ENTER

2. Use the set mode command to select the zero procedure:

   :sense:function zero ENTER

3. Send the perform calibration mode command to initiate the zero procedure:

   :calibrate:function ENTER

   The front panel will flash the message "CALIBRATING" while the instrument performs the zero function. *Table 16: Relationship Between Averaging Entry and Calibration Times,* page 73, lists the approximate time for the zero calibration.

4. Change the mode back to pressure by sending the command:

   :sense:function pressure ENTER

Trip Point Messages

The Trip Point messages define the trip point values, both high and low, the initial state of the trip point relays, and the hysteresis values. Refer to *The [TRIP POINTS] Key*, page 54, for a complete description of the trip points.

Trip Point Messages	
Function	**Message**
Trip Point High Value	
Command Shortcut command	**:control:relay** *A or B***:high** *TP value* **:cont:rela** *A or B***:high** *TP value*
	where *TP value* a number between ±105% of full scale
Query: Shortcut query:	**:control:relay** *A or B***:high?** **:cont:rela** *A or B***:high?**
Trip Point Low Value	
Command Shortcut command	**:control:relay** *A or B***:low** *TP value* **:cont:rela** *A or B***:low** *TP value*
	where *TP value* a number between ±105% of full scale
Query: Shortcut query:	**:control:relay** *A or B***:low?** **:cont:rela** *A or B***:low?**
Hysteresis Value	
Command Shortcut command	**:control:relay** *A or B***:hyst** *value* **:cont:rela** *A or B***:hyst** *value*
	where *value* is a ± percent of the trip point, from 0 to 10% (applied to the trip point value)
Query: Shortcut query:	**:control:relay** *A or B***:hyst?** **:cont:rela** *A or B***:hyst?**
Trip Point Normal State	
Command Shortcut command	**:control:relay** *A or B***:norm** *state* **:cont:rela** *A or B***:norm** *state*
	where *state* equals: ener for energized dent for de-energized
Query: Shortcut query:	**:control:relay** *A or B***:norm?** **:cont:rela** *A or B***:norm?**

Table 34: IEEE-488 Trip Point Messages
(Continued on next page)

Trip Point Messages (*Continued*)	
Function	**Message**
Trip Point Channel Command Shortcut command Query: Shortcut query:	**:control:relay** *A or B***:trip (@** *tp chan***)** **:cont:rela** *A or B***:trip (@** *tp chan***)** **:control:relay** *A or B***:trip?** **:cont:rela** *A or B***:trip?** where *tp chan* equals: 1 for Channel 1 2 for Channel 2 3 for Channel 3
Latch Mode Command Shortcut command Query: Shortcut query:	**:control:relay** *A or B***:latch** *state* **:cont:rela** *A or B***:latch** *state* **:control:relay** *A or B***:latch?** **:cont:rela** *A or B***:latch?** where *state* equals: enab for enabled disa for disabled

Table 34: IEEE-488 Trip Point Messages

Example 1: How To Configure the Trip Point A Value

To set the TP A high value to 900, issue the following command:

:control:relay a:high 900 ENTER

Example 2: How To Set the Trip Point Hysteresis

The trip point hysteresis value is defined as a ± percent of the trip point value and can range from 0 to 10%. Refer to *How To Adjust the Hysteresis,* page 78, for more information.

To change the hysteresis value to 2% for TP B, enter:

:control:relay b:hyst 2 ENTER

Note

The 670 instrument will accept fractional entries with or without the leading zero. For example, you may enter either “0.1” or “.1” to set the hysteresis value.

Example 3: How To Set the Trip Point Channel for Trip Point A

To set TP A channel to Channel 1, issue the following command:

:control:relay a:trip (@1) ENTER

Example 4: How To Set the Latch Mode for Trip Point A

To enable the latch mode for TP B, issue the following command:

:control:relay b:latch enab ENTER

Diagnostic Messages

The Diagnostic messages help to troubleshoot a problem with the 670 instrument. The messages in this category enable you to read the value of the input bits and define the value of the output bits on the I/O connector.

Diagnostic Messages	
Function	**Message**
Set the Output Bits on the I/O Connector	
Command	**:cont:out** *value* Refer to Table 25, page 99, for a list of the I/O connector output pins.
Read the Value of the Input Bits on the I/O Connector	
Query	**:cont:in?** where *value* is an ASCII number from 0 to 65535(16 bits) Refer to Table 26, page 101, for a list of the I/O connector input pins.

Table 35: IEEE-488 Diagnostic Messages

Example 1: How To Test the Output Signals on the I/O Connector

This diagnostic test allows you to set the values of the output signals on the I/O connector. Use a voltmeter to read the value of the signals at the connector to detect any problem. This command controls the 8 outputs on the I/O connector. Table 25, page 99, lists the output pins, the output bit number assignments, and the bit values. To determine the connector value, add the bit values of the bits you wish to pull low. A value of 255 will set all the outputs low. Enter the connector value as the <data> field in the command string.

1. Calculate the connector value by adding the value of the bits you wish to pull low, in this case bits 3 (Channel 1 selected) and 5 (x1 range):

   4 + 16 = 20 ← Connector value

   Value of bit 3 Value of bit 5

2. Send the following command:

   :cont:out 20 ENTER

3. Use a voltmeter to measure the output signals on pins 29 and 23 of the I/O connector. Each pin should be close to 0.00V.

Example 2: How To Read the Input Signals on the I/O Connector

To perform this diagnostic test you will need to configure each input so you know the bit value of the connector. The I/O connector has 16 inputs. Table 26, page 101, lists the input bit number assignments and their bit values. A value of 65535 indicates that all the inputs are high. To determine the connector value, add the bit values of the bits you wish to pull low, and subtract that value from 65535.

1. Connect bit 7 (I/O pin 24) and bit 15 (I/O pin 10) to digital ground (I/O pin 4) to pull the inputs low.

2. To determine the value of the inputs read by the 670 instrument, issue the query:

   :cont:in?

3. The 670 instrument will respond with:

   ```
   40987 <CR LF>
   ```

   To determine whether bits 7 and 15 are low, subtract the value of each bit from the total value of the connector:

   65535 - (64 + 16384) = 49087 ← Value returned by the 670 instrument

   Connector value when all bits are high — Value of bit 7 — Value of bit 15

   The value returned by the 670 instrument indicates that bits 7 and 15 are low.

This page intentionally left blank.

Chapter Eight: Maintenance and Troubleshooting

General Information

Periodically check for wear on the cables and inspect the enclosure for visible signs of damage. The only maintenance required on the 670 instrument is to change the fuses.

How To Clean the Unit

Periodically wipe down the unit with a damp cloth. Do not use any solvents to clean the unit.

How To Replace the Fuses

To replace the fuses:

1. Select the proper fuses.

   All units have two fuses installed to *fuse both sides* of the line. The fuse values, marked on the rear panel, are:

   - 100 to 120 VAC = 0.63 Amperes Time-Lag Type
   - 200 to 240 VAC = 0.315 Amperes Time-Lag Type

   Refer to Table 36 for a description of the fuses. To change the line voltage selection, refer to *How To Change the Line Voltage Selection*, page 82.

Fuses for the Type 670 Instrument		
Voltage Selector Setting	**Nominal Line Voltage Range**	**Fuse Type**
115 VAC	100 to 120 VAC @50/60 Hz 75 VA (max)	0.63A (T), 250 V, 5 x 20 mm
230 VAC	200 to 240 VAC @50/60 Hz 75 VA (max)	0.315A (T), 250 V, 5 x 20 mm

Table 36: Fuses for the Type 670 Instrument

Note

The fuses are IEC rated (where the name plate value is the expected current *carrying* rating) and not UL or CSA rated (where the name plate value is nearly the current *blowing* rating). Use of UL or CSA rated fuses will cause unnecessary blowing at high loads.

Appropriate replacement fuses include:

- Bussmann GDC-T315 mA or equivalent for the 0.315 A fuse
- Bussmann GDC-T630 mA or equivalent for the 0.63 A fuse

2. Disconnect the power cord from the 670 instrument.

Warning **To avoid an electrical shock, be sure to disconnect the power cord *before* proceeding.**

3. Disconnect all cables from the connectors located on the back of the unit.
4. Insert a small, flat head screw driver under one side of the black fuse holder, then the other, to disengage the fuse holder.

   The fuse holder will slide partially out of the instrument.
5. Carefully slide the fuse holder out and remove the fuse.
6. Insert the new fuse into the fuse holder.

   Be certain that the new fuse is the appropriate type for the line voltage selection.
7. Slide the fuse holder back into the Power Entry module.

   Be sure to snap the fuse holder completely into the instrument.
8. Connect any cables removed from the back of the 670 instrument in step 3 above.
9. Connect the power cord.

Troubleshooting

This section describes the most common problems encountered with the 670 instrument and offers possible solutions.

Note If possible, substitute another similar instrument to verify that the problem involves the 670 instrument *before* proceeding.

Noisy Pressure Reading

- Verify that all cable connections on the 670 instrument are screwed in securely.
- Check the pressure system to ensure that all connections are tight.
- Isolate any mechanical vibration from the pressure transducer with bellows.
- Use the averaging feature to average multiple pressure readings.

  Refer to *Averaging,* page 51, for discussion of the averaging feature.
- Use cables designed for high EMI environments.

Trip Point Relays Change State Erratically

- Verify that all connections are tight.
- Verify that the High and Low values are entered correctly for each trip point.

  Refer to *How To Configure the Trip Points,* page 75, for more information.
- Check the hysteresis value.

  Refer to *How To Adjust Hysteresis,* page 78, for an explanation of the hysteresis entries.

Overrange (>10.5 Volts) Pressure Readings

1. Verify that all vacuum fittings are tight and that the transducer is properly pumped down below its resolution.

   Low range absolute transducers (100 mmHg and below) will be overranged at atmospheric pressure.

2. Connect another meter, either analog or digital, to the output to verify that the display of the 670 instrument is operating correctly.

3. Press the [SETUP] key on the front panel of the 670 instrument.

   The system responds by displaying the setup parameters.

4. Repeatedly press an arrow key, ([△] or [▽]), until the pressure units screen appears.

5. Use the Adjust knob to select mmHg as the pressure units.

6. Press the [CAL] key to enter the calibration screen.

7. Press an arrow key, ([△] or [▽]), until the system check screen appears.

```
Ch 1              9.8799 Volts
         SYSCHK
```

   The SYSCHK reading should be between 9.5 and 10.5 Volts. A SYSCHK value outside this range, indicates a problem with the pressure transducer or its cable.

8. Perform the steps outlined in the flow chart in Figure 18, page 132.

Troubleshooting Chart

Before continuing to use the troubleshooting chart, verify that all vacuum fittings are tight and that the transducer is properly pumped down below its resolution. Low range absolute transducers (100 mmHg and below) will be overranged at atmospheric pressure.

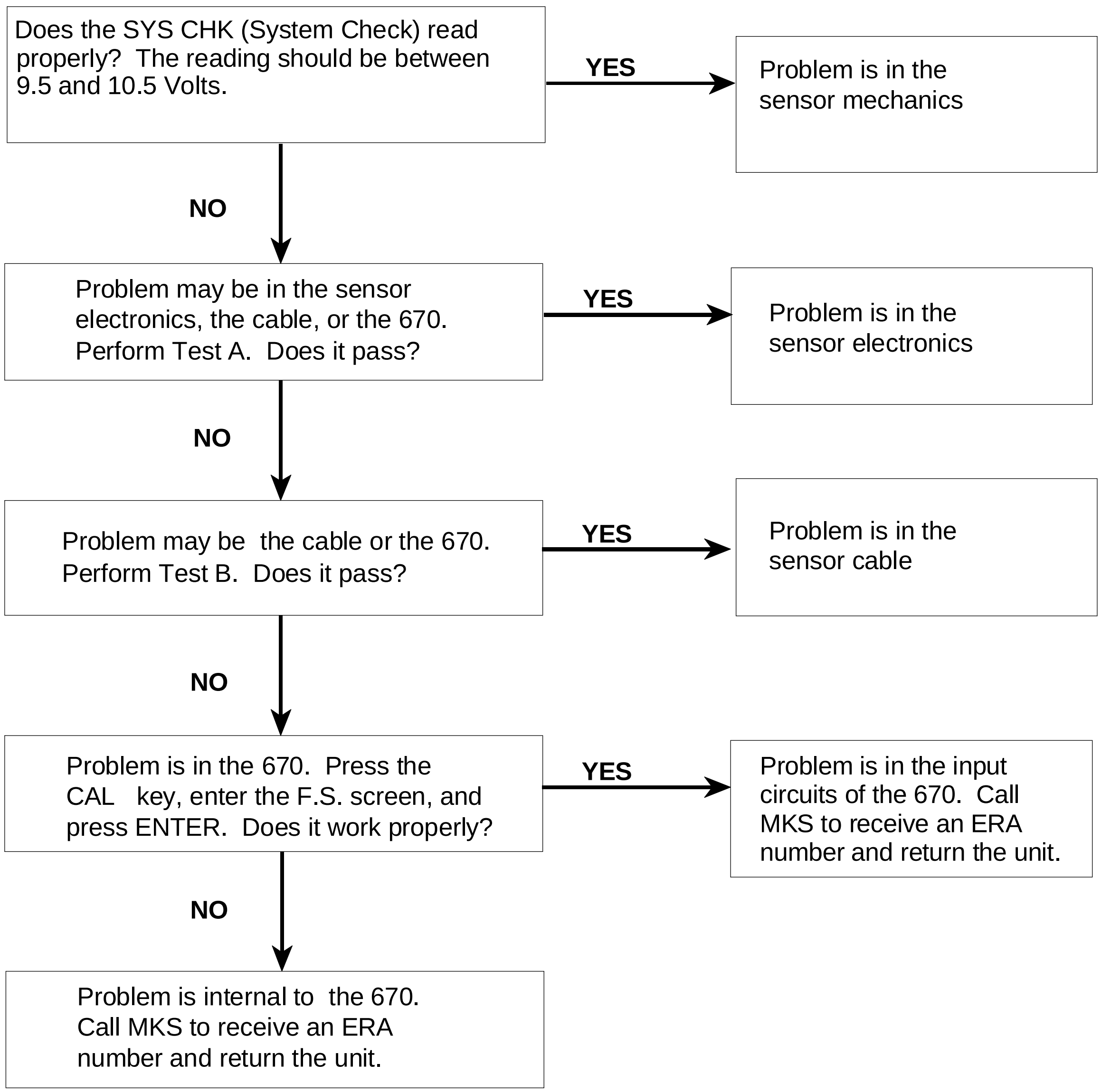


Figure 18: Troubleshooting Flow Chart

Test A: Localizing Malfunction to the Cable or the Electronics Unit

Equipment Required:

Digital Volt Meter (DVM)

1. Disconnect the transducer cable from the transducer.
2. Press the [CAL] key on the front panel of the 670 instrument.

   The system responds by displaying the calibration screen.
3. Press an arrow key, ([△] or [▽]), until the system check screen appears.

   ```
   Ch 1                9.8799 Volts
               SYSCHK
   ```

   The reading should be between 9.5 and 10.5 Volts. A reading outside this range indicates a problem with the pressure transducer or its cable.
4. Press the [SETUP] key.

   The system responds by displaying a setup screen.
5. Repeatedly press an arrow key, ([△] or [▽]), until the Heater screen appears.

   ```
         Ch 1       Heater OFF
   ```
6. Use the Adjust knob to turn the heater OFF.
7. Press the [ENTER] key to turn off the heater.

   The system responds by turning off the heater.

8. Use the DVM to check the voltages at the transducer end of the cable.

   Refer to Table 37 for the appropriate voltage values. Reference the DVM to pin H (2).

Transducer Cable Voltage Check		
Transducer Cable Pin Number	**Voltage**	**Function**
I or (13)	+12 to +13	Transducer electronics supply voltage
D or (14)	+12 to +13	System Check command
J or (15)	6 Volts RMS	Excitation voltage
Note that some transducer cables use numbers while others use letters.		

Table 37: Transducer Cable Voltage Check

9. Connect two resistors to the transducer cable, as shown in Figure 19.

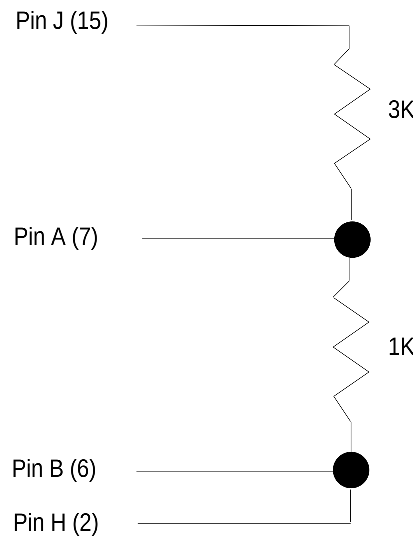


Figure 19: Two Resistors Added to the Transducer Cable

10. Press the [CAL] key to enter the calibration menu.

    The system responds by displaying the calibration screen.

11. Press an arrow key, ([△] or [▽]), until the system check screen appears.

```
Ch 1                -9.8799 Volts
            SYSCHK
```

This should produce a negative full scale reading, ±10%.

12. Connect a short circuit across the 1K resistor and press the [X0.01] range selection key.

The system responds by changing to the x0.01 range.

13. Press the [ZERO] key on the 670 instrument front panel.

The system responds by displaying the zero screen.

14. Use the Adjust knob to select ON for the zero enable entry.

15. Press the [ENTER] key to start the zeroing process.

You should be able to adjust this control ±40% of full scale.

Test B: Localizing Malfunctions to the Electronics Unit

1. Disconnect the transducer cable from the 670 instrument and check voltages at the Head (upper) connector on the Signal Conditioner Board.

Electronics Unit Voltage Check		
Connector Pin	**Voltage**	**Function**
13	+12 to +13	Transducer electronics supply voltage
14	+12 to +13	System Check command
15	6 Volts RMS	Excitation voltage

Table 38: Electronics Unit Voltage Check

2. Repeat step 5 of Test A at the transducer connection.

   The results should be the same.

Appendix A: Product Specifications

All specifications are at 23° C, 120 VAC

Performance Specifications

Ranges	x1, x0.1, and x0.01 of full range of the pressure transducer
Analog Signal Output	
Voltage available at rear connector	0 to ±10 V on each range (x1, x0.1, x0.01), into >10K ohm load
Impedance	<1 ohm
Temperature Coefficient (x1 range)	
Zero	± 4 ppm of range/° C (without calibration)
Span	±25 ppm of range/° C (without calibration) ±15 ppm of range/° C (with full scale calibration)
Accuracy[1]	
Zero	
x1	± 100 ppm of range F.S.
x0.1	± 100 ppm of range F.S.
x0.01	± 200 ppm of range F.S.
Span	
x1	± 300 ppm of range F.S.
x0.1	± 350 ppm of range F.S.
x0.01	± 800 ppm of range F.S.
Linearity	
0 to +10 Volts	<±25 ppm F.S.
0 to -10 Volts	<±50 ppm F.S.
Noise	
0.01 - 0.4 Hz	< 70 µVolts peak-to-peak, on the x1 and x0.1 ranges < 350 µVolts peak-to-peak, on the x0.01 range
1 kHz - 1 MHz	<4 mV peak-to-peak, on all ranges

[1] Includes non-repeatability

Performance Specifications *(Continued)*

Display and Digital Communications	
Accuracy Zero Span	 ± 50 ppm F.S. ± 200 ppm F.S.
Update Rate	4 times per second (every 0.25 seconds)
Linearity 0 to 10 Volts 0 to -10 Volts	 <± 15 ppm of F.S. <± 50 ppm of F.S.
Pressure Units	Torr, mmHg, mbar, Pa, kPa, psi, inHg, inH_2O, cmH_2O, % of Full Scale, ppm, mTorr
Temperature Coefficient Zero Span	 1 ppm/° C 25 ppm/° C
CE Compliance	
Electromagnetic Compatibility[2]	Electromagnetic Compatibility Directive 89/336/EEC
Low-Voltage	Low-Voltage Directive 73/23/EEC
Product Safety and Liability	Product Safety Directive 92/59/EEC
Installation Category	II, according to EN 61010-1
Pollution Degree	2, according to IEC 664

[2] An overall metal braided shielded cable, properly grounded at both ends, is required during use.

Physical Specifications

Connectors	
I/O	37-pin Type "D", female
Head (upper connector on the Signal Conditioner Board)	15-pin Type "D", female
Signal (lower connector on the Signal Conditioner Board)	9-pin Type "D", male
Remote Communications	
Serial Interface	9-pin Type "D", male
IEEE-488	24-pin IEEE/488.1 compliant, female
Remote Communications	RS-232C or IEEE-488.2
Trip Points	Two trip points, each controlling a relay, with front panel LED indicator lights.
Contact ratings	24 Volts AC/DC @ 1 Amp resistive
High trip points	Activated when the input pressure signal equals, or exceeds, the high trip point level
Low trip points	Activated when the input pressure signal equals, or falls below, the low trip point level
	De-activated between the high and low trip points
Relay state	User selectable — energized or de-energized
Action	An activated relay will change state and the front panel LED will illuminate
Dimensions	3½"H x 9½"W x 9"D *Standard MKS ½ rack* (8.9 cm H x 24.1 cm W x 22.9 cm D)
Weight	7 lbs. 14 oz. (3.6 kg)

Environmental Specifications

Operating Temperature Range	15 to 40° C (59 to 104° F)
Humidity Range	10 through 90% non-condensing

Electrical Specifications

Power Requirement	100 to 120 or 200 to 240 VAC @ 50 - 60 Hz, 75 VA maximum
Fuses	
100 to 120 VAC	0.63A (T), 250 V, 5 x 20 mm
200 to 240 VAC	0.315A (T), 250 V, 5 x 20 mm

Due to continuing research and development activities, these product specifications are subject to change without notice.

Appendix B: Model Code Explanation

Model Code

The options of your 670 instrument are identified in the model code when you order the unit. The model code is identified as follows:

670BXXX

where:

670B XXX

Type Number

Communication

Type Number (670B)

This designates the model number of the instrument.

Communication (XXX)

The communication option, either RS-232 or IEEE-488, is specified by a three character code.

Communication	Ordering Code
RS-232	D21
IEEE-488	D81

This page intentionally left blank.

Appendix C: Initial Settings

General Information

The 670 signal conditioner is shipped with the following initial configuration. This configuration is *not* a default configuration, however, since the 670 unit stores most of the configuration settings in non-volatile RAM. Settings stored in non-volatile RAM are saved when the power is turned off. When the power is restored, the 670 unit “remembers” the latest configuration, not the initial configuration. Refer to Table 39 for a complete list of the initial configuration settings. The last column lists the page number for information on each entry, should you wish to change the setting.

Initial Settings			
Parameter	**Default**	**Options**	**Page**
Display Size	5½	4½, 3½	45
Response	400	1, 4	46
Pressure Units	Torr	mmHg, mbar, Pa, kPa, psi, inHg, inH_2O, cmH_2O, % full scale, ppm, mTorr	48
Heater Current Display	Off	On	47
Temperature Compensation	0	User selectable, from 0 to 999	50
Sensor Range	10	User selectable	49
Averaging	20	User selectable, from 1 to 99	51
RS-232 Communication	Baud: 9600 Data Bits: 8 Parity: No End-of-line: CR	300, 1200, 2400, 4800 7 Even, Odd No option	85
IEEE-488 Address	8	1 to 30	53
Zero Enable	On	Off	62
Autoranging	Off	On	64

Table 39: Initial Settings
(Continued on next page)

Initial Settings *(Continued)*			
Parameter	**Default**	**Options**	**Page**
Trip Points, A and B			
High	+105.000%	User selectable	55
Low	-105.000%	User selectable	55
Hysteresis	±0.10%	User selectable	56
State	Energized	De-energized	58
Latch	Disabled	Enabled	58
Channel	1	2, 3 if connected to a Type 274 multiplexer	59
Line Voltage	115 VAC	230 VAC	82

Table 31: Initial Settings

Appendix D: Interface Cables for a Type 274 Multiplexer

I/O Connector Cables

When the 670 instrument is interfaced with a 274 multiplexer, two cables connect the two units. First, a CB270-2 cable must connect the Head connector (upper connector on the Signal Conditioner board) to the ELEC connector on the 274 unit. Second, the I/O connector must be connected to the DVM connector on the 274 unit, by *either* a CB670-1 or CB670-2 cable. The CB670-1 is a straight cable, so the cable pins match the pinout listed in Table 9, page 37. The CB670-2 is a Y-cable that allows access to the trip point relays and remote functions included on the I/O connector.

CB670-2 Y Cable

Cable CB670-2 consists of one 37-pin male connector (P1) that connects to the I/O connector on the 670 instrument, one 25-pin male connector (P2), and one 25-pin female connector (P3). Table 40, page 146, lists the pinout of the 25-pin male connector. Table 41, page 147, lists the pinout of the 25-pin female connector. The trip point relays and the remote functions are available on the 25-pin female connector.

Note There is no internal connection on the pins assigned a "No Connection" function.

Pinout of the Y-Cable 25-pin Male Connector	
Pin	**Signal**
1	$\overline{\text{Special}}$
2	$\overline{\text{10K}}$
3	$\overline{\text{1K}}$
4	$\overline{\text{100}}$
5	$\overline{\text{10}}$
6	$\overline{\text{1}}$
7	No Connection
8	$\overline{\text{Channel 1 ID}}$
9	$\overline{\text{Channel 2 ID}}$
10	$\overline{\text{Channel 3 ID}}$
11	Channel ID Common
12	$\overline{\text{Select Channel 1}}$
13	$\overline{\text{Select Channel 2}}$
14	No Connection
15	No Connection
16	No Connection
17	No Connection
18	No Connection
19	No Connection
20	No Connection
21	No Connection
22	Digital Ground
23	No Connection
24	No Connection
25	No Connection

Table 40: Pinout of the Y-Cable 25-pin Male Connector

Pinout of the Y-Cable Female Connector	
Pin	**Signal**
1	Trip Point A NC
2	Trip Point A Common
3	Trip Point A NO
4	Trip Point B NC
5	Trip Point B Common
6	Trip Point B NO
7	$\overline{\text{Latch TP A}}$
8	$\overline{\text{Latch TP B}}$
9	$\overline{\text{Remote Zero}}$
10	Analog Ground
11	Pressure Output
12	$\overline{\text{X0.01 Select}}$
13	$\overline{\text{X0.1 Select}}$
14	$\overline{\text{X1 Range ID}}$
15	$\overline{\text{X0.1 Range ID}}$
16	$\overline{\text{X0.01 Range ID}}$
17	Digital Ground
18	Power Ground
19	No Connection
20	No Connection
21	No Connection
22	Digital Ground
23	No Connection
24	No Connection
25	No Connection

Table 41: Pinout of the Y-Cable 25-pin Female Connector

This page intentionally left blank.

Index

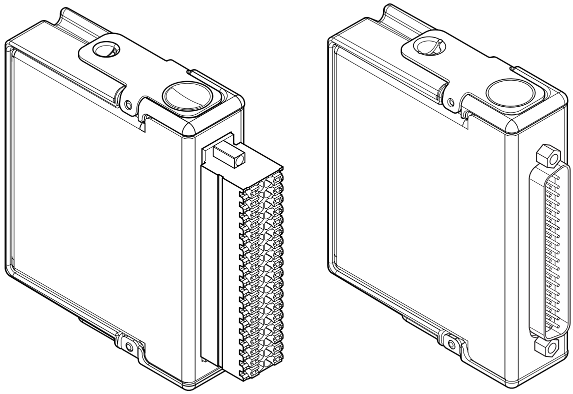
V

Z

DATASHEET

NI 9207

16 AI, ±20 mA/±10 V, 24 Bit, 500 S/s Aggregate



- 8 current and 8 voltage inputs, 500 S/s
- ±20 mA current inputs, ±10 V voltage inputs, 24-bit resolution
- High-Resolution Mode with 50/60 Hz rejection
- 250 Vrms, CAT II, channel-to-earth isolation (spring terminal); 60 VDC, CAT I, channel-to-earth isolation (DSUB)
- DSUB or spring-terminal connectivity
- -40 °C to 70 °C operating range, 5 g vibration, 50 g shock

The NI 9207 combination voltage and current input C Series module has eight channels of ±20 mA input and eight channels of ±10 V input with built-in 50/60 Hz rejection for noise rejection.

Designed with industrial systems in mind, the NI 9207 combines the two most common inputs to reduce the overall number of modules you need. A system that uses fewer modules has the benefit of leaving slots open for other measurement types or reducing the overall cost and size of the system. The NI 9207 has a standard 37-pin DSUB and 36-pin spring terminal connections for use with cables and connector blocks.

	Kit Contents	• NI 9207 • NI 9207 Getting Started Guide
	Accessories	• NI 9940 Backshell Connector Kit (Spring Terminal) • NI 9923 Screw-Terminal Block (DSUB)

NI C Series Overview

NI provides more than 100 C Series modules for measurement, control, and communication applications. C Series modules can connect to any sensor or bus and allow for high-accuracy measurements that meet the demands of advanced data acquisition and control applications.

- Measurement-specific signal conditioning that connects to an array of sensors and signals
- Isolation options such as bank-to-bank, channel-to-channel, and channel-to-earth ground
- -40 °C to 70 °C temperature range to meet a variety of application and environmental needs
- Hot-swappable

The majority of C Series modules are supported in both CompactRIO and CompactDAQ platforms and you can move modules from one platform to the other with no modification.

CompactRIO

CompactRIO combines an open-embedded architecture with small size, extreme ruggedness, and C Series modules in a platform powered by the NI LabVIEW reconfigurable I/O (RIO) architecture. Each system contains an FPGA for custom timing, triggering, and processing with a wide array of available modular I/O to meet any embedded application requirement.

CompactDAQ

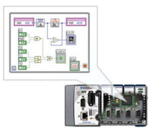
CompactDAQ is a portable, rugged data acquisition platform that integrates connectivity, data acquisition, and signal conditioning into modular I/O for directly interfacing to any sensor or signal. Using CompactDAQ with LabVIEW, you can easily customize how you acquire, analyze, visualize, and manage your measurement data.

Software

LabVIEW Professional Development System for Windows

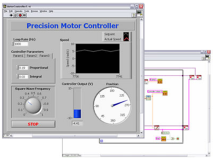
- Use advanced software tools for large project development
- Generate code automatically using DAQ Assistant and Instrument I/O Assistant
- Use advanced measurement analysis and digital signal processing
- Take advantage of open connectivity with DLLs, ActiveX, and .NET objects
- Build DLLs, executables, and MSI installers

NI LabVIEW FPGA Module



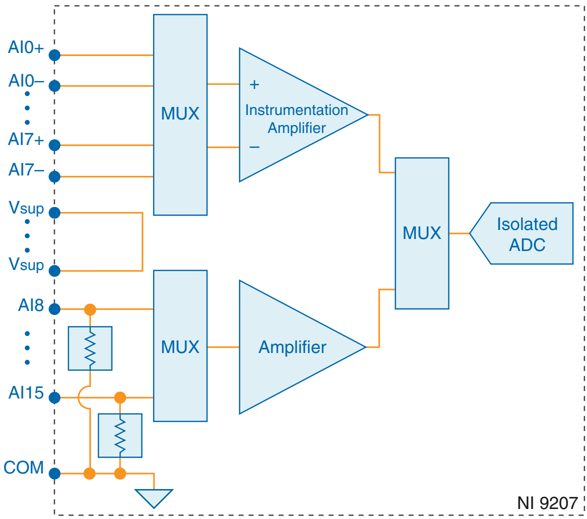
- Design FPGA applications for NI RIO hardware
- Program with the same graphical environment used for desktop and real-time applications
- Execute control algorithms with loop rates up to 300 MHz
- Implement custom timing and triggering logic, digital protocols, and DSP algorithms
- Incorporate existing HDL code and third-party IP including Xilinx IP generator functions
- Purchase as part of the LabVIEW Embedded Control and Monitoring Suite

NI LabVIEW Real-Time Module



- Design deterministic real-time applications with LabVIEW graphical programming
- Download to dedicated NI or third-party hardware for reliable execution and a wide selection of I/O
- Take advantage of built-in PID control, signal processing, and analysis functions
- Automatically take advantage of multicore CPUs or set processor affinity manually
- Take advantage of real-time OS, development and debugging support, and board support
- Purchase individually or as part of a LabVIEW suite

Circuitry



The input signals are scanned, amplified, conditioned, and then sampled by a single 24-bit ADC.

NI 9207 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted. All voltages are relative to COM unless otherwise noted.

Caution Do not operate the NI 9207 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

Input Characteristics

Number of channels	16 analog input channels: 8 voltage and 8 current
ADC resolution	24 bits
Type of ADC	Delta-Sigma
Sampling mode	Scanned
Input range	
Voltage channels	
Minimum	±10.2 V
Typical	±10.4 V
Current channels	
Minimum	±21.5 mA
Typical	±22.0 mA
Maximum working voltage for analog inputs (signal voltage + common mode voltage), voltage channels only	Each channel must remain within ±10.2 V of common
Conversion time (per channel)	
High-Resolution Mode	52 ms
High-Speed Mode	2 ms
Overvoltage protection, channel-to-COM, all channels	±30 V maximum on one channel at a time
Vsup pins, current channels only	
Current	2 A maximum
Voltage	0 to 30 V maximum
Input impedance	
Voltage channels	>1 GΩ
Current channels	85 Ω

Table 1. Accuracy

Calibrated Measurement Conditions	Channels	Percent of Reading (Gain Error)	Percent of Range[1] (Offset Error)
Maximum (-40 °C to 70 °C)	Voltage channels	±0.52%	±0.04%
	Current channels	±0.87%	±0.05%

Input noise	
Voltage channels	
High-Resolution Mode	16 µVrms
High-Speed Mode	80 µVrms
Current channels	
High-Resolution Mode	50 nArms
High-Speed Mode	200 nArms
Stability	
Voltage channels	
Gain drift	±21 ppm/°C
Offset drift	±14 µV/°C
Current channels	
Gain drift	±43 ppm/°C
Offset drift	±30 nA/°C
CMRR (f_{in}= 0 Hz to 60 Hz), voltage channels only	86 dB
CMRR, channel-to-earth ground (50/60 Hz)[2]	
High-Resolution Mode	160 dB
High-Speed Mode	120 dB
NMRR (High-Resolution Mode only)	
50 Hz	66 dB
60 Hz	68 dB

1 Range equals 10.4 V for voltage channels and 22.0 mA for current channels.
2 Voltage channel of NI 9207 with spring terminal only.

Power Requirements

Power consumption from chassis	
Active mode	295 mW maximum
Sleep mode	25 µW maximum
Thermal dissipation (at -40 °C)	
Active mode	0.75 W maximum
Sleep mode	0.59 W maximum

Physical Characteristics

If you need to clean the module, wipe it with a dry towel.

Tip For two-dimensional drawings and three-dimensional models of the C Series module and connectors, visit *ni.com/dimensions* and search by module number.

Push-in spring-terminal wiring	
Gauge	0.14 mm^2 to 1.5 mm^2 (26 AWG to 16 AWG) copper conductor wire
Wire strip length	10 mm (0.394 in.) of insulation stripped from the end
Temperature rating	90 °C minimum
Wires per spring terminal	One wire per spring terminal; two wires per spring terminal using a 2-wire ferrule
Ferrules	0.14 mm^2 to 1.5 mm^2
Connector securement	
Securement type	Screw flanges provided
Torque for screw flanges	0.2 N · m (1.80 lb · in.)
Weight	
NI 9207 with spring terminal	161 g (5.7 oz)
NI 9207 with DSUB	144 g (5.1 oz)

NI 9207 with Spring Terminal Safety Voltages

Connect only voltages that are within the following limits:

Isolation	
Channel-to-channel	None

Channel-to-earth ground	
Continuous	250 Vrms, Measurement Category II
Withstand up to 5,000 m	3,000 Vrms, verified by a 5 s dielectric withstand test

Measurement Category II is for measurements performed on circuits directly connected to the electrical distribution system. This category refers to local-level electrical distribution, such as that provided by a standard wall outlet, for example, 115 V for U.S. or 230 V for Europe.

Caution Do not connect the NI 9207 to signals or use for measurements within Measurement Categories III or IV.

NI 9207 with DSUB Safety Voltages

Connect only voltages that are within the following limits:

Isolation	
Channel-to-channel	None
Channel-to-earth ground	
Continuous	60 VDC, Measurement Category I
Withstand up to 2,000 m	1,000 Vrms, verified by a 5 s dielectric withstand test
Withstand up to 5,000 m	500 Vrms, verified by a 5 s dielectric withstand test

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do not connect the NI 9207 with DSUB to signals or use for measurements within Measurement Categories II, III, or IV.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, Ex nA IIC T4
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc

Safety and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 6, UL 60079-15; Ed 4
- CSA 60079-0:2011, CSA 60079-15:2012

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- EN 55022 (CISPR 22): Class A emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, and additional information, refer to the *Online Product Certification* section.

Caution For EMC compliance, operate the NI 9207 with DSUB with shielded cables.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2014/34/EU; Potentially Explosive Atmospheres (ATEX)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random (IEC 60068-2-64)	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz to 500 Hz
Operating shock (IEC 60068-2-27)	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Environmental

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP40
Operating humidity (IEC 60068-2-78)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-78)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	5,000 m

Indoor use only.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Calibration

You can obtain the calibration certificate and information about calibration services for the NI 9207 at *ni.com/calibration*.

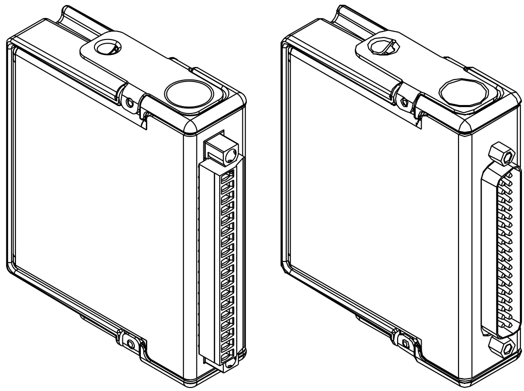
Calibration interval	2 years

375206B-02 Sep16

DATASHEET

NI 9266 Datasheet

8 AO, 0 mA to 20 mA, 16 Bit Simultaneous



- DSUB or screw terminal connectivity
- 250 V RMS, CAT II, channel-to-earth isolation (screw terminal); 60 V DC, CAT I, channel-to-earth isolation (DSUB)
- 8 channels, 24 kS/s per channel simultaneous analog output
- 0 mA to 20 mA output range, 16-bit resolution
- Open-loop detection with interrupt, 0.0 mA power-on
- -40 °C to 70 °C operating range, 5 g vibration, 50 g shock

Note In this document, the NI 9266 with screw terminal and the NI 9266 with DSUB are referred to inclusively as the NI 9266.

The NI 9266 is ideal for interfacing and controlling industrial current-driven actuators. The module has built-in open-loop detection, which generates an interrupt in software when an open loop is detected as well as zeroing outputs to ensure safety and avoid driving actuators at system power on. The NI 9266 includes channel-to-earth ground isolation for safety and noise immunity.

Kit Contents	• NI 9266 • NI 9266 Getting Started Guide
Accessories	• NI 9928 Backshell Kit (784819-01) (Screw Terminal) OR • NI 9923 Front Mount Screw Terminal Block (DSUB) • DIN-Rail Mount Terminal Block (DSUB)

C SERIES ANALOG OUTPUT FOR CONTROL APPLICATIONS MODULE COMPARISON								
Product Name	**Module Type**	**Signal Ranges**	**Channels**	**Update Rate**	**Settling Time**		**Isolation**	**Connectivity**
					Small Step	**Full Scale**		
NI 9263	Voltage Output	±10 V	4	100 kS/s/ch	10 µs	20 µs	250 Vrms CH-Earth	Screw-Terminal, Spring-Terminal
NI 9264	Voltage Output	±10 V	16	25 kS/s/ch	13 µs	20 µs	250 Vrms CH-Earth (Spring) 60 VDC CH-Earth (DSUB)	Spring-Terminal, 37-Pin DSUB
NI 9265	Current Output	0 mA to 20 mA	4	100 kS/s/ch	5 µs	10 µs	250 Vrms CH-Earth	Screw-Terminal, Spring-Terminal
NI 9266	Current Output	0 mA to 20 mA	8	24 kS/s/ch	40 µs	1000 µs	250 Vrms CH-Earth	Screw-Terminal
NI 9269	Voltage Output	±10 V	4	100 kS/s/ch	10 µs	20 µs	250 Vrms CH-CH 250 Vrms CH-Earth	Screw-Terminal

NI C Series Overview

NI provides more than 100 C Series modules for measurement, control, and communication applications. C Series modules can connect to any sensor or bus and allow for high-accuracy measurements that meet the demands of advanced data acquisition and control applications.

- Measurement-specific signal conditioning that connects to an array of sensors and signals
- Isolation options such as bank-to-bank, channel-to-channel, and channel-to-earth ground
- -40 °C to 70 °C temperature range to meet a variety of application and environmental needs
- Hot-swappable

The majority of C Series modules are supported in both CompactRIO and CompactDAQ platforms and you can move modules from one platform to the other with no modification.

CompactRIO

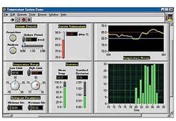
CompactRIO combines an open-embedded architecture with small size, extreme ruggedness, and C Series modules in a platform powered by the NI LabVIEW reconfigurable I/O (RIO) architecture. Each system contains an FPGA for custom timing, triggering, and processing with a wide array of available modular I/O to meet any embedded application requirement.

CompactDAQ

CompactDAQ is a portable, rugged data acquisition platform that integrates connectivity, data acquisition, and signal conditioning into modular I/O for directly interfacing to any sensor or signal. Using CompactDAQ with LabVIEW, you can easily customize how you acquire, analyze, visualize, and manage your measurement data.

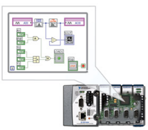
Software

LabVIEW Professional Development System for Windows



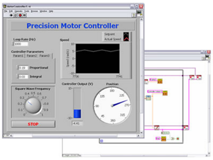
- Use advanced software tools for large project development
- Generate code automatically using DAQ Assistant and Instrument I/O Assistant
- Use advanced measurement analysis and digital signal processing
- Take advantage of open connectivity with DLLs, ActiveX, and .NET objects
- Build DLLs, executables, and MSI installers

NI LabVIEW FPGA Module



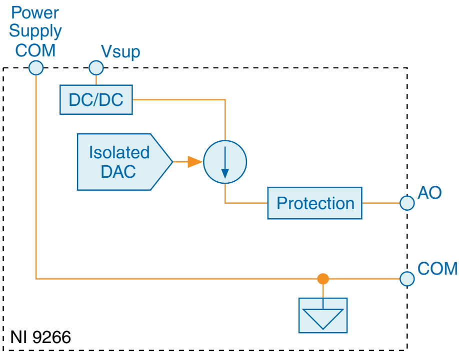
- Design FPGA applications for NI RIO hardware
- Program with the same graphical environment used for desktop and real-time applications
- Execute control algorithms with loop rates up to 300 MHz
- Implement custom timing and triggering logic, digital protocols, and DSP algorithms
- Incorporate existing HDL code and third-party IP including Xilinx IP generator functions
- Purchase as part of the LabVIEW Embedded Control and Monitoring Suite

NI LabVIEW Real-Time Module



- Design deterministic real-time applications with LabVIEW graphical programming
- Download to dedicated NI or third-party hardware for reliable execution and a wide selection of I/O
- Take advantage of built-in PID control, signal processing, and analysis functions
- Automatically take advantage of multicore CPUs or set processor affinity manually
- Take advantage of real-time OS, development and debugging support, and board support
- Purchase individually or as part of a LabVIEW suite

Circuitry



- Each AO channel has a digital-to-analog converter (DAC) that produces a current signal.
- Each channel also has overvoltage and short-circuit protection.

Dynamic Power Supply Control

The NI 9266 uses a technique called dynamic power supply control featuring a DC-DC converter circuit, which allows reductions in power consumption from standard designs. The NI 9266 circuitry senses the output voltage and regulates the internal DC-DC converter in order to limit the power dissipation while maintaining the necessary compliance voltage for the given load and output current. The NI 9266 has a dedicated DC-DC converter for each channel, allowing it to dynamically adjust to a specific use case.

The DC-DC converters have a slower slew rate than linear stages, so the module will respond slower to a step response than a classic linear output module, resulting in slower settling times.

Current Loop Status

The NI 9266 provides channel-based indicators for open current loop condition or if the loop is out of regulation. This could be the result of a wire disconnect or a violation of the maximum load or maximum compliance voltage. When an output channel is set to a nonzero current value, an Open Current Loop status bit corresponding to that channel can be read in software. The external power supply connected to the NI 9266 terminals is monitored for non-compliance to the voltage range shown in the Specifications section. The external power supply is part of the current loop, so a fault at the power supply terminals will also trigger the Open Current Loop status bits on all channels. The Power Supply Fault status bit can also be read in the software. Refer to the documentation for the software you are using with the NI 9266 for information about reading status indicators.

NI 9266 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted. All voltages are relative to COM unless otherwise noted.

Caution Do not operate the NI 9266 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

Output Characteristics

Number of channels	8 analog output channels
DAC resolution	16 bits
Type of DAC	String
Power-on output state	0
Startup current	0.0 mA
Power-down current	0.0 mA
Full-scale output current	
Minimum	20.3 mA
Typical	20.77 mA
Maximum	21.2 mA
Output range	0 mA to 20 mA
Compliance voltage[1]	12 V DC maximum
Maximum load	600 Ω

[1] The maximum voltage a current source can provide to the load.

Table 1. Accuracy

Measurement Conditions		Percent of Reading (Gain Error)	Percent of Range[2] (Offset Error)
Calibrated	Maximum (-40 °C to 70 °C)	0.27%	0.36%
	Typical (25 °C, ±5 °C)	0.035%	0.02%
Uncalibrated[3]	Maximum (-40 °C to 70 °C)	0.76%	1.4%
	Typical (25 °C, ±5 °C)	0.2%	0.64%

Stability	
Gain drift	35 ppm/°C
Offset drift	47 ppm/°C
External power supply voltage range (V_{sup}-to-COM)	9 V DC to 30 V DC
Protection (AO-to-COM, V_{sup}-to-COM)	
Overvoltage	±36 V
Short-circuit	Indefinitely

Table 2. Update Time

Number of Channels	Update Time for R Series Expansion Chassis	Update Time for Any Other Chassis
One	7.5 µs	6 µs
Four	26.5 µs	21.5 µs
Eight	51.5 µs	41.5 µs

Noise	600 nA RMS
Crosstalk	-90 dB
Settling time (to 1 LSB)	
Full-scale step	1 ms
1 mA step	40 µs
Glitch energy	Unmeasurable

2 Range equals 0 mA to 20.77 mA.

3 Uncalibrated accuracy refers to the accuracy achieved when acquiring in raw or unscaled modes where the calibration constants stored in the module are not applied to the data.

Monotonicity	16 bits
DNL	1 LSB maximum
INL	±16 LSB
External power supply fault response time	100 ms
Open Current Loop response time	2.5 ms

Power Requirements

Power consumption from chassis	
Active mode	230 mW maximum
Sleep mode	25 µW maximum
Thermal dissipation (at 70 °C)	
Active mode	1.5 W maximum
Sleep mode	10 mW maximum
Power consumption from external power supply	
Active mode	3.1 W maximum[4]
Sleep mode	20 mW

NI 9266 with Screw Terminal Safety Voltages

Connect only voltages that are within the following limits:

AO-to-COM and V_{sup}-to-COM	±36 V DC maximum
Isolation	
Channel-to-channel	None
Channel-to-earth ground, V_{sup}-to-earth ground, or COM-to-earth ground	
Continuous	250 V RMS, Measurement Category II
Withstand up to 3,000 m	3,000 V RMS, verified by a 5 s dielectric withstand test

Measurement Category II is for measurements performed on circuits directly connected to the electrical distribution system. This category refers to local-level electrical distribution, such as that provided by a standard wall outlet, for example, 115 V for U.S. or 230 V for Europe.

Caution Do not connect the NI 9266 with screw terminal to signals or use for measurements within Measurement Categories III or IV.

[4] When the NI 9266 outputs 20 mA into a 600 Ohms user load on all eight channels, 1.92 W are dissipated at the user load.

NI 9266 with DSUB Safety Voltages

Connect only voltages that are within the following limits.

AO-to-COM and V_{sup}-to-COM	±36 V DC maximum
Isolation	
Channel-to-channel	None
Channel-to-earth ground	
Continuous	60 V DC, Measurement Category I
Withstand up to 3,000 m	1,000 V RMS, verified by a 5 s dielectric withstand test
Withstand up to 5,000 m	860 V RMS

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do not connect the NI 9266 with DSUB to signals or use for measurements within Measurement Categories II, III, or IV.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are for other circuits not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Physical Characteristics

If you need to clean the module, wipe it with a dry towel.

Tip For two-dimensional drawings and three-dimensional models of the C Series module and connectors, visit *ni.com/dimensions* and search by module number.

Screw-terminal wiring	
Gauge	$0.05\ mm^2$ to $0.82\ mm^2$ (30 AWG to 18 AWG) copper conductor wire
Wire strip length	5 mm to 6 mm (0.20 in. to 0.24 in.) of insulation stripped from the end
Temperature rating	90 °C, minimum
Torque for screw terminals	0.20 N · m to 0.25 N · m (1.8 lb · in. to 2.2 lb · in.)

Wires per screw terminal	One wire per screw terminal; two wires per screw terminal using a 2-wire ferrule
Ferrules	0.25 mm^2 to 1.0 mm^2
Connector securement	
Securement type	Screw flanges provided
Torque for screw flanges	0.3 N · m to 0.4 N · m (2.7 lb · in. to 3.5 lb · in.)
Weight	
NI 9266 with screw terminal	147 g (5.2 oz)
NI 9266 with DSUB	151 g (5.3 oz)

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4 Gc
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Ex nA IIC T4 Gc
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc

Safety and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA C22.2 No. 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 6, UL 60079-15; Ed 4
- CSA C22.2 No. 60079-0, CSA C22.2 No. 60079-15

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- EN 55022 (CISPR 22): Class A emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class A emissions

- AS/NZS CISPR 22: Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, and additional information, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2014/34/EU; Potentially Explosive Atmospheres (ATEX)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random (IEC 60068-2-64)	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz to 500 Hz
Operating shock (IEC 60068-2-27)	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Environmental

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP40
Operating humidity (IEC 60068-2-78)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-78)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	
NI 9266 with screw terminal	3,000 m
NI 9266 with DSUB	5,000 m

Indoor use only.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Calibration

You can obtain the calibration certificate and information about calibration services for the NI 9266 at *ni.com/calibration*.

Calibration interval	1 year

376325C-02 October 13, 2017

DATASHEET

NI 9375

16 DI/16 DO, 30 VDC, 7 µs Sinking DI, 500 µs Sourcing DO

- DSUB or spring-terminal connectivity
- 60 VDC, DI-bank-to-DO-bank isolation
- 60 VDC, CAT I, channel-to-earth isolation

The NI 9375 is a combination digital input, digital output module for CompactDAQ and CompactRIO systems. The digital input lines are compatible with 24 V logic levels and the digital output lines are compatible with 6 V to 30 V signals, based on the external power supply. The NI 9375 offers 1,000 Vrms withstand isolation from channel to earth ground. It works with industrial logic levels and signals for direct connection to a wide array of industrial switches, transducers, and other devices.

Kit Contents	• NI 9375 • NI 9375 Getting Started Guide • Flathead Screwdriver (Spring Terminal)
Accessories	• NI 9940 Backshell Connector Kit (Spring Terminal) • NI 9923 Screw-Terminal Block (DSUB)

NATIONAL INSTRUMENTS™

C SERIES DIGITAL MODULE COMPARISON					
Product Name	**Signal Levels**	**Channels**	**Direction**	**Update Rate**	**Connectivity**
NI 9375	12 V, 24 V	8 DI, 8 DO	Sinking Input, Sourcing Output	7 µs (DI), 500 µs (DO)	Spring-Terminal, DSUB
NI 9421	12 V to 24 V	8 DI	Sinking Input	100 µs	Screw-Terminal, Spring-Terminal, DSUB
NI 9425	12 V, 24 V	32 DI	Sinking Input	7 µs	DSUB
NI 9472	6 V to 30 V	8 DO	Sourcing Output	100 µs	Screw-Terminal, Spring-Terminal
NI 9476	6 V to 30 V	32 DO	Sourcing Output	500 µs	DSUB

NI C Series Overview

NI provides more than 100 C Series modules for measurement, control, and communication applications. C Series modules can connect to any sensor or bus and allow for high-accuracy measurements that meet the demands of advanced data acquisition and control applications.

- Measurement-specific signal conditioning that connects to an array of sensors and signals
- Isolation options such as bank-to-bank, channel-to-channel, and channel-to-earth ground
- -40 °C to 70 °C temperature range to meet a variety of application and environmental needs
- Hot-swappable

The majority of C Series modules are supported in both CompactRIO and CompactDAQ platforms and you can move modules from one platform to the other with no modification.

CompactRIO

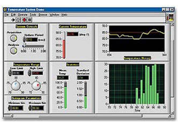
CompactRIO combines an open-embedded architecture with small size, extreme ruggedness, and C Series modules in a platform powered by the NI LabVIEW reconfigurable I/O (RIO) architecture. Each system contains an FPGA for custom timing, triggering, and processing with a wide array of available modular I/O to meet any embedded application requirement.

CompactDAQ

CompactDAQ is a portable, rugged data acquisition platform that integrates connectivity, data acquisition, and signal conditioning into modular I/O for directly interfacing to any sensor or signal. Using CompactDAQ with LabVIEW, you can easily customize how you acquire, analyze, visualize, and manage your measurement data.

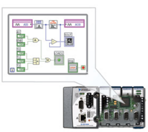
Software

LabVIEW Professional Development System for Windows



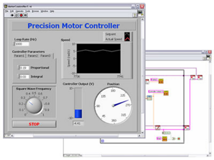
- Use advanced software tools for large project development
- Generate code automatically using DAQ Assistant and Instrument I/O Assistant
- Use advanced measurement analysis and digital signal processing
- Take advantage of open connectivity with DLLs, ActiveX, and .NET objects
- Build DLLs, executables, and MSI installers

NI LabVIEW FPGA Module



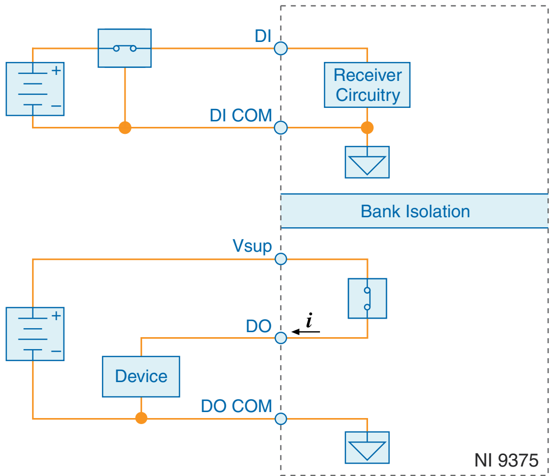
- Design FPGA applications for NI RIO hardware
- Program with the same graphical environment used for desktop and real-time applications
- Execute control algorithms with loop rates up to 300 MHz
- Implement custom timing and triggering logic, digital protocols, and DSP algorithms
- Incorporate existing HDL code and third-party IP including Xilinx IP generator functions
- Purchase as part of the LabVIEW Embedded Control and Monitoring Suite

NI LabVIEW Real-Time Module



- Design deterministic real-time applications with LabVIEW graphical programming
- Download to dedicated NI or third-party hardware for reliable execution and a wide selection of I/O
- Take advantage of built-in PID control, signal processing, and analysis functions
- Automatically take advantage of multicore CPUs or set processor affinity manually
- Take advantage of real-time OS, development and debugging support, and board support
- Purchase individually or as part of a LabVIEW suite

NI 9375 Circuitry



- The bank of 16 digital input channels and the bank of 16 digital output channels on the NI 9375 are isolated from each other and isolated from earth ground.
- The NI 9375 internally limits current signals connected to DI.
- The NI 9375 has sinking inputs. Sinking inputs provide a path to COM when the sourcing device connected to the NI 9375 drives current or applies voltage to DI.
- The NI 9375 has sourcing outputs. Sourcing outputs drive current from Vsup to DO when the channel is on.

Tip For more information about sinking inputs and sourcing outputs, visit *ni.com/info* and enter the Info Code `sinksource`.

Allowable Current Per Module

The NI 9375 has a per module continuous output current specification. Use the following equation to determine whether the total module current of your loads for channels that are turned on are within the specification.

Figure 1. Total Module Current Equation

$$(I_{\mathrm{DO0}})^2 + (I_{\mathrm{DO1}})^2 + \ldots + (I_{\mathrm{DO15}})^2 = \text{Total Module Current}$$

For example, an NI 9375 with spring terminal with two channels at 250 mA, six channels at 125 mA, and eight channels at 62 mA has the following per module continuous output current.

Figure 2. Total Module Current Example

$$\left\{\left[(250\ \mathrm{mA})^2 * 2\right] + \left[(125\ \mathrm{mA})^2 * 6\right] + \left[(62\ \mathrm{mA})^2 * 8\right]\right\} = 0.25\ \mathrm{A}^2$$

NI 9375 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted. All voltages are relative to COM unless otherwise noted.

Caution Do not operate the NI 9375 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

Input/Output Characteristics

Number of channels	32 channels: 16 digital input and 16 digital output

Digital Input

Input type	Sinking
Input voltage range	0 VDC to 30 VDC
Digital logic levels	
OFF state	
Input voltage	≤5 V
Input current	≤150 µA

ON state	
Input voltage	≥10 V
Input current	≥330 μA
Hysteresis	
Input voltage	1.7 V minimum
Input current	50 μA minimum
Input impedance	30 kΩ ±5%
Setup time[1]	1 μs maximum
Update/transfer time[2]	7 μs maximum

Digital Output

Output type	Sourcing
Power-on output state	Channels off
External power supply voltage range (Vsup)	6 VDC to 30 VDC
Continuous output current (I_O)	
NI 9375 with spring terminal	
All channels on	125 mA maximum (per channel)
One channel on	500 mA maximum
Per module	0.25 A^2
NI 9375 with DSUB	
All channels on	100 mA maximum (per channel)
One channel on	400 mA maximum
Per module	0.16 A^2 maximum
Output impedance (R_O)	0.3 Ω maximum
Output voltage (V_O)	Vsup - ($I_O R_O$)
Reversed-voltage protection	None
Current limiting	None
Vsup current consumption	18 mA

[1] *Setup time* is the amount of time input signals must be stable before reading from the module.

[2] *Update/transfer time* is the maximum time the software takes to read data from the module. The update/transfer is valid when the module is used in a CompactRIO system. When used in other systems, driver software and system latencies impact this time.

Update/transfer time[3]	7 µs maximum
Propagation delay[4]	500 µs maximum

Related Information

Allowable Current Per Module on page 5

Power Requirements

Power consumption from chassis	
Active mode	450 mW maximum
Sleep mode	25 µW maximum
Thermal dissipation (at 70 °C)	
Active mode	1.5 W maximum
Sleep mode	0.6 W maximum

Physical Characteristics

If you need to clean the module, wipe it with a dry towel.

Tip For two-dimensional drawings and three-dimensional models of the C Series module and connectors, visit *ni.com/dimensions* and search by module number.

Spring-terminal wiring	
Gauge	0.08 mm^2 to 1.0 mm^2 (28 AWG to 18 AWG) copper conductor wire
Wire strip length	7 mm (0.28 in.) of insulation stripped from the end
Temperature rating	90 °C minimum
Wires per spring terminal	One wire per spring terminal
Connector securement	
Securement type	Screw flanges provided
Torque for screw flanges	0.2 N · m (1.80 lb · in.)
Weight	
NI 9375 with spring terminal	159 g (5.6 oz)
NI 9375 with DSUB	148 g (5.3 oz)

3 *Update/transfer time* is the maximum time the software takes to write data to the module. The update/transfer is valid when the module is used in a CompactRIO system. When used in other systems, driver software and system latencies impact this time.

4 *Propagation delay* is the amount of time it takes the output signals to change state after being written to.

Safety Voltages

Connect only voltages that are within the following limits:

Channel-to-COM or Vsup-to-COM	30 VDC maximum
Isolation	
DI bank-to-DO bank	60 VDC maximum
Channel-to-Channel	No isolation between channels
Channel-to-earth ground	
Continuous	60 VDC, Measurement Category I
Withstand	1,000 Vrms, verified by a 5 s dielectric withstand test

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do not connect the NI 9375 to signals or use for measurements within Measurement Categories II, III, or IV.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, Ex nA IIC T4
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc

Safety and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4

- UL 60079-0; Ed 5, UL 60079-15; Ed 3
- CSA 60079-0:2011, CSA 60079-15:2012

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note For EMC declarations and certifications, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 94/9/EC; Potentially Explosive Atmospheres (ATEX)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit *ni.com/certification*, search by model number or product line, and click the appropriate link in the Certification column.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random (IEC 60068-2-64)	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz to 500 Hz
Operating shock (IEC 60068-2-27)	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Environmental

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP40
Operating humidity (IEC 60068-2-78)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-78)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m

Indoor use only.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at *ni.com/environment*. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit *ni.com/environment/weee*.

电子信息产品污染控制管理办法（中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。(For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

374644A-02 Feb16

Tel +1 (717) 767-6511
Fax +1 (717) 764-0839
www.redlion.net

Bulletin No. PAXICR-E
Drawing No. LP0896
Released 04/16

MODEL PAX® - 1/8 DIN DIGITAL INPUT PANEL METERS

- *COUNT, DUAL COUNTER, RATE AND SLAVE DISPLAY*
- *0.56" RED SUNLIGHT READABLE DISPLAY*
- *VARIABLE INTENSITY DISPLAY*
- *10 POINT SCALING FOR NON-LINEAR PROCESSES (PAXI)*
- *FOUR SETPOINT ALARM OUTPUTS (W/Option Card)*
- *RETRANSMITTED ANALOG OUTPUT (W/Option Card) (PAXI)*
- *COMMUNICATION AND BUS CAPABILITIES (W/Option Card) (PAXI)*
- *BUS CAPABILITIES; DEVICENET, MODBUS, AND PROFIBUS-DP*
- *CRIMSON® PROGRAMMING SOFTWARE (PAXI)*
- *ETHERNET(W/ External Gateway) (PAXI)*
- *NEMA 4X/IP65 SEALED FRONT BEZEL*

C UL US LISTED
IND. CONT. EQ.
51EB

GENERAL DESCRIPTION

The PAX Digital Input Panel Meters offer many features and performance capabilities to suit a wide range of industrial applications. Available in three different models, PAXC Counter/Dual Counter, PAXR Rate Meter and the PAXI which offers both counting and rate in the same package. Refer to pages 4 - 5 for the details on the specific models. The PAXC and PAXR offer only the Setpoint Option, while the PAXI is the fully featured version offering all the capabilities as outlined in this bulletin as well as a slave display feature. The option cards allow the opportunity to configure the meter for present applications, while providing easy upgrades for future needs.

The meters employ a bright 0.56" LED display. The meters are available with a red sunlight readable or standard green LED display. The intensity of the display can be adjusted from dark room applications up to sunlight readable, making it ideal for viewing in bright light applications.

The meters accept digital inputs from a variety of sources including switch contacts, outputs from CMOS or TTL circuits, magnetic pickups and all standard RLC sensors. The meter can accept directional, uni-directional or Quadrature signals simultaneously. The maximum input signal varies up to 34 KHz depending on the count mode and function configurations programmed. Each input signal can be independently scaled to various process values.

The Rate Meters provide a MAX and MIN reading memory with programmable capture time. The capture time is used to prevent detection of false max or min readings which may occur during start-up or unusual process events.

Optional digital output cards provide the meter with up to four setpoint outputs. The cards are available as dual relay, quad relay, quad sinking transistor, quad sourcing transistor/SSR drive, or dual triac/dual SSR drive outputs. The setpoint alarms can be configured to suit a variety of control and alarm requirements.

Communication and Bus Capabilities are also available as option cards for the PAXI only. These include RS232, RS485, Modbus, DeviceNet, and Profibus-DP. Readout values and setpoint alarm values can be controlled through the bus. Additionally, the meters have a feature that allows a remote computer to directly control the outputs of the meter. With an RS232 or RS485 card installed, it is possible to configure the meter using Red Lion's Crimson software. The configuration data can be saved to a file for later recall.

A linear DC output signal is available as an option card for the PAXI only. The card provides either 20 mA or 10 V signals. The output can be scaled independent of the input range and can track any of the counter or rate displays.

Once the meters have been initially configured, the parameter list may be locked out from further modification in its entirety or only the setpoint values can be made accessible.

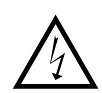
The meters have been specifically designed for harsh industrial environments. With NEMA 4X/IP65 sealed bezel and extensive testing of noise effects to CE requirements, the meter provides a tough yet reliable application solution.

SAFETY SUMMARY

All safety related regulations, local codes and instructions that appear in this literature or on equipment must be observed to ensure personal safety and to prevent damage to either the instrument or equipment connected to it. If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Do not use this meter to directly command motors, valves, or other actuators not equipped with safeguards. To do so can be potentially harmful to persons or equipment in the event of a fault to the meter.

CAUTION: Risk of Danger. Read complete instructions prior to installation and operation of the unit.



CAUTION: Risk of electric shock.

DIMENSIONS In inches (mm)

Note: Recommended minimum clearance (behind the panel) for mounting clip installation is 2.1" (53.4) H x 5" (127) W.

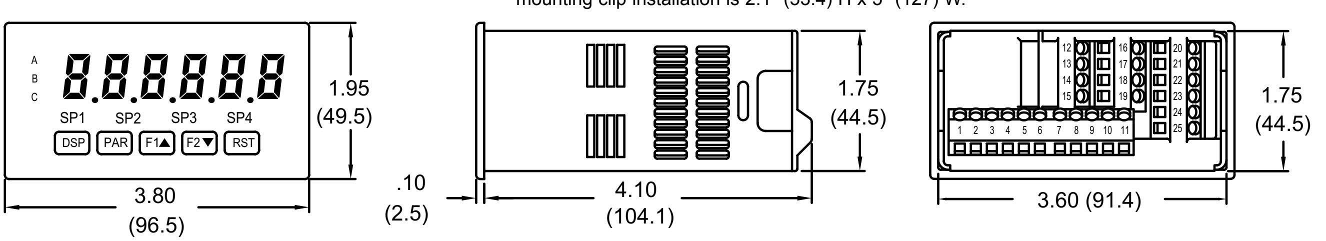
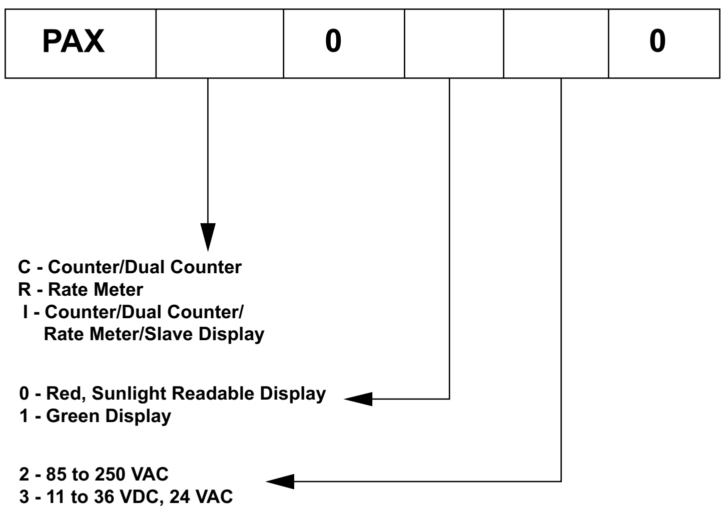


Table Of Contents

Ordering Information

Meter Part Numbers



Option Card and Accessories Part Numbers

TYPE	MODEL NO.	DESCRIPTION	PART NUMBER
Option Cards	PAXCDS	Dual Setpoint Relay Output Card	PAXCDS10
		Quad Setpoint Relay Output Card	PAXCDS20
		Quad Setpoint Sinking Open Collector Output Card	PAXCDS30
		Quad Setpoint Sourcing Open Collector Output Card	PAXCDS40
		Dual Triac/Dual SSR Drive Output Card	PAXCDS50
		Quad Form C Relay Output Card	PAXCDS60 *
	PAXCDC[1]	RS485 Serial Communications Card with Terminal Block	PAXCDC10
		Extended RS485 Serial Communications Card with Dual RJ11 Connector	PAXCDC1C
		RS232 Serial Communications Card with Terminal Block	PAXCDC20
		Extended RS232 Serial Communications Card with 9 Pin D Connector	PAXCDC2C
		DeviceNet Communications Card	PAXCDC30
		Profibus-DP Communications Card	PAXCDC50
	PAXUSB	PAX USB Programming Card (Not included in PAX product UL E179259 file).	PAXUSB00
	PAXCDL	Analog Output Card	PAXCDL10
Accessories	SFCRD[2]	Crimson PC Configuration Software for Windows 2000, XP and Windows 7	SFCRD200
	ICM8	Communication Gateway	ICM80000

** This card is not suitable for use in older PAX models. For proper installation, a case knock-out feature must be present on the top surface of the PAX case. This feature began to be introduced to the standard PAX units in July of 2014 (2614).*

Notes:

1. For Modbus communications use RS485 Communications Card and configure Communication Type parameter (tYPE) for Modbus.
2. Crimson software is available for free download from http://www.redlion.net/
3. Shaded areas are only available for the PAXI

General Meter Specifications

1. **DISPLAY:** 6 digit, 0.56" (14.2 mm) red sunlight readable or standard green LED
2. **POWER:**
   AC Versions:
   AC Power: 85 to 250 VAC, 50/60 Hz, 18 VA
   Isolation: 2300 Vrms for 1 min. to all inputs and outputs. (300 V working)
   DC Versions:
   DC Power: 11 to 36 VDC, 14 W
   (derate operating temperature to 40° C if operating <15 VDC and three option cards are installed)
   AC Power: 24 VAC, ± 10%, 50/60 Hz, 15 VA
   Isolation: 500 Vrms for 1 min. to all inputs and outputs (50 V working).
3. **SENSOR POWER:** 12 VDC, ±10%, 100 mA max. Short circuit protected
4. **KEYPAD:** 3 programmable function keys, 5 keys total
5. **USER INPUTS:** Three programmable user inputs
   Max. Continuous Input: 30 VDC
   Isolation To Sensor Input Commons: Not isolated
   Logic State: Jumper selectable for sink/source logic

INPUT STATE	SINKING INPUTS 5.1 KΩ pull-up to +12 V	SOURCING INPUTS 5.1 KΩ pull-down
Active	V_{IN} < 0.9 VDC	V_{IN} > 2.4 VDC
Inactive	V_{IN} > 2.4 VDC	V_{IN} < 0.9 VDC

   Response Time: 6 msec. typical; function dependent. Certain resets, stores and inhibits respond within 25 µsec if an edge occurs with the associated counter or within 6 msec if no count edge occurs with the associated counter. These functions include CtrStL, CtrStE, HLrStL, HLrStE, InHibt, StOrE, and PrnrSt. Once activated, all functions are latched for 50 msec min. to 100 msec max. After that period, another edge/level may be recognized.
6. **OUTPUT:**
   Response Time: 25 µsec.; add 6 msec (typical) if a relay card is installed
   Timed Output Accuracy: Counter = ± 0.01% + 10 msec.
   Rate = ± 0.01% + 20 msec.
7. **MEMORY:** Nonvolatile memory retains all programmable parameters and display values when power is removed.
8. **CERTIFICATIONS AND COMPLIANCES:**
   CE Approved
   EN 61326-1 Immunity to Industrial Locations
   Emission CISPR 11 Class A
   Safety requirements for electrical equipment for measurement, control, and laboratory use:
   EN 61010-1: General Requirements
   EN 61010-2-030: Particular Requirements for Testing and Measuring Circuits
   RoHS Compliant
   UL Recognized Component: File #E179259
   UL Listed: File #E137808
   Type 4X Indoor/Outdoor Enclosure rating (Face only)
   IP65 Enclosure rating (Face only)
   IP20 Enclosure rating (Rear of unit)
   Refer to EMC Installation Guidelines section of the bulletin for additional information.
9. **ENVIRONMENTAL CONDITIONS:**
   Operating Temperature Range: 0 to 50°C (0 to 45°C with all three cards installed)
   Storage Temperature Range: -40 to 60°C
   Operating and Storage Humidity: 0 to 85% max. relative humidity non-condensing
   Vibration to IEC 68-2-6: Operational 5 to 150 Hz, 2 g.
   Shock to IEC 68-2-27: Operational 25 g (10 g relay).
   Altitude: Up to 2000 meters
10. **CONNECTIONS:** High compression cage-clamp terminal block
    Wire Strip Length: 0.3" (7.5 mm)
    Wire Gage: 30-14 AWG copper wire
    Torque: 4.5 inch-lbs (0.51 N-m) max.
11. **CONSTRUCTION:** This unit is rated for Type 4X/IP65 use. IP20 Touch safe. Installation Category II, Pollution Degree 2. One piece bezel/case. Flame resistant. Synthetic rubber keypad. Panel gasket and mounting clip included.
12. **WEIGHT:** 10.1 oz. (286 g)

MODEL PAXC - 1/8 DIN COUNTER

- *6-DIGIT LED DISPLAY (Alternating 8 digits for counting)*
- *DUAL COUNT QUAD INPUTS*
- *UP TO 3 COUNT DISPLAYS*
- *SETPOINT ALARM OUTPUTS (W/Option card)*

PAXC SPECIFICATIONS

MAXIMUM SIGNAL FREQUENCIES:
To determine the maximum frequency for the input(s), first answer the questions with a yes (Y) or no (N). Next determine the Count Mode to be used for the counter(s). If dual counters are used with different Count Modes, then the lowest frequency applies to both counters.

FUNCTION QUESTIONS	**Single**: Counter A or B				**Dual**: Counter A & B			
Are any setpoints used?	N	N	Y	Y	N	N	Y	Y
Is Counter C used?	N	Y	N	Y	N	Y	N	Y
COUNT MODE	(Values are in KHz)				(Values are in KHz)			
Count x1	34	25	18	15	13	12	9	7.5
Count x2	17	13	9	7	9	7	5	4
Quadrature x1	22	19	12	10	7	6	4	3.5
Quadrature x2	17	13	9	7	7	6	4	3.5
Quadrature x4	8	6	4	3				

Notes:
1. Counter Modes are explained in the Module 1 programming section.
2. Listed values are with frequency DIP switch set on HI frequency.

ANNUNCIATORS:
A - Counter A
B - Counter B
C - Counter C
OF - Upper significant digit display of counter
SP1 - setpoint 1 output state
SP2 - setpoint 2 output state
SP3 - setpoint 3 output state
SP4 - setpoint 4 output state

COUNTER DISPLAYS:
Maximum display: 8 digits: ± 99999999 (greater than 6 digits, display alternates between high order and low order.)

INPUTS A and B:
DIP switch selectable to accept pulses from a variety of sources including switch contacts, TTL outputs, magnetic pickups and all standard RLC sensors.
LOGIC: Input trigger levels V_{IL} = 1.5 V max.; V_{IH} = 3.75 V min.
Current sinking: Internal 7.8 KΩ pull-up to +12 VDC, I_{MAX} = 1.9 mA.
Current sourcing: Internal 3.9 KΩ pull-down, 7.3 mA max. @ 28 VDC, V_{MAX} = 30 VDC.
Filter: Damping capacitor provided for switch contact bounce. Limits input frequency to 50 Hz and input pulse widths to 10 msec. minimum.
DUAL COUNT MODES:
When any dual count mode is used, then User Inputs 1 and/or 2 will accept the second signal of each signal pair. The user inputs do not have the Logic/Mag, HI/LO Freq, and Sink/Source input setup switches. The user inputs are inherently a logic input with no low frequency filtering. Any mechanical contacts used for these inputs in a dual count mode must be debounced externally. The user input may only be selected for sink/source by the User Jumper placement.

MODEL PAXR - 1/8 DIN RATE METER

- *5-DIGIT LED DISPLAY*
- *RATE INDICATION*
- *MINIMUM/MAXIMUM RATE DISPLAYS*
- *SETPOINT ALARM OUTPUTS (W/Option card)*

PAXR SPECIFICATIONS

ANNUNCIATORS:
r - Rate
H - Maximum (High) Rate
L - Minimum (Low) Rate
SP1 - setpoint 1 output state
SP2 - setpoint 2 output state
SP3 - setpoint 3 output state
SP4 - setpoint 4 output state

RATE DISPLAY:
Accuracy: ±0.01%
Minimum Frequency: 0.01 Hz
Maximum Frequency: 34 KHz
Maximum Display: 5 Digits: 99999
Adjustable Display (low) Update: 0.1 to 99.9 seconds
Over Range Display: “r OLOL”

INPUT A:
DIP switch selectable to accept pulses from a variety of sources including TTL outputs, magnetic pickups and all standard RLC sensors.
LOGIC: Input trigger levels V_{IL} = 1.5 V max.; V_{IH} = 3.75 V min.
Current sinking: Internal 7.8 KΩ pull-up to +12 VDC, I_{MAX} = 1.9 mA.
Current sourcing: Internal 3.9 KΩ pull-down, 7.3 mA max. @ 28 VDC, V_{MAX} = 30 VDC.
MAGNETIC PICKUP:
Sensitivity: 200 mV peak
Hysteresis: 100 mV
Input impedance: 3.9 KΩ @ 60 Hz
Maximum input voltage: ±40 V peak, 30 Vrms

MODEL PAXI - 1/8 DIN COUNTER/RATE METER

- *COUNT, RATE AND SLAVE DISPLAY*
- *6-DIGIT 0.56" RED SUNLIGHT READABLE DISPLAY*
- *VARIABLE INTENSITY DISPLAY*
- *10 POINT SCALING (FOR NON-LINEAR PROCESSES)*
- *FOUR SETPOINT ALARM OUTPUTS (W/OPTION CARD)*
- *RETRANSMITTED ANALOG OUTPUT (W/OPTION CARD)*
- *COMMUNICATION AND BUS CAPABILITIES (W/OPTION CARD)*
- *BUS CAPABILITIES; DEVICENET, MODBUS, AND PROFIBUS-DP*
- *CRIMSON PROGRAMMING SOFTWARE*

PAXI SPECIFICATIONS

MAXIMUM SIGNAL FREQUENCIES TABLE

To determine the maximum frequency for the input(s), first answer the questions with a yes (Y) or no (N). Next determine the Count Mode to be used for the counter(s). If dual counters are used with different Count Modes, then the lowest frequency applies to both counters.

FUNCTION QUESTIONS	**Single**: Counter A or B (with/without rate) or Rate only								**Dual**: Counter A & B or Rate not assigned to active single counter							
Are any setpoints used?	N	N	N	N	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y
Is Prescaler Output used?	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
Is Counter C used?	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
COUNT MODE	(Values are in KHz)				(Values are in KHz)				(Values are in KHz)				(Values are in KHz)			
Count x1	34	25	21	17	18	15	13	11	13	12	13	11	9	7.5	9	7
Count x2	17	13	16	12	9	7	8	7	9 *	7 *	9 *	7 *	5 *	4 *	5 *	4 *
Quadrature x1	22	19	20	17	12	10	11	10	7 *	6 *	6 *	5 *	4 *	3.5 *	3.5 *	3 *
Quadrature x2	17	13	16	12	9	7	8	6	7 *	6 *	6 *	5 *	4 *	3.5 *	3.5 *	3 *
Quadrature x4	8	6	8	6	4	3	4	3								
Rate Only	34	N/A	21	N/A	34	N/A	21	N/A								

Notes:
1. Counter Modes are explained in the Module 1 programming section.
2. If using Rate with single counter with direction or quadrature, assign it to Input A for the listed frequency.
3. * Double the listed value for Rate frequency.
4. Listed values are with frequency DIP switch set on HI frequency.
5. Derate listed frequencies by 20% during serial communications. (Placing a 5 msec. delay between serial characters will eliminate the derating.)

ANNUNCIATORS:
A - Counter A
B - Counter B
C - Counter C
r - Rate
H - Maximum (High) Rate
L - Minimum (Low) Rate
OF - Upper significant digit display of counter
SP1 - setpoint 1 output state
SP2 - setpoint 2 output state
SP3 - setpoint 3 output state
SP4 - setpoint 4 output state

RATE DISPLAY:
Accuracy: ±0.01%
Minimum Frequency: 0.01 Hz
Maximum Frequency: see Max Signal Frequencies Table.
Maximum Display: 5 Digits: 99999
Adjustable Display (low) Update: 0.1 to 99.9 seconds
Over Range Display: "r OLOL"

COUNTER DISPLAYS:
Maximum display: 8 digits: ± 99999999 (greater than 6 digits, the display alternates between high order and low order.)

INPUTS A and B:
DIP switch selectable to accept pulses from a variety of sources including switch contacts, TTL outputs, magnetic pickups and all standard RLC sensors.
LOGIC: Input trigger levels V_{IL} = 1.5 V max.; V_{IH} = 3.75 V min.
Current sinking: Internal 7.8 KΩ pull-up to +12 VDC, I_{MAX} = 1.9 mA.
Current sourcing: Internal 3.9 KΩ pull-down, 7.3 mA max. @ 28 VDC, V_{MAX} = 30 VDC.
Filter: Damping capacitor provided for switch contact bounce. Limits input frequency to 50 Hz and input pulse widths to 10 msec. minimum.
MAGNETIC PICKUP:
Sensitivity: 200 mV peak
Hysteresis: 100 mV
Input impedance: 3.9 KΩ @ 60 Hz
Maximum input voltage: ±40 V peak, 30 Vrms
DUAL COUNT MODES:
When any dual count mode is used, then User Inputs 1 and/or 2 will accept the second signal of each signal pair. The user inputs do not have the Logic/Mag, HI/LO Freq, and Sink/Source input setup switches. The user inputs are inherently a logic input with no low frequency filtering. Any mechanical contacts used for these inputs in a dual count mode must be debounced externally. The user input may only be selected for sink/source by the User Jumper placement.

PRESCALER OUTPUT:
NPN Open Collector: I_{SNK} = 100 mA max. @ V_{OL} = 1 VDC max. V_{OH} = 30 VDC max. With duty cycle of 25% min. and 50 % max.

OPTION CARDS

WARNING: Disconnect all power to the unit before installing option cards.

Adding Option Cards

The PAX and MPAX series meters can be fitted with up to three option cards. The details for each option card can be reviewed in the specification section below. Only one card from each function type can be installed at one time. The function types include Setpoint Alarms (PAXCDS), Communications (PAXCDC), and Analog Output (PAXCDL). The option cards can be installed initially or at a later date.

PAXI COMMUNICATION CARDS (PAXCDC)

A variety of communication protocols are available for the PAX and MPAX series. Only one of these cards can be installed at a time. When programming the unit via Crimson, a Windows® based program, the RS232, RS485 or USB Cards must be used. *Note: For Modbus communications use RS485 Communications Output Card and configure Communication Type parameter (tYPE) for Modbus.*

SERIAL COMMUNICATIONS CARD: PAXCDC1_ and PAXCDC2_
Type: RS485 or RS232
Communication Type: RLC Protocol (ASCII), Modbus RTU, and Modbus ASCII
Isolation To Sensor & User Input Commons: 500 Vrms for 1 min. Not Isolated from all other commons.
Data: 7/8 bits
Baud: 1200 to 38,400
Parity: no, odd or even
Bus Address: Selectable 0 to 99 (RLC Protocol), or 1 to 247 (Modbus Protocol), Max. 32 meters per line (RS485)
Transmit Delay: Selectable for 0 to 0.250 sec (+2 msec min)

DEVICENET™ CARD: PAXCDC30
Compatibility: Group 2 Server Only, not UCMM capable
Baud Rates: 125 Kbaud, 250 Kbaud, and 500 Kbaud
Bus Interface: Phillips 82C250 or equivalent with MIS wiring protection per DeviceNet™ Volume I Section 10.2.2.
Node Isolation: Bus powered, isolated node
Host Isolation: 500 Vrms for 1 minute between DeviceNet™ and meter input common.

PAXUSB PROGRAMMING CARD: PAXUSB00
Type: USB Virtual Comms Port
Connection: Type mini B
Isolation To Sensor & User Input Commons: 500 Vrms for 1 min. Not Isolated from all other commons.
Baud Rate: 1200 to 38,400
Unit Address: Selectable 0 to 99 (RLC Protocol), or 1 to 247 (Modbus Protocol)

PROFIBUS-DP CARD: PAXCDC50
Fieldbus Type: Profibus-DP as per EN 50170, implemented with Siemens SPC3 ASIC
Conformance: PNO Certified Profibus-DP Slave Device
Baud Rates: Automatic baud rate detection in the range 9.6 Kbaud to 12 Mbaud
Station Address: 0 to 125, set by rotary switches.
Connection: 9-pin Female D-Sub connector
Network Isolation: 500 Vrms for 1 minute between Profibus network and sensor and user input commons. Not isolated from all other commons.

SETPOINT CARDS (PAXCDS)

The PAX and MPAX series has 6 available setpoint alarm output option cards. Only one of these cards can be installed at a time. (Logic state of the outputs can be reversed in the programming.)

DUAL RELAY CARD: PAXCDS10
Type: Two FORM-C relays
Isolation To Sensor & User Input Commons: 2000 Vrms for 1 min.
Contact Rating:
One Relay Energized: 5 amps @ 120/240 VAC or 28 VDC (resistive load).
Total current with both relays energized not to exceed 5 amps
Life Expectancy: 100 K cycles min. at full load rating. External RC snubber extends relay life for operation with inductive loads

QUAD RELAY CARD: PAXCDS20
Type: Four FORM-A relays
Isolation To Sensor & User Input Commons: 2300 Vrms for 1 min.
Contact Rating:
One Relay Energized: 3 amps @ 250 VAC or 30 VDC (resistive load).
Total current with all four relays energized not to exceed 4 amps
Life Expectancy: 100K cycles min. at full load rating. External RC snubber extends relay life for operation with inductive loads

QUAD SINKING OPEN COLLECTOR CARD: PAXCDS30
Type: Four isolated sinking NPN transistors.
Isolation To Sensor & User Input Commons: 500 Vrms for 1 min. Not Isolated from all other commons.
Rating: 100 mA max @ V_{SAT} = 0.7 V max. V_{MAX} = 30 V

QUAD SOURCING OPEN COLLECTOR CARD: PAXCDS40
Type: Four isolated sourcing PNP transistors.
Isolation To Sensor & User Input Commons: 500 Vrms for 1 min. Not Isolated from all other commons.
Rating: Internal supply: 24 VDC ± 10% , 30 mA max. total
External supply: 30 VDC max., 100 mA max. each output

DUAL TRIAC/DUAL SSR DRIVE CARD: PAXCDS50
Triac:
Type: Isolated, zero crossing detection
Voltage: 260 VAC max., 20 VAC min.
Max Load Current: 1 Amp @ 25°C
0.75 Amp @ 50°C
Total load current with both triacs ON not to exceed 1.5 Amps
Min Load Current: 5 mA
Off State Leakage Current: 1 mA max @ 60 Hz
Operating Frequency: 20-400 Hz
SSR Drive:
Type: Two isolated sourcing PNP Transistors.
Isolation To Sensor & User Input Commons: 500 Vrms for 1 min. Not Isolated from all other commons.
Rating:
Output Voltage: 18/24 VDC (unit dependent) ± 10%, 30 mA max. total both outputs

QUAD FORM C RELAY CARD: PAXCDS60
Type: Four FORM-C relays
Isolation To Sensor & User Input Commons: 500 Vrms for 1 min.
Contact Rating:
Rated Load: 3 Amp @ 30 VDC/125 VAC
Total Current With All Four Relays Energized not to exceed 4 amps
Life Expectancy: 100 K cycles min. at full load rating. External RC snubber extends relay life for operation with inductive loads

PAXI LINEAR DC OUTPUT CARD (PAXCDL)

Either a 0(4)-20 mA or 0-10 V retransmitted linear DC output is available from the analog output option card. The programmable output low and high scaling can be based on various display values. Reverse slope output is possible by reversing the scaling point positions.

ANALOG OUTPUT CARD: PAXCDL10 **- Self-Powered Output (Active)**
Types: 0 to 20 mA, 4 to 20 mA or 0 to 10 VDC
Isolation To Sensor & User Input Commons: 500 Vrms for 1 min. Not Isolated from all other commons.
Accuracy: 0.17% of FS (18 to 28°C); 0.4% of FS (0 to 50°C)
Resolution: 1/3500
Compliance: 10 VDC: 10 KΩ load min., 20 mA: 500 Ω load max.
Response Time: 50 msec. max., 10 msec. typ.

Crimson Programming Software

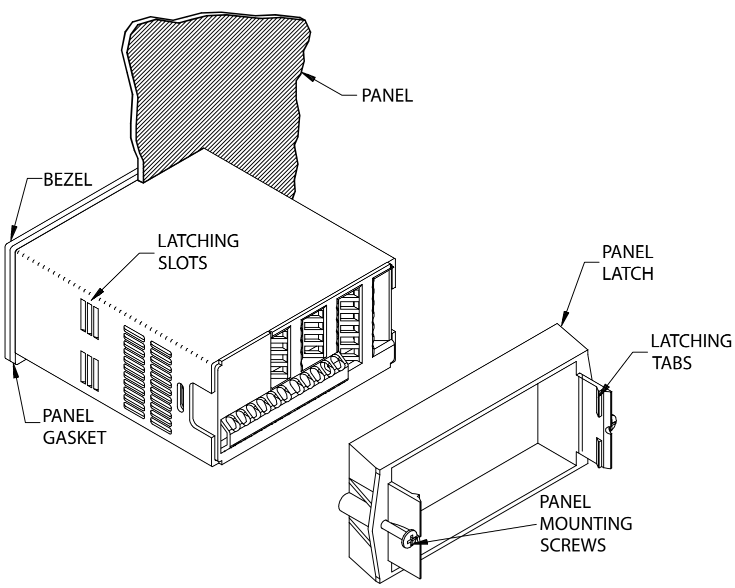
Crimson software is a Windows® based program that allows configuration of the PAX meter from a PC. Crimson offers standard drop-down menu commands, that make it easy to program the meter. The meter's program can then be saved in a PC file for future use. A PAX serial option card or PAX USB programming card is required to program the meter using the software.

1.0 Installing the Meter

Installation

The PAX meets NEMA 4X/IP65 requirements when properly installed. The unit is intended to be mounted into an enclosed panel. Prepare the panel cutout to the dimensions shown. Remove the panel latch from the unit. Slide the panel gasket over the rear of the unit to the back of the bezel. The unit should be installed fully assembled. Insert the unit into the panel cutout.

While holding the unit in place, push the panel latch over the rear of the unit so that the tabs of the panel latch engage in the slots on the case. The panel latch should be engaged in the farthest forward slot possible. To achieve a proper seal, tighten the latch screws evenly until the unit is snug in the panel (Torque to approximately 7 in-lbs [79N-cm]). Do not over-tighten the screws.



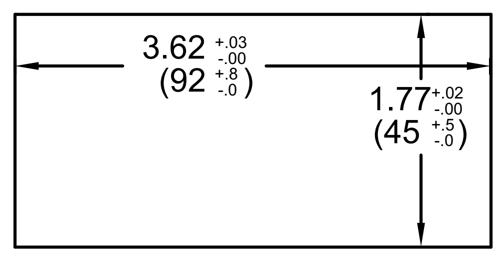
Installation Environment

The unit should be installed in a location that does not exceed the operating temperature and provides good air circulation. Placing the unit near devices that generate excessive heat should be avoided.

The bezel should only be cleaned with a soft cloth and neutral soap product. Do NOT use solvents. Continuous exposure to direct sunlight may accelerate the aging process of the bezel.

Do not use tools of any kind (screwdrivers, pens, pencils, etc.) to operate the keypad of the unit.

PANEL CUT-OUT



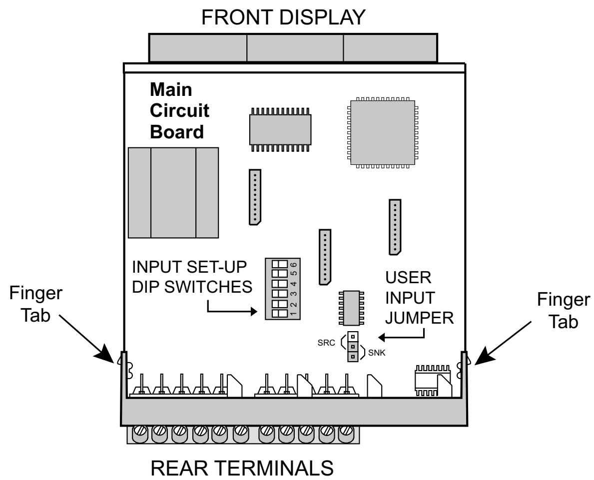
2.0 SETTING THE JUMPER AND DIP SWITCHES

To access the jumper and switches, remove the meter base from the meter case by firmly squeezing and pulling back on the side rear finger tabs. This should lower the latch below the case slot (which is located just in front of the finger tabs). It is recommended to release the latch on one side, then start the other side latch.

2.1 SETTING THE JUMPER

The meter has one jumper for user input logic. When using the user inputs this jumper must be set before applying power. The Main Circuit Board figure shows the location of the jumper and DIP switch.

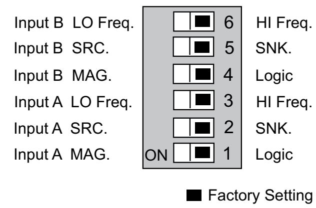
The user input jumper determines signal logic for the user inputs, when they are used with user functions or for input signal direction. All user inputs are set by this jumper.



Warning: Exposed line voltage exists on the circuit boards. Remove all power to the meter and load circuits before accessing inside of the meter.

2.2 SETTING THE INPUT DIP SWITCHES

The meter has six DIP switches for Input A and Input B terminal set-up that must be set before applying power. NOTE: The PAXR only uses switches 1-3.



SWITCHES 1 and 4

LOGIC: Input trigger levels V_{IL} = 1.5 V max.; V_{IH} = 3.75 V min.
MAG: 200 mV peak input (must also have SRC on). Not recommended with counting applications.

SWITCHES 2 and 5

SRC.: Adds internal 3.9 KΩ pull-down resistor, 7.3 mA max. @ 28 VDC, V_{MAX} = 30 VDC.
SNK.: Adds internal 7.8 KΩ pull-up resistor to +12 VDC, I_{MAX} = 1.9 mA.

SWITCHES 3 and 6

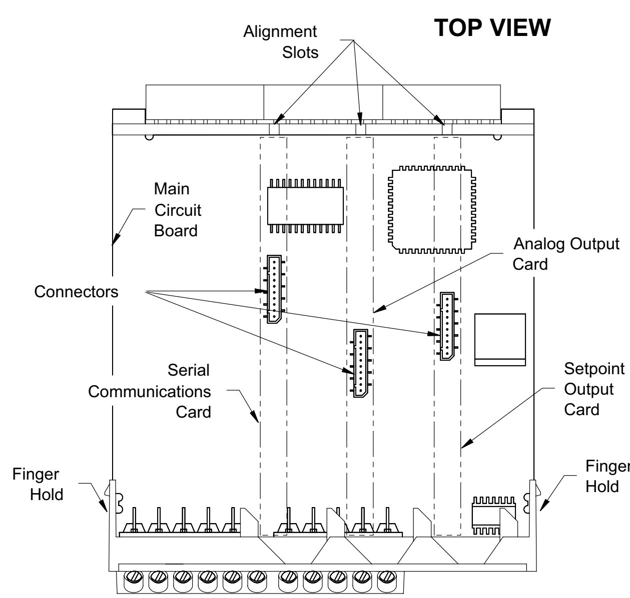
HI Frequency: Removes damping capacitor and allows max. frequency.

LO Frequency: Adds a damping capacitor for switch contact bounce. Also limits input frequency to 50 Hz and input pulse widths to 10 msec.

3.0 INSTALLING OPTION CARDS

The option cards are separately purchased optional cards that perform specific functions. These cards plug into the main circuit board of the meter. The option cards have many unique functions when used with the PAX.
Note: The PAXC and PAXR only use the setpoint option card.

CAUTION: The option card and main circuit board contain static sensitive components. Before handling the cards, discharge static charges from your body by touching a grounded bare metal object. Ideally, handle the cards at a static controlled clean workstation. Also, only handle the cards by the edges. Dirt, oil or other contaminants that may contact the cards can adversely affect circuit operation.

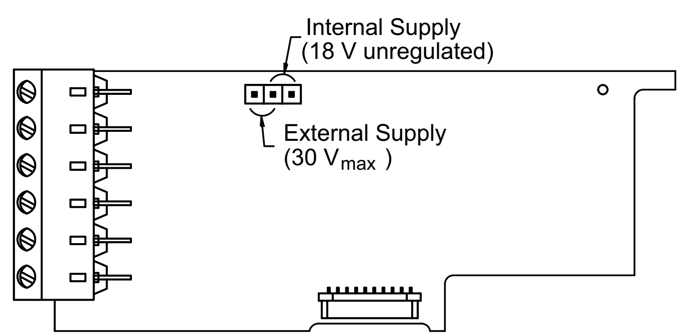


To Install:

1. With the case open, locate the option card connector for the card type to be installed. The types are keyed by position with different main circuit board connector locations. When installing the card, hold the meter by the rear terminals and not by the front display board.*
2. Install the option card by aligning the card terminals with the slot bay in the rear cover. Be sure the connector is fully engaged and the tab on the option card rests in the alignment slot on the display board.
3. Slide the meter base back into the case. Be sure the rear cover latches fully into the case.
4. Apply the option card label to the bottom side of the meter in the designated area. Do Not Cover the vents on the top surface of the meter. The surface of the case must be clean for the label to adhere properly.

Quad Sourcing Open Collector Output Card Supply Select

* If installing the Quad sourcing Option Card (PAXCDS40), set the jumper for internal or external supply operation before continuing.



4.0 WIRING THE METER

WIRING OVERVIEW

Electrical connections are made via screw-clamp terminals located on the back of the meter. All conductors should conform to the meter's voltage and current ratings. All cabling should conform to appropriate standards of good installation, local codes and regulations. It is recommended that the power supplied to the meter (DC or AC) be protected by a fuse or circuit breaker.

When wiring the meter, compare the numbers embossed on the back of the meter case against those shown in wiring drawings for proper wire position. Strip the wire, leaving approximately 0.3" (7.5 mm) bare lead exposed (stranded wires should be tinned with solder.) Insert the lead under the correct screw-clamp terminal and tighten until the wire is secure. (Pull wire to verify tightness.) Each terminal can accept up to one #14 AWG (2.55 mm) wire, two #18 AWG (1.02 mm), or four #20 AWG (0.61 mm).

EMC INSTALLATION GUIDELINES

Although Red Lion Controls Products are designed with a high degree of immunity to Electromagnetic Interference (EMI), proper installation and wiring methods must be followed to ensure compatibility in each application. The type of the electrical noise, source or coupling method into a unit may be different for various installations. Cable length, routing, and shield termination are very important and can mean the difference between a successful or troublesome installation. Listed are some EMI guidelines for a successful installation in an industrial environment.

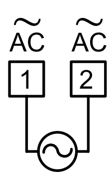
1. A unit should be mounted in a metal enclosure, which is properly connected to protective earth.
2. Use shielded cables for all Signal and Control inputs. The shield connection should be made as short as possible. The connection point for the shield depends somewhat upon the application. Listed below are the recommended methods of connecting the shield, in order of their effectiveness.
   a. Connect the shield to earth ground (protective earth) at one end where the unit is mounted.
   b. Connect the shield to earth ground at both ends of the cable, usually when the noise source frequency is over 1 MHz.
3. Never run Signal or Control cables in the same conduit or raceway with AC power lines, conductors, feeding motors, solenoids, SCR controls, and heaters, etc. The cables should be run through metal conduit that is properly grounded. This is especially useful in applications where cable runs are long and portable two-way radios are used in close proximity or if the installation is near a commercial radio transmitter. Also, Signal or Control cables within an enclosure should be routed as far away as possible from contactors, control relays, transformers, and other noisy components.
4. Long cable runs are more susceptible to EMI pickup than short cable runs.
5. In extremely high EMI environments, the use of external EMI suppression devices such as Ferrite Suppression Cores for signal and control cables is effective. The following EMI suppression devices (or equivalent) are recommended:
   Fair-Rite part number 0443167251 (RLC part number FCOR0000)
   Line Filters for input power cables:
   Schaffner # FN2010-1/07 (Red Lion Controls # LFIL0000)
6. To protect relay contacts that control inductive loads and to minimize radiated and conducted noise (EMI), some type of contact protection network is normally installed across the load, the contacts or both. The most effective location is across the load.
   a. Using a snubber, which is a resistor-capacitor (RC) network or metal oxide varistor (MOV) across an AC inductive load is very effective at reducing EMI and increasing relay contact life.
   b. If a DC inductive load (such as a DC relay coil) is controlled by a transistor switch, care must be taken not to exceed the breakdown voltage of the transistor when the load is switched. One of the most effective ways is to place a diode across the inductive load. Most RLC products with solid state outputs have internal zener diode protection. However external diode protection at the load is always a good design practice to limit EMI. Although the use of a snubber or varistor could be used.
   RLC part numbers: Snubber: SNUB0000
   Varistor: ILS11500 or ILS23000
7. Care should be taken when connecting input and output devices to the instrument. When a separate input and output common is provided, they should not be mixed. Therefore a sensor common should NOT be connected to an output common. This would cause EMI on the sensitive input common, which could affect the instrument's operation.

Visit RLC's web site at http://www.redlion.net/emi for more information on EMI guidelines, Safety and CE issues as they relate to Red Lion Controls products.

4.1 POWER WIRING

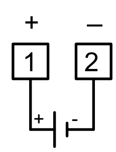
AC Power

Terminal 1: VAC
Terminal 2: VAC



DC Power

Terminal 1: +VDC
Terminal 2: -VDC



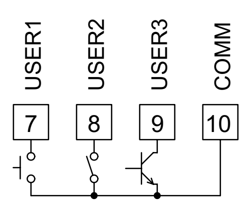
4.2 USER INPUT WIRING

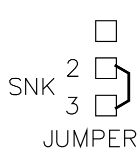
Before connecting the wires, the User Input Logic Jumper should be verified for proper position. If User Input 1 and/ or 2 are wired for quadrature or directional counting, an additional switching device should not be connected to that User Input terminal. Only the appropriate User Input terminal has to be wired.

Sinking Logic

Terminals 7-9 } Connect external switching device between the
Terminal 10 } appropriate User Input terminal and User Comm.

The user inputs of the meter are internally pulled up to +12 V with 5.1 K resistance. The input is active when it is pulled low (<0 .9 V).

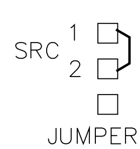


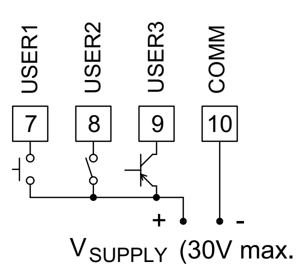


Sourcing Logic

Terminals 7-9:
+ VDC through external switching device
Terminal 10:
-VDC through external switching device

The user inputs of the meter are internally pulled down to 0 V with 5.1 K resistance. The input is active when a voltage greater than 2.4 VDC is applied.

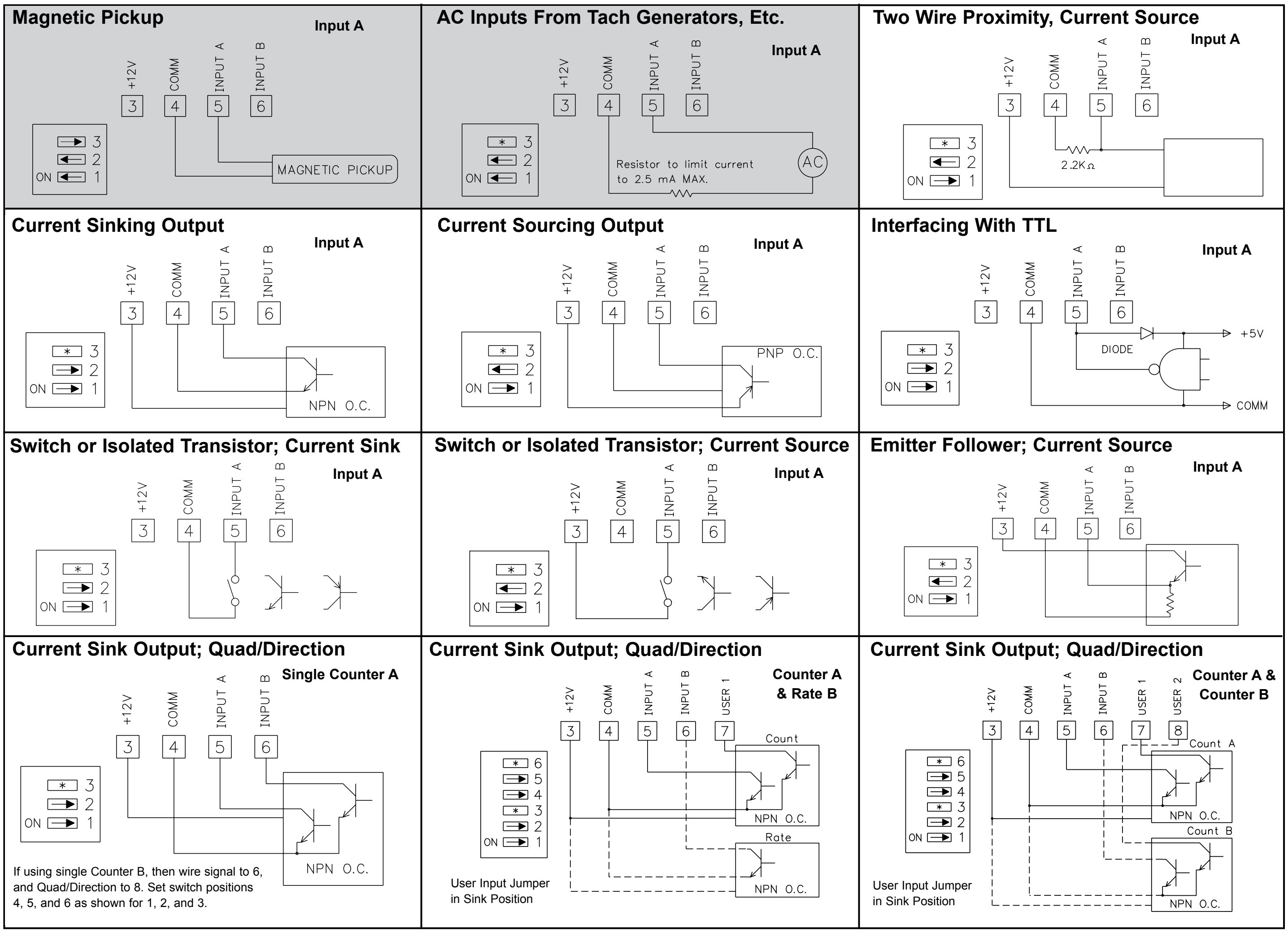




4.3 INPUT WIRING

CAUTION: Sensor input common is NOT isolated from user input common. In order to preserve the safety of the meter application, the sensor input common must be suitably isolated from hazardous live earth referenced voltage; or input common must be at protective earth ground potential. If not, hazardous voltage may be present at the User Inputs and User Input Common terminals. Appropriate considerations must then be given to the potential of the user input common with respect to earth ground; and the common of the isolated option cards with respect to input common.

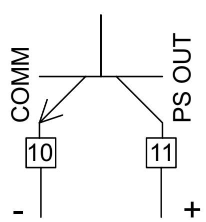
If you are wiring Input B, connect signal to Terminal 6 instead of 5, and set DIP switches 4, 5, and 6 to the positions shown for 1, 2, and 3.



Switch position is application dependent.

Shaded areas not recommended for counting applications.

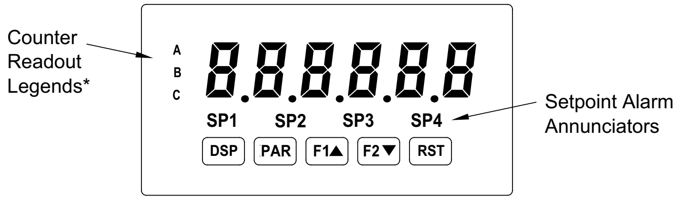
4.4 PAXI PRESCALER OUTPUT WIRING (NPN O.C.)



4.5 SETPOINT (ALARMS) WIRING
4.6 SERIAL COMMUNICATION WIRING
4.7 ANALOG OUTPUT WIRING

See appropriate option card bulletin for wiring details.

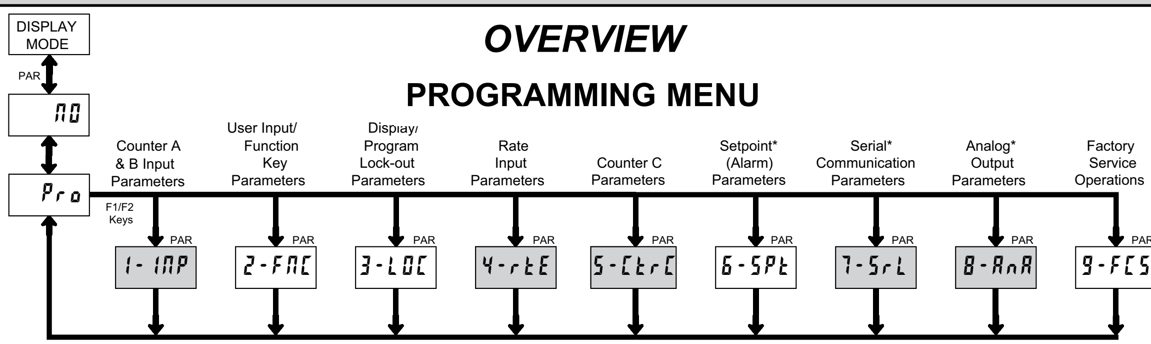
5.0 Reviewing the Front Buttons and Display



KEY	DISPLAY MODE OPERATION	PROGRAMMING MODE OPERATION
DSP	Index display through the selected displays.	Quit programming and return to Display Mode
PAR	Access Programming Mode	Store selected parameter and index to next parameter
F1▲	Function key 1; hold for 3 seconds for Second Function 1 **	Increment selected parameter value or selections
F2▼	Function key 2; hold for 3 seconds for Second Function 2 **	Decrement selected parameter value or selections
RST	Reset (Function key) ***	Advances digit location in parameter values

* Counters B, and C are locked out in Factory Settings (PAXC and PAXI only).
** Factory setting for the F1, and F2 keys is NO mode.
*** Factory setting for the RST key is dSPrSt (Reset Display).

6.0 Programming the Meter



Shaded areas represent program access that is model dependent.

* Only accessible with appropriate option card.

PROGRAMMING MODE ENTRY (PAR KEY)

The meter normally operates in the Display Mode. No parameters can be programmed in this mode. The Programming Mode is entered by pressing the **PAR** key. If it is not accessible then it is locked by either a security code, or a hardware lock.

Two types of programming modes are available. Quick Programming Mode permits only certain parameters to be viewed and/or modified. All meter functions continue to operate except the front panel keys change to Programming Mode Operations. Quick Programming Mode is configured in Module 3. Full Programming Mode permits all parameters to be viewed and modified. In this mode, incoming counts may not be recognized correctly, the front panel keys change to Programming Mode Operations and certain user input functions are disabled. Throughout this document, Programming Mode (without Quick in front) always refers to "Full" Programming.

MODULE ENTRY (ARROW & PAR KEYS)

The Programming Menu is organized into nine modules. These modules group together parameters that are related in function. The display will alternate between Pro and the present module. The arrow keys (**F1▲** and **F2▼**) are used to select the desired module. The displayed module is entered by pressing the **PAR** key.

MODULE MENU (PAR KEY)

Each module has a separate module menu (which is shown at the start of each module discussion). The **PAR** key is pressed to advance to a particular parameter to be changed, without changing the programming of preceding parameters. After completing a module, the display will return to Pro NO. Programming may continue by accessing additional modules.

SELECTION / VALUE ENTRY (ARROW & PAR KEYS)

For each parameter, the display alternates between the present parameter and the selections/value for that parameter. The arrow keys (**F1▲** and **F2▼**) are used to move through the selections/values for that parameter. Pressing the **PAR** key, stores and activates the displayed selection/value. This also advances the meter to the next parameter.

For numeric values, the **RST** key may be used to select a specific digit to be changed. Once a digit is selected, the arrow keys are used to increment or decrement that digit to the desired number.

PROGRAMMING MODE EXIT (DSP KEY or at Pro NO PAR KEY)

The Programming Mode is exited by pressing the **DSP** key (from anywhere in the Programming Mode) or the **PAR** key (with Pro NO displayed). This will commit any stored parameter changes to memory and return the meter to the Display Mode. If a parameter was just changed, the **PAR** key should be pressed to store the change before pressing the **DSP** key. (If power loss occurs before returning to the Display Mode, verify recent parameter changes.)

PROGRAMMING TIPS

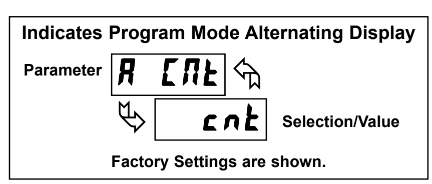
It is recommended to start with Module 1 for counting and Module 4 for rate. If lost or confused while programming, press the **DSP** key and start over. When programming is complete, it is recommended to record the parameter programming on the Parameter User Chart and lock out parameter programming with a user input or lock-out code.

FACTORY SETTINGS

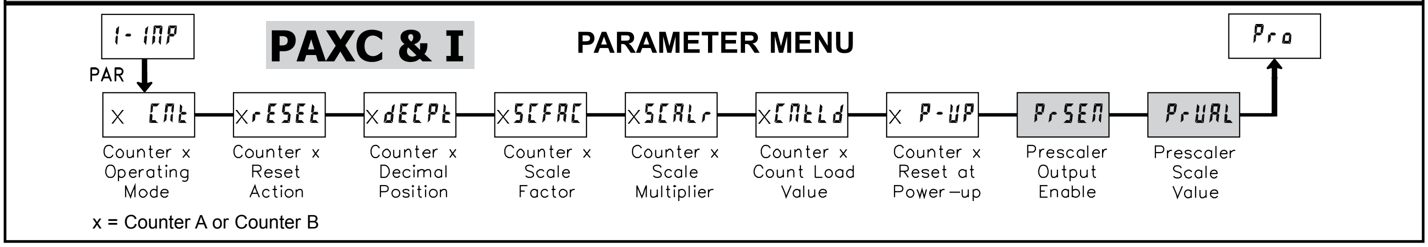
Factory Settings may be completely restored in Module 9. This is a good starting point for programming problems. Most parameters can be left at their Factory Settings without affecting basic start-up.

ALTERNATING SELECTION DISPLAY

In the explanation of the modules, the following dual display with arrows will appear. This is used to illustrate the display alternating between the parameter on top and the parameter's Factory Setting on the bottom. In most cases, selections and values for the parameter will be listed on the right.



6.1 MODULE 1 - COUNT A & B INPUT PARAMETERS (1-INP)



Module 1 is the programming for Counter A, Counter B and the Prescaler Output. Counter B parameters follow the Prescaler parameters. For maximum input frequency, the counters should be set to mode NONE and the Prescaler to NO when they are not in use. When set to NONE or NO, the remaining related parameters are not accessible. A corresponding annunciator indicates the counter being shown in the Display Mode. An Exchange Parameter Lists feature for scale factors and count load values is explained in Module 2.

COUNTER A OPERATING MODE

A CNt → cnt

NONE cnt cntud dcntud quAd1 quAd2 quAd4 dquAd1 dquAd2 cnt2 cntud2 dctud2

Select the operating mode for Counter A.

SELECTION	MODE	DESCRIPTION
NONE		Does not count.
cnt	Count X1	Adds Input A falling edge.
cntud	Count X1 w/direction	Adds Input A falling edge if Input B is high. Subtracts Input A falling edge if Input B is low.
dcntud	Count X1 w/direction	Adds Input A falling edge if User 1 is high. Subtracts Input A falling edge if User 1 is low.
quAd1	Quad X1	Adds Input A rising edge when Input B is high. Subtracts Input A falling edge when Input B is high.
quAd2	Quad X2	Adds Input A rising edge when Input B is high and Input A falling edge when Input B is low. Subtracts Input A falling edge when Input B is high and Input A rising edge when Input B is low.
quAd4	Quad X4	Adds Input A rising edge when Input B is high, Input A falling edge when Input B is low, Input B rising edge when Input A is low, and Input B falling edge when Input A is high. Subtracts Input A falling edge when Input B is high, Input A rising edge when Input B is low, Input B rising edge when Input A is high, and Input B falling edge when Input A is low.
dquAd1	Quad X1	Adds Input A rising edge when User 1 is high. Subtracts Input A falling edge when User 1 is high.
dquAd2	Quad X2	Adds Input A rising edge when User 1 is high and Input A falling edge when User 1 is low. Subtracts Input A falling edge when User 1 is high and Input A rising edge when User 1 is low.
cnt2	Count X2	Adds Input A rising and falling edges.
cntud2	Count X2 w/direction	Adds Input A rising and falling edges if Input B is high. Subtracts Input A rising and falling edge if Input B is low.
dctud2	Count X2 w/direction	Adds Input A rising and falling edges if User 1 is high. Subtracts Input A rising and falling edge if User 1 is low.

COUNTER A RESET ACTION

ArESEt → ZErO

ZErO CNtLd

When Counter A is reset, it returns to zero or Counter A count load value. This reset action affects all Counter A resets, except the Setpoint Counter Auto Reset in Module 6.

COUNTER A DECIMAL POSITION

AdECPt → 0

0 0.00 0.0000 0.0 0.000 0.00000

This selects the decimal point position for Counter A and any setpoint value assigned to Counter A. The selection will also affect Counter A scale factor calculations.

COUNTER A SCALE FACTOR

ASCFAC → 1.00000

0.00001 to 9.99999

The number of input counts is multiplied by the scale factor and the scale multiplier to obtain the desired process value. A scale factor of 1.00000 will result in the display of the actual number of input counts. (Details on scaling calculations are explained at the end of this section.)

COUNTER A SCALE MULTIPLIER

ASCALr → 1

1 0.1 0.01

The number of input counts is multiplied by the scale multiplier and the scale factor to obtain the desired process value. A scale multiplier of 1 will result in only the scale factor affecting the display. (Details on scaling calculations are explained at the end of this section.)

COUNTER A COUNT LOAD VALUE

ACNtLd → 500

-99999 to 999999

When reset to count load action is selected, Counter A will reset to this value.

COUNTER A RESET POWER-UP

A P-UP → NO

YES NO

Counter A may be programmed to reset at each meter power-up.

PAXI: PRESCALER OUTPUT ENABLE

PrSEN → NO

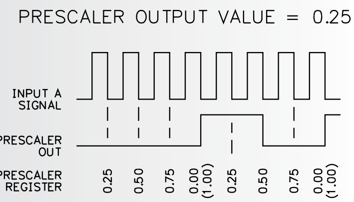
YES NO

This enables the prescaler output. The prescaler output is useful for providing a lower frequency scaled pulse train to a PLC or another external counter. On each falling edge of Input A, the prescaler output register increments by the prescaler scale value (PrVAL). When the register equals or exceeds 1.0000, a pulse is output and the register is lowered by 1.0000. The prescaler register is reset to zero whenever Counter A is reset (except for Setpoint Counter Auto Reset). (See Prescaler Output Figure.)

PAXI: PRESCALER SCALE VALUE

PrVAL → 1.0000   0.0001 to 1.0000

The prescaler output frequency is the Input A frequency times the prescaler scale value.



COUNTER B OPERATING MODE

b CNt → NONE   NONE   cnt   dcntud   dquAd1   dquAd2   cnt2   dctud2

Select the operating mode for Counter B.

SELECTION	MODE	DESCRIPTION
NONE		Does not count.
cnt	Count X1	Adds Input B falling edge.
dcntud	Count X1 w/direction	Adds Input B falling edge if User 2 is high. Subtracts Input B falling edge if User 2 is low.
dquAd1	Quad X1	Adds Input B rising edge when User 2 is high. Subtracts Input B falling edge when User 2 is high.
dquAd2	Quad X2	Adds Input B rising edge when User 2 is high and Input B falling edge when User 2 is low. Subtracts Input B falling edge when User 2 is high and Input B rising edge when User 2 is low.
cnt2	Count X2	Adds Input B rising and falling edges.
dctud2	Count X2 w/direction	Adds Input B rising and falling edges if User 2 is high. Subtracts Input B rising and falling edge if User 2 is low.

COUNTER B RESET ACTION

brESEt → ZEro   ZEro   CNtLd

When Counter B is reset, it returns to zero or Counter B count load value. This reset action affects all Counter B resets, except the Setpoint Counter Auto Reset Action in Module 6.

COUNTER B DECIMAL POSITION

bdECPt → 0   0   0.00   0.0000   0.0   0.000   0.00000

This selects the decimal point position for Counter B and any setpoint value assigned to Counter B. The selection will also affect Counter B scale factor calculations.

COUNTER B SCALE FACTOR

bSCFAC → 1.00000   0.00001 to 9.99999

The number of input counts is multiplied by the scale factor and the scale multiplier to obtain the desired process value. A scale factor of 1.00000 will result in the display of the actual number of input counts. (Details on scaling calculations are explained at the end of this section.)

COUNTER B SCALE MULTIPLIER

bSCALr → 1   1   0.1   0.01

The number of input counts is multiplied by the scale multiplier and the scale factor to obtain the desired process value. A scale multiplier of 1 will result in only the scale factor affecting the display. (Details on scaling calculations are explained at the end of this section.)

COUNTER B COUNT LOAD VALUE

bCNtLd → 500   -99999 to 999999

When reset to count load action is selected, Counter B will reset to this value.

COUNTER B RESET POWER-UP

b P-UP → NO   YES   NO

Counter B may be programmed to reset at each meter power-up.

8 DIGIT COUNT VALUES

Any counter display value below -99999 or above 999999 (less decimal point) will consist of a two part display. This display alternates between the least 6 significant digits and the remaining most significant digits beginning with "OF" in the display. If the display exceeds ± 99999999 the display will roll to zero and continue counting. Outputs cannot be set to counter values above 6 digits. The annunciator, indicating the counter being displayed, will flash when the value is above 6 digits.

SCALING CALCULATIONS

Each counter has the ability to scale an input signal to a desired display value. This is accomplished by the counter mode (x-CNt), scale factor (xSCFAC), scale multiplier (xSCALr) and decimal point (xdECPt). The scale factor is calculated using:

$$\text{SF (xSCFAC)} = \frac{\text{Desired Display Decimal DDD}}{\text{(Number of pulses per 'single' unit x CM x SM)}}$$

Where:

Desired Display Decimal DDD	xdECPt	Counter Decimal Selection
1	0	None
10	0.0	Tenths
100	0.00	Hundredths
1000	0.000	Thousandths
10000	0.0000	Ten Thousandths
100000	0.00000	Hundred Thousandths

Number of pulses per 'single' unit: pulses per unit generated by the process (i.e. # of pulses per foot)
CM: Counter Mode(x-CNt) times factor of the mode 1,2 or 4.
SM: Scale Multiplier (xSCALr) selection of 1, 0.1 or 0.01.

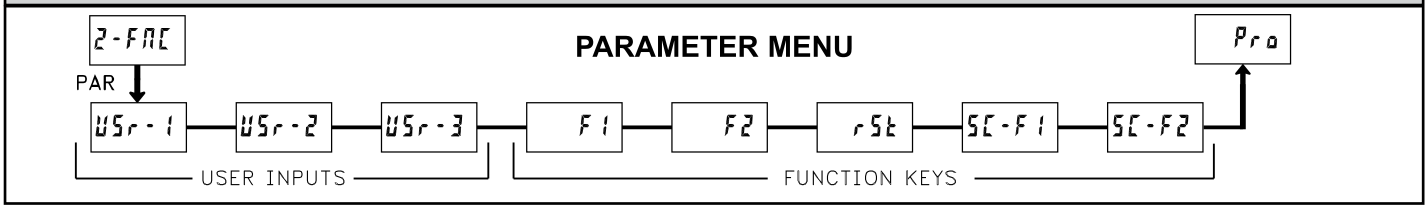
Example:

1. Show feet to the hundredths (0.00) with 100 pulses per foot:
   Scale Factor would be 100 / (100 x 1 x 1) = 1
   (In this case, the scale multiplier and counter mode factor are 1)
2. Show feet with 120 pulses per foot: Scale Factor would be 1 / (120 x 1 x 1) = 0.0083333. (In this case, the scale multiplier of 0.01 could be used: 1 / (120 x 1 x 0.01) = 0.83333 or show to hundredths (0.00): 100 / (120 x 1 x 1) = 0.8333.)

General Rules on Scaling

1. It is recommended that, the scale factor be as close as possible to, but not exceeding 1.00000. This can be accomplished by increasing or decreasing the counter decimal point position, using the scale multiplier, or selecting a different count mode.
2. To double the number of pulses per unit, use counter modes direction X2 or quad X2. To increase it by four times, use counter mode quad X4. Using these modes will decrease the maximum input frequency.
3. A scale factor greater than 1.00000 will cause Counter display rounding. In this case, digit jumps could be caused by the internal count register rounding the display. The precision of a counter application cannot be improved by using a scale factor greater than 1. 00000.
4. The number of pulses per single unit must be greater than or equal to the DDD value for the scale factor to be less than or equal to one.
5. Lowering the scale factor can be accomplished by lowering the counter decimal position. (Example: 100 (Hundredths)/10 pulses = 10.000 lowering to 10 (Tenths)/10 = 1.000.)

6.2 MODULE 2 - USER INPUT AND FRONT PANEL FUNCTION KEY PARAMETERS (2-FNC)



Module 2 is the programming for rear terminal user inputs and front panel function keys.

Three rear terminal user inputs are individually programmable to perform specific meter control functions. While in the Display Mode, the function is executed when the user input transitions to the active state. (Refer to the user input specifications for active state response times.) Certain user input functions are disabled in "full" Programming Mode.

Three front panel function **F1**, **F2** and **RST** keys are also individually programmable to perform specific meter control functions. While in the Display Mode, the primary function is executed when the key is pressed. Holding the **F1** and **F2** function keys for three seconds executes a secondary function. It is possible to program a secondary function without a primary function. The front panel key functions are disabled in both Programming Modes.

In most cases, if more than one user input and/or function key is programmed for the same function, the maintained (level trigger) actions will be performed while at least one of those user inputs or function keys are activated. The momentary (edge trigger) actions are performed every time any of those user inputs or function keys transition to the active state. All functions are available to both user inputs and function keys.

Some of the user functions have a sublist of parameters. The sublist is accessed when **PAR** is pressed at the listed function. The function will only be performed for the parameters entered as YES. If a user input or function key is configured for a function with a sublist, then that sublist will need to be scrolled through each time to access the following user inputs or function keys parameters.

NO FUNCTION

USr-1 / NO F1 / NO

With this selection, NO function is performed. This is the factory setting for all user inputs and function keys except the Reset (**RST**) Key.

NOTE: When a user input is used to accept a quad or directional input signal, then that user input should be programmed for NO function.

PROGRAMMING MODE LOCK-OUT

USr-1 / PLOC

Programming Mode is locked-out, as long as activated (maintained action). In Module 3, certain parameters can be setup where they are still accessible during Programming Mode Lockout. A security code can be configured to allow complete programming access during user input lockout. Function keys should not be programmed for PLOC.

ADVANCE DISPLAY

USr-1 / dSPSEL F1 / dSPSEL

When activated (momentary action), the display advances to the next display that is not locked out from the Display Mode.

RESET DISPLAY

USr-1 / dSPrSt F1 / dSPrSt

When activated (momentary action), the shown display is reset. This is the factory setting for the Reset (**RST**) Key.

EXCHANGE PARAMETER LISTS

USr-1 / LISt F1 / LISt

Two lists of values are available for SP-1, SP-2, SP-3, SP-4, ASCFAC, bSCFAC, CSCFAC, ACNtLd, bCNtLd, CCNtLd. The two lists are named LISt-A and LISt-b. If a user input is used to select the list then LISt-A is selected when the user input is not active and and LISt-b is selected when the user input is active, (maintained action). If a front panel key is used to select the list then the list will toggle for each key press, (momentary action). The meter will suspend ALL operations for approximately 1 msec. while the new values are loaded. The display will only indicate which list is active when the list is changed or when entering any Programming Mode.

To program the values for LISt-A and LISt-b, first complete the programming of all the parameters. Exit programming and switch to the other list. Re-enter programming and enter the values for SP-1, SP-2, SP-3, SP-4, ASCFAC, bSCFAC, CSCFAC, ACNtLd, bCNtLd, CCNtLd. If any other parameters are changed then the other list values must be reprogrammed.

Shaded parameters do not apply to the PAXR.

PAXI: PRINT REQUEST

USr-1 / PrINt F1 / PrINt

The meter issues a block print through the serial port when activated. The data transmitted during the print request is configured in Module 7. If the user input is still active after the transmission is complete (about 100 msec.), an additional transmission will occur. Only one transmission will take place with each function key depression. This selection will only function when a serial communications option card is installed in the meter.

PAXI: PRINT REQUEST AND RESET DISPLAYS

USr-1 / PrNrSt F1 / PrNrSt

The meter issues a block print through the serial port when activated just like the Print Request function. In addition, when activated (momentary action), the meter performs a reset of the displays configured as YES. The print aspect of this action only functions when a serial communication option card is installed. The reset action functions regardless.

DISPLAY	DESCRIPTION	FACTORY
A CNt	Counter A	NO
b CNt	Counter B	NO
C CNt	Counter C	NO
HI	Maximum	NO
LO	Minimum	NO

MAINTAINED (LEVEL) RESET AND INHIBIT

USr-1 F1

CtrStL CtrStL

The meter performs a reset and inhibits the displays configured as YES, as long as activated (maintained action).

DISPLAY	DESCRIPTION	FACTORY
A CNt	Counter A	NO
b CNt	Counter B	NO
C CNt	Counter C	NO
HI	Maximum	NO
LO	Minimum	NO

PAXR: MAINTAINED (LEVEL) RESET AND INHIBIT

USr-1 F1

HLrStL HLrStL

The meter performs a reset and inhibits the displays configured as YES, as long as activated (maintained action).

DISPLAY	DESCRIPTION	FACTORY
HI	Maximum	NO
LO	Minimum	NO

MOMENTARY (EDGE) RESET

USr-1 F1

CtrStE CtrStE

When activated (momentary action), the meter resets the displays configured as YES. (Momentary resets improve max. input frequencies over maintained resets.)

DISPLAY	DESCRIPTION	FACTORY
A CNt	Counter A	NO
b CNt	Counter B	NO
C CNt	Counter C	NO
HI	Maximum	NO
LO	Minimum	NO

PAXR: MOMENTARY (EDGE) RESET

USr-1 F1

HLrStE HLrStE

When activated (momentary action), the meter resets the displays configured as YES. (Momentary resets improve max. input frequencies over maintained resets.)

DISPLAY	DESCRIPTION	FACTORY
HI	Maximum	NO
LO	Minimum	NO

INHIBIT

USr-1 F1

INHIbt INHIbt

The meter inhibits the displays configured as YES, as long as activated (maintained action).

DISPLAY	DESCRIPTION	FACTORY
A CNt	Counter A	NO
b CNt	Counter B	NO
C CNt	Counter C	NO
HI	Maximum	NO
LO	Minimum	NO

STORE DISPLAY

USr-1 F1

StOrE StOrE

The meter holds (freeze) the displays configured as YES, as long as activated (maintained action). Internally the counters and max. and min. values continue to update.

DISPLAY	DESCRIPTION	FACTORY
A CNt	Counter A	NO
b CNt	Counter B	NO
C CNt	Counter C	NO
HI	Maximum	NO
LO	Minimum	NO

DEACTIVATE SETPOINT MAINTAINED (LEVEL)

USr-1 F1

SPrStL SPrStL

The meter deactivates the setpoints configured as YES, as long as activated (maintained action). This action only functions with a Setpoint card installed.

DISPLAY	DESCRIPTION	FACTORY
SP-1	Setpoint 1	NO
SP-2	Setpoint 2	NO
SP-3	Setpoint 3	NO
SP-4	Setpoint 4	NO

DEACTIVATE SETPOINT MOMENTARY (EDGE)

USr-1 F1

SPrStE SPrStE

When activated (momentary action), the meter deactivates the setpoints configured as YES. This action only functions with a Setpoint card installed.

DISPLAY	DESCRIPTION	FACTORY
SP-1	Setpoint 1	NO
SP-2	Setpoint 2	NO
SP-3	Setpoint 3	NO
SP-4	Setpoint 4	NO

HOLD SETPOINT STATE

USr-1 F1

SPHOLd SPHOLd

The meter holds the state of the setpoints configured as YES, as long as activated (maintained action). This action only functions with a Setpoint option card installed.

DISPLAY	DESCRIPTION	FACTORY
SP-1	Setpoint 1	NO
SP-2	Setpoint 2	NO
SP-3	Setpoint 3	NO
SP-4	Setpoint 4	NO

ACTIVATE SETPOINT MAINTAINED (LEVEL)

USr-1 F1

SPStEL SPStEL

The meter activates the setpoints configured as YES, as long as activated (maintained action). This action only functions with a Setpoint card installed.

DISPLAY	DESCRIPTION	FACTORY
SP-1	Setpoint 1	NO
SP-2	Setpoint 2	NO
SP-3	Setpoint 3	NO
SP-4	Setpoint 4	NO

ACTIVATE SETPOINT MOMENTARY (EDGE)

USr-1 F1

SPStEtE SPStEtE

When activated (momentary action), the meter activates the setpoints configured as YES. This action only functions with a Setpoint card installed.

DISPLAY	DESCRIPTION	FACTORY
SP-1	Setpoint 1	NO
SP-2	Setpoint 2	NO
SP-3	Setpoint 3	NO
SP-4	Setpoint 4	NO

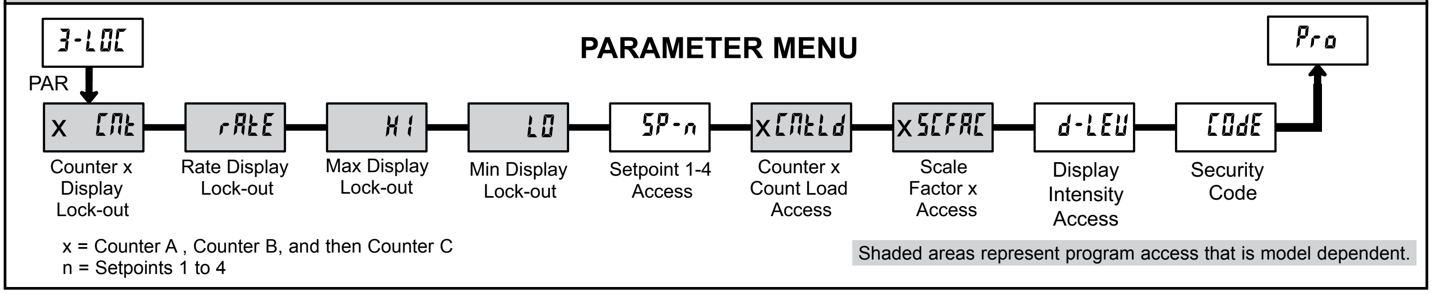
CHANGE DISPLAY INTENSITY LEVEL

USr-1 F1

d-LEV d-LEV

When activated (momentary action), the display intensity changes to the next intensity level (of 4). The four levels correspond to Display Intensity Level (d-LEV) settings of 0, 3, 8 & 15.

6.3 MODULE 3 - DISPLAY AND PROGRAM LOCK-OUT PARAMETERS (3-LOC)



Module 3 is the programming for Display lock-out and "Full" and "Quick" Program lock-out.

When in the Display Mode, the available displays can be read consecutively by repeatedly pressing the **DSP** key. An annunciator indicates the display being shown. These displays can be locked from being visible. It is recommended that the display be set to LOC when the corresponding function is not used.

SELECTION	DESCRIPTION
rEd	Visible in Display Mode
LOC	Not visible in Display Mode

"Full" Programming Mode permits all parameters to be viewed and modified. This Programming Mode can be locked with a security code and/or user input. When locked and the **PAR** key is pressed, the meter enters a Quick Programming Mode. In this mode, setpoint, count load, scale factor values, and the Display Intensity Level (d-LEU) parameter can still be read and/or changed per the selections below.

SELECTION	DESCRIPTION
rEd	Visible but not changeable in Quick Programming Mode
ENt	Visible and changeable in Quick Programming Mode
LOC	Not visible in Quick Programming Mode

COUNTER A B C DISPLAY LOCK-OUT
RATE DISPLAY LOCK-OUT
MAX. MIN. DISPLAY LOCK-OUT

A CNt → rEd

b CNt → LOC

C CNt → LOC

rAtE → rEd

HI → LOC

LO → LOC

These displays can be programmed for LOC or rEd.

Shaded areas are model dependent.

SETPOINT 1 to 4 ACCESS LOCK-OUT

SP-1 → LOC

SP-2 → LOC

SP-3 → LOC

SP-4 → LOC

The setpoint displays can be programmed for LOC, rEd, or ENt (See the following table). Accessible only with the Setpoint option card installed.

COUNT LOAD A B C ACCESS LOCK-OUT

ACNtLd → LOC

bCNtLd → LOC

CCNtLd → LOC

The Count Load Values can be programmed for LOC, rEd, or ENt.

SCALE FACTOR A B C ACCESS LOCK-OUT

ASCFAC → LOC

bSCFAC → LOC

CSCFAC → LOC

The Scale Factor values can be programmed for LOC, rEd, or ENt.

DISPLAY INTENSITY ACCESS LOCK-OUT

d-LEU → LOC

The Display Intensity Level can be programmed for LOC, rEd, or ENt.

SECURITY CODE

COdE → 0

0 to 999

Entry of a non-zero value will cause the prompt COdE to appear when trying to access the "Full" Programming Mode. Access will only be allowed after entering a matching security code or universal code of 222. With this lock-out, a user input would not have to be configured for Program Lock-out. However, this lock-out is overridden by an inactive user input configured for Program Lock-out.

PROGRAMMING MODE ACCESS

SECURITY CODE	USER INPUT CONFIGURED	USER INPUT STATE	WHEN PAR KEY IS PRESSED	"FULL" PROGRAMMING MODE ACCESS
0	not PLOC	———	"Full" Programming	Immediate access.
>0	not PLOC	———	Quick Programming	After Quick Programming with correct code # at COdE prompt.
>0	PLOC	Active	Quick Programming	After Quick Programming with correct code # at COdE prompt.
>0	PLOC	Not Active	"Full" Programming	Immediate access.
0	PLOC	Active	Quick Programming	No access
0	PLOC	Not Active	"Full" Programming	Immediate access.

Throughout this document, Programming Mode (without Quick in front) always refers to "Full" Programming (all meter parameters are accessible).

6.4 MODULE 4 - RATE INPUT PARAMETERS (4-rtE) - PAXR & I

PARAMETER MENU

4-rtE → PAR → rAtEEN — LO-Udt — HI-Udt — rtE dP — SEGS — rdSP x — r INP x — rOUNd — LOCUt — HI-t — LO-t → Pro

rAtEEN	LO-Udt	HI-Udt	rtE dP	SEGS	rdSP	r INP	rOUNd	LOCUt	HI-t	LO-t
Rate Assignment	Low Update Time	High Update Time	Rate Decimal Position	Linearizer Segments	Rate Scaling Display	Rate Scaling Input	Rate Display Rounding	Min. Low Cut-out	Max. Capture Delay Time	Min. Capture Delay Time

Module 4 is the programming for the Rate parameters. For maximum input frequency, Rate assignment should be set to NO when not in use. When set to NO, the remaining related parameters are not accessible. The Rate value is shown with an annunciator of 'r' in the Display Mode.

Note: For PAXR, r INP is actually rtE INP on the unit's display and rdSP is actually rtEdSP on the unit's display.

PAXI: RATE ASSIGNMENT

rAtEEN / rAtE-A   NO   rAtE-A   rAtE-b

For measuring the rate (speed) of pulses on Input A, select rAtE-A. For Input B select rAtE-b. This assignment is independent of the counting modes.

LOW UPDATE TIME (DISPLAY UPDATE)

LO-Udt / 1.0   0.1 to 99.9 seconds

The Low Update Time is the minimum amount of time between display updates for the Rate display. Values of 0.1 and 0.2 seconds will update the display correctly but may cause the display to appear unsteady. The factory setting of 1.0 will update the display every second minimum.

HIGH UPDATE TIME (DISPLAY ZERO)

HI-Udt / 2.0   0.2 to 99.9 seconds

The High Update Time is the maximum amount of time before the Rate display is forced to zero. (For more explanation, refer to Input Frequency Calculation.) The High Update Time **must** be higher than the Low Update Time and higher than the desired slowest readable speed (one divided by pulses per second). The factory setting of 2.0, will force the display to zero for speeds below 0.5 Hz or a pulse every 2 seconds.

RATE DECIMAL POSITION

rtE dP / 0   0   0.0   0.00   0.000   0.0000

This selects the decimal point position for Rate, Minimum and Maximum rate displays and any setpoint value assigned to these displays. This parameter does not affect rate scaling calculations.

PAXI: LINEARIZER SEGMENTS

SEGS / 0   0 to 9

This parameter specifies the number of linear segments used for the Rate Scaling function. Each linear segment has two scaling points which define the upper and lower endpoints of the segment. The number of segments used depends on the linearity of the process and the display accuracy required as described below.

Linear Application – 2 Scaling Points

Linear processes use a single segment (two scaling points) to provide a linear Rate display from 0 up to the maximum input frequency. For typical zero based frequency measurements (0 Hz = 0 on display), leave SEGS=0 (factory setting). For non-zero based 2 scaling point applications, set SEGS=1, to enter both the zero segment (r INP 0 & rdSP 0) and segment 1 (r INP 1 & rdSP 1).

Non-linear Application – Up to 10 Scaling Points

Non-linear processes may utilize up to nine segments (ten scaling points) to provide a piece-wise linear approximation representing the non-linear function. The Rate display will be linear throughout each individual segment (i.e. between sequential scaling points). Thus, the greater the number of segments, the greater the conformity accuracy. Several linearization equations are available in the software.

About Scaling Points

Each Scaling Point is specified by two programmable parameters: A desired Rate Display Value (rdSP) and a corresponding Rate Input Value (r INP). Scaling points are entered sequentially in ascending order of Rate Input Value.

Two scaling points must be programmed to define the upper and lower endpoints of the first linear segment. Setting SEGS=0, automatically factory sets the first scaling point to 0.0 for typical single segment, zero based applications. When multiple segments are used, the upper scaling point for a given segment becomes the lower scaling point for the next sequential segment. Thus, for each additional segment used, only one additional scaling point must be programmed.

The following chart shows the Scaling Points, the corresponding Parameter mnemonics, and the Factory Default Settings for each point.

SEGMENT	SCALING POINT	DISPLAY PARAMETER	DISPLAY DEFAULT	INPUT PARAMETER	INPUT DEFAULT
	1	rdSP 0	000000	r INP 0	00000.0
1	2	rdSP 1	001000	r INP 1	01000.0
2	3	rdSP 2	002000	r INP 2	02000.0
3	4	rdSP 3	003000	r INP 3	03000.0
4	5	rdSP 4	004000	r INP 4	04000.0
5	6	rdSP 5	005000	r INP 5	05000.0
6	7	rdSP 6	006000	r INP 6	06000.0
7	8	rdSP 7	007000	r INP 7	07000.0
8	9	rdSP 8	008000	r INP 8	08000.0
9	10	rdSP 9	009000	r INP 9	09000.0

PAXI: RATE DISPLAY VALUE FOR SCALING POINT 1

rdSP 0 / 0   0 to 999999

Confirm the Rate Display Value for the first Scaling Point is 0. This parameter is automatically set to 0 and does not appear when SEGS=0. *(See Note)*

PAXI: RATE INPUT VALUE FOR SCALING POINT 1

r INP 0 / 0.0   0 to 99999.9

Confirm the Rate Input Value for the first Scaling Point is 0.0. *(See Note)*

Note: For all linear and most non-linear applications, the Scaling Point 1 parameters (rdSP 0 and r INP 0) should be set to 0 and 0.0 respectively. Consult the factory before using any non-zero values for Scaling Point 1. These parameters are automatically set to 0 and do not appear when SEGS=0.

RATE DISPLAY VALUE FOR SCALING POINT 2

rdSP 1 / 1000   0 to 999999

Enter the desired Rate Display Value for the second Scaling Point by using the arrow keys.

RATE INPUT VALUE FOR SCALING POINT 2

r INP 1 — 0 to 99999.9

1000.0

Enter the corresponding Rate Input Value for the second Scaling Point by using the arrow keys. Rate Input values for scaling points can be entered by using the Key-in or the Applied method described below.

Key-in Method:

Enter the Rate Input value (r INP) that corresponds to the entered Rate Display value (rdSP) by pressing the **F1** or **F2** keys. This value is always in pulses per second (Hz).

Applied Method:

Apply an external rate signal to the appropriate input terminals. At the Rate Input Value (r INP) press and hold the **F1** and **F2** keys at the same time. The applied input frequency (in Hz) will appear on the display. (To verify correct reading wait for at least the length of the Low Update Time. Then press and hold the **F1** and **F2** keys at the same time again. The new value should be ± 0.1% of the previous entered value.) Press **PAR** to enter the displayed frequency as the Rate Input value. To prevent the displayed value from being entered, press **DSP**. This will take the meter out of Programming Mode and the previous Rate Input value will remain.

RATE DISPLAY ROUND

rOUNd — 1, 2, 5, 10, 20, 50, 100

1

Rounding values other than one round the Rate display to the nearest increment selected (e.g. rounding of '5' causes 122 to round to 120 and 123 to round to 125). Rounding starts at the least significant digit of the Rate display.

LOW CUT OUT

LOCUt — 0 to 999999

0

The Low Cut Out value forces the Rate display to zero when the Rate display falls below the value entered.

MAXIMUM CAPTURE DELAY TIME

HI-t — 0.0 to 999.9 seconds

2.0

When the Rate value is above the present Maximum rate value for the entered amount of time, the meter will capture that Rate value as the new Maximum value. A delay time helps to avoid false captures of sudden short spikes. Maximum detection will only function if Rate is assigned to Input A or B. The Maximum rate value is shown with an annunciator of 'H' in the display and will continue to function independent of being displayed.

MINIMUM CAPTURE DELAY TIME

LO-t — 0.0 to 999.9 seconds

2.0

When the Rate value is below the present Minimum rate value for the entered amount of time, the meter will capture that Rate value as the new Minimum value. A delay time helps to avoid false captures of sudden short spikes. Minimum detection will only function if Rate is assigned to Input A or B. The Minimum rate value is shown with an annunciator of 'L' in the display and will continue to function independent of being displayed.

RATE DISPLAY EXCEEDED

If the rate of the input signal causes a display that exceeds the capacity of the Rate display (5 digits, 99999), then the display will indicate an overflow condition by showing "r OLOL". During this overflow condition, the Minimum and Maximum rate values will stay at their values even during resets.

RATE SCALING

To scale the Rate, enter a Scaling Display value with a corresponding Scaling Input value. (The Display and Input values can be entered by Key-in or Applied Methods.) These values are internally plotted to a Display value of 0 and Input value of 0 Hz. A linear relationship is formed between these points to yield a rate display value that corresponds to the incoming input signal rate. The PAXI and PAXR are capable of showing a rate display value for any linear process.

KEY-IN SCALING METHOD CALCULATION

If a display value versus input signal (in pulses per second) is known, then those values can be entered into Scaling Display (rdSPx) and Scaling Input (r INPx). No further calculations are needed.

If only the number of pulses per 'single' unit (i.e. # of pulses per foot) is known, then it can be entered as the Scaling Input value and the Scaling Display value will be entered as the following:

RATE PER	DISPLAY (rdSPx)	INPUT (r INPx)
Second	1	# of pulses per unit
Minute	60	# of pulses per unit
Hour	3600	# of pulses per unit

NOTES:

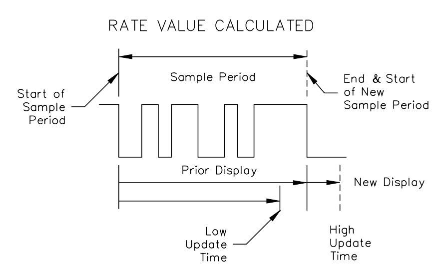
1. If # of pulse per unit is less than 10, then multiply both Input and Display values by 10.
2. If # of pulse per unit is less than 1, then multiply both Input and Display values by 100.
3. If the Display value is raised or lowered, then Input value must be raised or lowered by the same proportion (i.e. Display value for per hour is entered by a third less (1200) then Input value is a third less of # of pulses per unit). The same is true if the Input value is raised or lowered, then Display value must be raised or lowered by the same proportion.
4. Both values must be greater than 0.0.

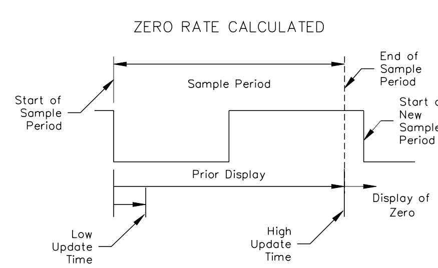
EXAMPLE:

1. With 15.1 pulses per foot, show feet per minute in tenths. Scaling Display = 60.0 Scaling Input = 15.1.
2. With 0.25 pulses per gallon, show whole gallons per hour. (To have greater accuracy, multiply both Input and Display values by 10.) Scaling Display = 36000 Scaling Input = 2.5.

INPUT FREQUENCY CALCULATION

The meter determines the input frequency by summing the number of falling edges received during a sample period of time. The sample period begins on the first falling edge. At this falling edge, the meter starts accumulating time towards Low Update and High Update values. Also, the meter starts accumulating the number of falling edges. When the time reaches the Low Update Time value, the meter looks for one more falling edge to end the sample period. If a falling edge occurs (before the High Update Time value is reached), the Rate display will update to the new value and the next sample period will start on the same edge. If the High Update Time value is reached (without receiving a falling edge after reaching Low Update Time), then the sample period will end but the Rate display will be forced to zero. The High Update Time value must be greater than the Low Update Time value. Both values must be greater than 0.0. The input frequency calculated during the sample period, is then shown as a Rate value determined by either scaling method.





6.5 MODULE 5 - COUNTER C INPUT PARAMETERS (5-CtrC)

PAXC & I **PARAMETER MENU**

5-CtrC → PAR → C CNt — CrESEt — CdECPt — CSCFAC — CSCALr — CCNtLd — C P-UP → Pro

C CNt	CrESEt	CdECPt	CSCFAC	CSCALr	CCNtLd	C P-UP
Counter C Operating Mode	Counter C Reset Action	Counter C Decimal Position	Counter C Scale Factor	Counter C Scale Multiplier	Counter C Count Load Value	Counter C Reset at Power-up

Module 5 is the programming for Counter C. For maximum input frequency, the counter operating mode should be set to NONE when not in use. When set to NONE the remaining related parameters are not accessible. The C annunciator indicates that Counter C is being shown in the Display Mode. An Exchange Parameter List feature for scale factor and count load values is explained in Module 2.

COUNTER C OPERATING MODE

C CNt
NONE

NONE A Add Ab Sub Ab SLAVE

Select the operating mode for Counter C.

NONE	Does not count.
A	Counter C counts the incoming pulses from Counter A input as per Counter A mode of operation. The signal is scaled only according to Counter C parameters.
Add Ab	Counter C counts the incoming pulses from Counter A and B inputs as per Counter A and B modes of operation. The result is scaled only according to Counter C parameters. (Example: If Counter A is set for Count X1 mode and Counter B is set for Count X2 mode, then Counter C will increment by 1 for each pulse received on Input A and increment by 2 for each pulse received on Input B. Counter C scale settings are then applied and the result is displayed.)
Sub Ab	Counter C counts the incoming pulses from Counter A and B inputs as per Counter A and B modes of operation and subtracts the B counts from the A counts. The result is scaled only according to Counter C parameters. (Example: If Counter A is set for Count X1 mode and Counter B is set for Count X2 mode, then Counter C will increment by 1 for each pulse received on Input A and decrement by 2 for each pulse received on Input B. Counter C scale settings are then applied and the result is displayed.)

Note: When using Add Ab or Sub Ab, Counter A, B and C must all be reset at the same time for the math to be performed on the display values.

SLAVE (PAXI only)	See Serial Communications for details.

COUNTER C RESET ACTION

CrESEt
ZErO

ZErO CNtLd

When Counter C is reset, it returns to zero or Counter C count load value. This reset action affects all Counter C resets, except the Setpoint Counter Auto Reset Action in Module 6.

COUNTER C DECIMAL POSITION

CdECPt
0

0 0.0 0.00 0.000 0.0000 0.00000

This selects the decimal point position for Counter C and any setpoint value assigned to Counter C. The selection will also affect Counter C scale factor calculations.

COUNTER C SCALE FACTOR

CSCFAC
1.00000

0.00001 to 9.99999

The number of input counts is multiplied by the scale factor and the scale multiplier to obtain the desired process value. A scale factor of 1.00000 will result in the display of the actual number of input counts. For the A mode of operation, the input signal is scaled directly. For Add Ab and Sub Ab modes of operation, the math is performed on the input signals and then the result is scaled. To achieve correct results, both Input A and Input B must provide the same amount of pulses per unit of measurement. (Details on scaling calculations are explained at the end of Module 1 section.)

COUNTER C SCALE MULTIPLIER

CSCALr
1

1 0.1 0.01

The number of input counts is multiplied by the scale multiplier and the scale factor to obtain the desired process value. A scale multiplier of 1 will result in only the scale factor affecting the display. (Details on scaling calculations are explained at the end of Module 1 section.)

COUNTER C COUNT LOAD VALUE

CCNtLd
500

-99999 to 999999

When reset to count load action is selected, Counter C will reset to this value.

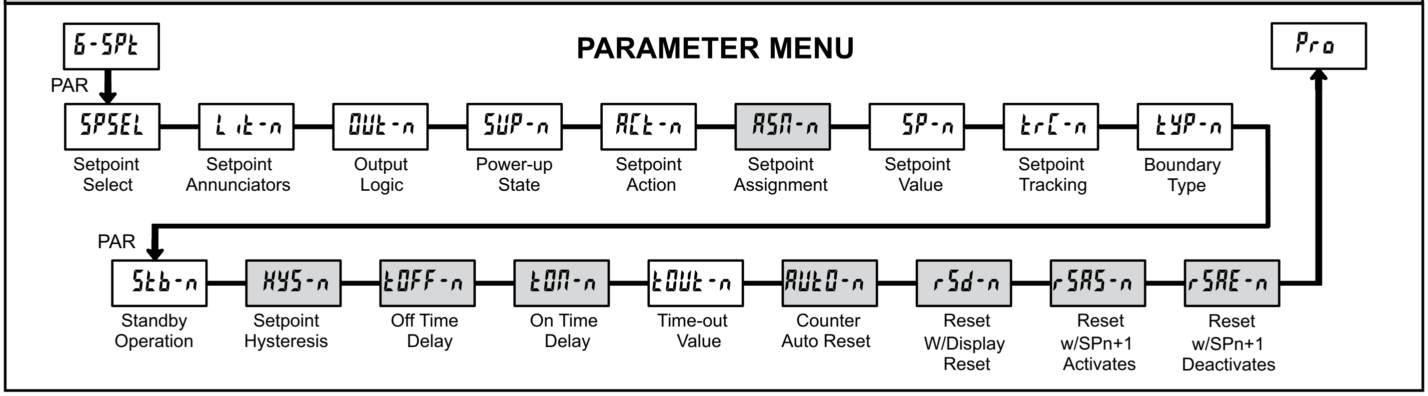
COUNTER C RESET POWER-UP

C P-UP
NO

YES NO

Counter C may be programmed to reset at each meter power-up.

6.6 MODULE 6 - Setpoint (Alarm) Parameters (6-SPt)



Module 6 is the programming for the setpoint (alarms) output parameters. To have setpoint outputs, a setpoint option card needs to be installed into the PAX (see Ordering Information). Depending on the card installed, there will be two or four setpoint outputs available. For setpoint hardware and wiring details, refer to the bulletin shipped with the option card. For maximum input frequency, unused Setpoints should be configured for OFF action.

The setpoint assignment and the setpoint action determine certain setpoint feature availability. The chart below illustrates this.

SETPOINT PARAMETER AVAILABILITY

PARAMETER	DESCRIPTION	RATE			COUNTER		
		TIMED OUT tOUt	BOUNDARY bOUNd	LATCH LAtCH	TIMED OUT tOUt	BOUNDARY bOUNd	LATCH LAtCH
LIt-n	Annunciators	Yes	Yes	Yes	Yes	Yes	Yes
OUt-n	Output Logic	Yes	Yes	Yes	Yes	Yes	Yes
SUP-n	Power Up State	Yes	Yes	Yes	Yes	Yes	Yes
SP-n	Setpoint Value	Yes	Yes	Yes	Yes	Yes	Yes
trC-n	Setpoint Tracking	Yes	Yes	Yes	Yes	Yes	Yes
tYP-n	Boundary Type	Yes	Yes	Yes	No	Yes	No
Stb-n	Standby Operation	Yes	Yes	Yes	No	Yes	No
HYS-n	Setpoint Hysteresis	No	Yes	No	No	No	No
tOFF-n	Setpoint Off Delay	No	Yes	No	No	No	No
tON-n	Setpoint On Delay	Yes	Yes	Yes	No	No	No
tOUt-n	Setpoint Time Out	Yes	No	No	Yes	No	No
AUtO-n	Counter Auto Reset	No	No	No	Yes	No	Yes
rSd-n	Reset With Display Reset	No	No	No	Yes	No	Yes
rSAS-n	Reset When SPn+1 Activates	No	No	No	Yes	No	Yes
rSAE-n	Reset When SPn+1 Deactivates	No	No	No	Yes	No	Yes

SETPOINT SELECT

SPSEL NO — NO SP-1 SP-2 SP-3 SP-4

Select a setpoint (alarm output) to open the remaining module menu. (The "n" in the following parameters will reflect the chosen setpoint number.) After the chosen setpoint is programmed, the display will default to SPSEL NO. Select the next setpoint to be programmed and continue the sequence for each setpoint. Pressing **PAR** at SPSEL NO will exit Module 6.

SETPOINT ANNUNCIATORS

LIt-n NOr — OFF NOr rEU FLASH

OFF disables the display of the setpoint annunciator. Normal (NOr) displays the corresponding setpoint annunciator of an "on" alarm output. Reverse (rEU) displays the corresponding setpoint annunciator of an "off" alarm output. FLASH flashes the display and the corresponding setpoint annunciator of an "on" alarm output.

SETPOINT OUTPUT LOGIC

OUt-n NOr — NOr rEU

Normal (NOr) turns the output "on" when activated and "off" when deactivated. Reverse (rEU) turns the output "off" when activated and "on" when deactivated.

SETPOINT POWER UP STATE

SUP-n OFF — SAUE ON OFF

SAUE will restore the output to the same state it was at before the meter was powered down. ON will activate the output at power up. OFF will deactivate the output at power up.

SETPOINT ACTION

ACt-n
OFF   OFF   tOUt   bOUNd   LAtCH

OFF: When not using a setpoint, it should be set to OFF (no action).

For Counter Assignments:

- **tOUt** With Timed Out action, the setpoint output activates when the count value equals the setpoint value and deactivates after the Time Out value. This action is not associated with Boundary types.
- **bOUNd** With boundary action, the setpoint output activates when the count value is greater than or equal to (for tYP = HI) or less than or equal to (for tYP = LO) the setpoint value. The setpoint output will deactivate when the count value is less than (for tYP = HI) or greater than (for tYP = LO) the setpoint value.
- **LAtCH** With Latch action, the setpoint output activates when the count value equals the setpoint value. The output remains active until reset. This action is not associated with Boundary types.

For Rate Assignments:

- **tOUt** With Timed Out action, the setpoint output cycles when the rate value is greater than or equal to (for tYP = HI) or less than or equal to (for tYP = LO) the setpoint value. The Setpoint Time Out (tOUt-n) and Setpoint On Delay (tON-n) values determine the cycling times.
- **bOUNd** With Boundary action, the setpoint output activates when the rate value is greater than or equal to (for tYP = HI) or less than or equal to (for tYP = LO) the setpoint value. The setpoint output will deactivate (Auto reset) as determined by the hysteresis value.
- **LAtCH** With Latch action, the setpoint output activates when the rate value is equal to the setpoint value. The setpoint output remains active until reset. If after reset, the rate value is greater than or equal to (for tYP = HI) or less than or equal to (for tYP = LO) the setpoint value, the output will reactivate.

PAXC & I: SETPOINT ASSIGNMENT

ASN-n
A CNt   A CNt   b CNt   C CNt   rAtE

Select the display that the setpoint is to be assigned.

SETPOINT VALUE

SP-n
100   -99999 to 999999

Enter the desired setpoint value. Setpoint values can also be entered in the Quick Programming Mode when the setpoint is configured as ENt in Module 3. (See Module 2 for Exchange Parameter Lists explanation.)

SETPOINT TRACKING

trC-n
NO   NO   SP-1   SP-2   SP-3
SP-4   ACNtLd   bCNtLd   CCNtLd

If a selection other than NO is chosen, then the value of the setpoint being programmed (“n”) will track the entered selection’s value. Tracking means that when the selection’s value is changed, the “n” setpoint value will also change (or follow) by the same amount.

SETPOINT BOUNDARY TYPE

tYP-n
HI   HI   LO

HI activates the output when the assigned display value (ACt-n) equals or exceeds the setpoint value. LO activates the setpoint when the assigned display value is less than or equal to the setpoint.

SETPOINT STANDBY OPERATION

Stb-n
NO   YES   NO

Selecting YES will disable low acting setpoints at a power up until the display value crosses into the alarm “off” area. Once in the alarm “off” area, the setpoint will function according to the configured setpoint parameters.

PAXI & R: SETPOINT HYSTERESIS

HYS-n
0   0 to 9999

The hysteresis value is added to (for tYP = LO), or subtracted from (for tYP = HI), the setpoint value to determine at what value to deactivate the associated setpoint output. Hysteresis is only available for setpoints assigned to the Rate with boundary action.

PAXI & R: SETPOINT OFF DELAY

tOFF-n
0.00   0.00 to 99.99 seconds

This is the amount of time the Rate display must meet the setpoint deactivation requirements (below hysteresis for high acting and above hysteresis for low acting) before the setpoint’s output deactivates.

PAXI & R: SETPOINT ON DELAY

tON-n
0.00   0.00 to 99.99 seconds

This is the amount of time the Rate display must meet the setpoint activation requirements (below setpoint for tYP = LO and above setpoint for tYP = HI) before the setpoint’s output activates. If the Rate Setpoint Action is Timed Out, this is the amount of time the output is off during the on / off output cycling.

SETPOINT TIME OUT

tOUt-n
1.00   0.00 to 99.99 seconds

If the setpoint action is Timed Out and the setpoint is assigned to Rate, then this is the amount of time the output is on during the on / off output cycling. If the setpoint action is Timed Out and the setpoint is assigned to Count, then this is the amount of time the output will activate once the count value equals the setpoint value.

PAXC & I: COUNTER AUTO RESET

AUtO-n
NO   NO   ZErOAS   CLdAS
ZErOAE   CLdAE

This automatically resets the display value of the Setpoint Assignment (ASN-n) counter each time the setpoint value is reached. This reset may be different than the Counter’s Reset Action (xrESEt) in Module 1 or 5.

SELECTION	ACTION
NO	No auto reset.
ZErOAS	Reset to zero at the start of output activation.
CLdAS	Reset to count load value at the start of output activation.
ZErOAE	Reset to zero at the end of output activation. (tOUt action only).
CLdAE	Reset to count load value at the end of output activation. (tOUt action only).

PAXC & I: SETPOINT RESET WITH DISPLAY RESET

rSd-n

NO

YES NO

Select YES, so the setpoint output will deactivate (reset) when the Setpoint Assignment (ASN-n) counter display resets. The only exception is if the assigned counter is reset by a Counter Auto reset generated by another setpoint.

PAXC & I: SETPOINT RESET WHEN SPn+1 ACTIVATES

rSAS-n

NO

YES NO

Select YES, so the setpoint output will deactivate (reset) when SPn +1 activates. (Example: SP1 deactivates when SP2 activates and SP4 when SP1 activates.) The last setpoint will wrap around to the first.

PAXC & I: SETPOINT RESET WHEN SPn+1 DEACTIVATES

rSAE-n

NO

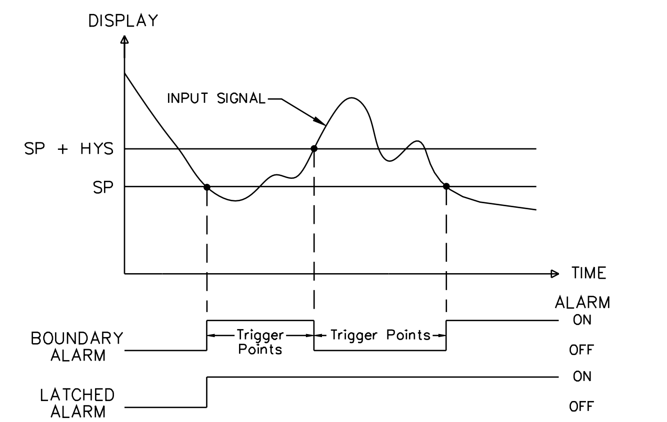
YES NO

Select YES, so the setpoint output will deactivate (reset) when SPn +1 activates and then times out (deactivates). This function may only be used if the SPn+1 is programmed for Setpoint Action of tOUt. (Example SP1 deactivates when SP2 is activated and then times out.) The last setpoint will wrap around to the first.

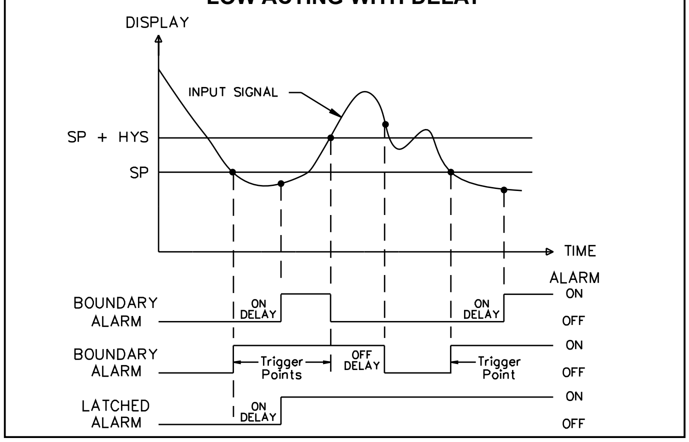
PAXR & I: SETPOINT (ALARM) FIGURES FOR RATE

(For Reverse Action, The Alarm state is opposite.)

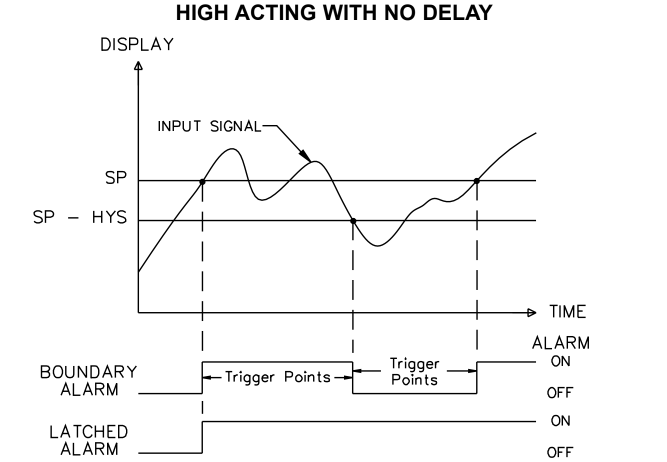
LOW ACTING WITH NO DELAY



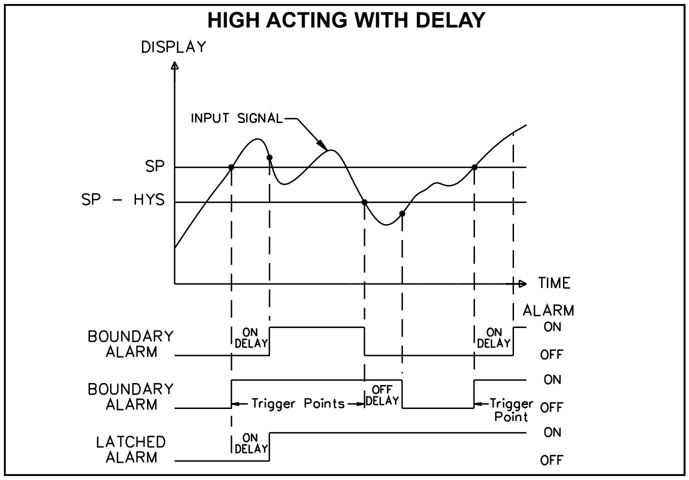
LOW ACTING WITH DELAY



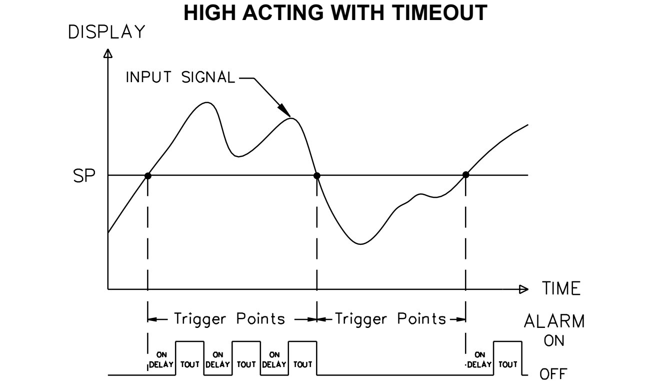
HIGH ACTING WITH NO DELAY



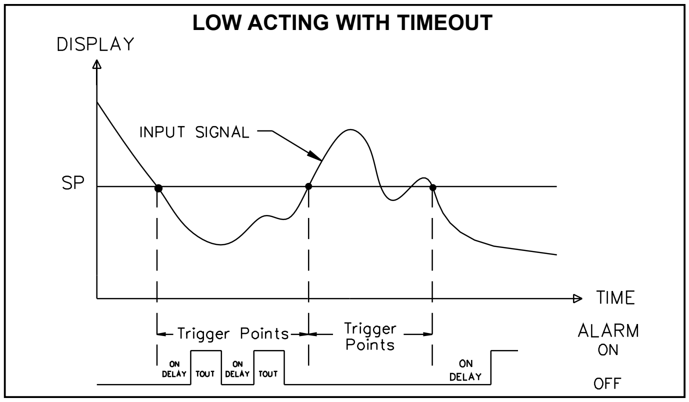
HIGH ACTING WITH DELAY



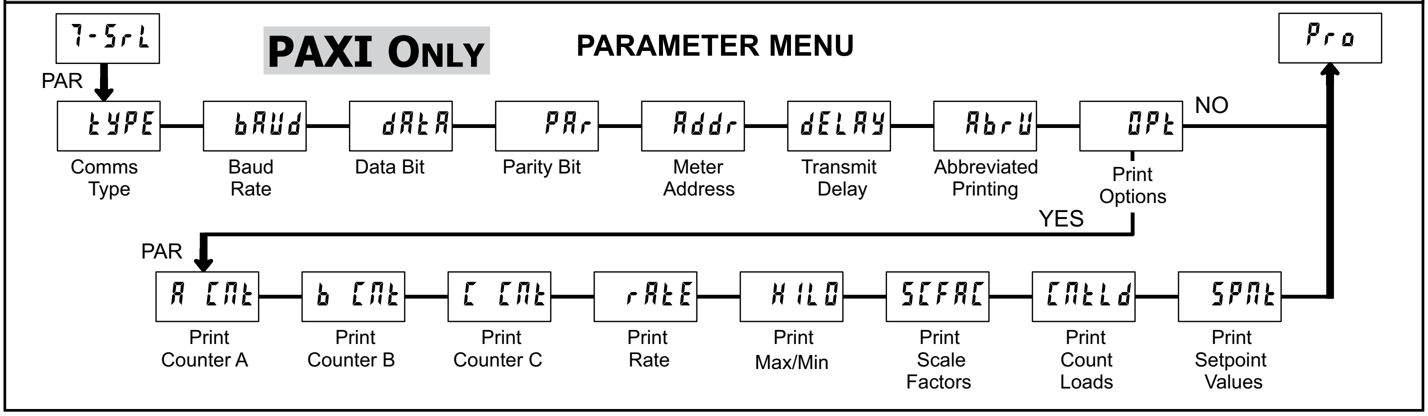
HIGH ACTING WITH TIMEOUT



LOW ACTING WITH TIMEOUT



6.7 MODULE 7 - SERIAL COMMUNICATIONS PARAMETERS (7-SrL)



Module 7 is the programming module for the Serial Communications Parameters. These parameters are used to match the serial settings of the PAXI with those of the host computer or other serial device, such as a terminal or printer. This programming module can only be accessed if an RS232 or RS485 Serial Communications card is installed.

This section also includes an explanation of the commands and formatting required for communicating with the PAXI. In order to establish serial communications, the user must have host software that can send and receive ASCII characters or Modbus protocol. Red Lion's Crimson software can be used for configuring the PAXI (See Ordering Information). For serial hardware and wiring details, refer to the bulletin shipped with the option card.

This section does NOT apply to the DeviceNet or Profibus-DP communication cards. For details on the operation of the Fieldbus cards, refer to the bulletin shipped with each card.

COMMUNICATIONS TYPE

tYPE
Mbrtu

Mbrtu - Modbus RTU
MbASC - Modbus ASCII
rLC - RLC Protocol (ASCII)

Select the desired communications protocol. Modbus protocol provides access to all meter values and parameters. Since Modbus is included within the PAXI, the PAX Modbus option card, PAXCDC4, should not be used. The PAXCDC1 (RS485), or PAXCDC2 (RS232) card should be used instead.

BAUD RATE

bAUd
38400

1200 2400 4800
9600 19200 38400

Set the baud rate to match the other serial communications equipment on the serial link. Normally, the baud rate is set to the highest value that all the serial equipment is capable of transmitting and receiving.

DATA BIT

dAtA
8

7 8

Select either 7 or 8 bit data word lengths. Set the word length to match the other serial communications equipment on the serial link.

PARITY BIT

PAr
NO

NO Odd EUEN

Set the parity bit to match that of the other serial communications equipment on the serial link. The meter ignores the parity when receiving data and sets the parity bit for outgoing data. If no parity is selected with 7 bit word length, an additional stop bit is used to force the frame size to 10 bits.

METER ADDRESS

Addr
247

1 to 247 - Modbus
0 to 99 - RLC Protocol

Enter the serial meter (node) address. The address range is dependent on the tYPE parameter. With a single unit, configured for RLC protocol (tYPE = rLC), an address is not needed and a value of zero can be used. With multiple units (RS485 applications), a unique 2 digit address number must be assigned to each meter.

TRANSMIT DELAY

dELAY
0.010

0.000 to 0.250 seconds

Following a transmit value ('*' terminator) or Modbus command, the PAXI will wait this minimum amount of time before issuing a serial response.

Parameters below only appear when Communications Type parameter (tYPE) is set to rLC.

ABBREVIATED PRINTING

AbrU
NO

YES NO

Select NO for full print or Command T transmissions (meter address, parameter data and mnemonics) or YES for abbreviated print transmissions (parameter data only). This will affect all the parameters selected in the print options. (If the meter address is 0, it will not be sent during a full transmission.)

PRINT OPTIONS

OPt
NO

YES - Enters the sub-menu to select the meter parameters to appear during a print request. For each parameter in the sub-menu, select YES for that parameter information to be sent during a print request or NO for that parameter information not to be sent. A print request is sometimes referred to as a block print because more than one parameter information (meter address, parameter data and mnemonics) can be sent to a printer or computer as a block.

PARAMETER	DESCRIPTION	FACTORY	MNEMONIC
A CNt	Counter A	YES	CTA
b CNt	Counter B	NO	CTB
C CNt	Counter C	NO	CTC
rAtE	Rate	NO	RTE
HiLO	Max. & Min.	NO	MIN MAX
SCFAC	A B C Scale Factors	NO	SFA SFB SFC
CNtLd	A B C Count Load	NO	LDA LDB LDC
SPNt	1 2 3 4 Setpoints *	NO	SP1 SP2 SP3 SP4

**Setpoints are option card dependent.*

SERIAL MODBUS COMMUNICATIONS

Modbus Communications requires that the Serial Communications Type Parameter (tYPE) be set to Modbus RTU (Mbrtu) or Modbus ASCII (MbASC).

PAXI CONFIGURATION USING CRIMSON AND SERIAL COMMUNICATIONS CARD

1. Install Crimson software.
2. Install RS232 or RS485 card and connect communications cable from PAXI to PC.
3. Supply power to PAXI.
4. Configure serial parameters to Modbus RTU (Mbrtu), 38,400 baud, address 247. (Note:These are the factory default settings.)
5. Create a new file (File, New) or open an existing PAXI V3.0+ database.
6. Configure Crimson Link options (Link, Options) to the serial port which the communication cable is attached (in step 2).

SUPPORTED FUNCTION CODES

FC03: Read Holding Registers

1. Up to 64 registers can be requested at one time.
2. HEX <8000> is returned for non-used registers.

FC04: Read Input Registers

1. Up to 64 registers can be requested at one time.
2. Block starting point can not exceed register boundaries.
3. HEX <8000> is returned in registers beyond the boundaries.
4. Input registers are a mirror of Holding registers.

FC06: Preset Single Register

1. HEX <8001> is echoed back when attempting to write to a read only register.
2. If the write value exceeds the register limit (see Register Table), then that register value changes to its high or low limit. It is also returned in the response.

FC16: Preset Multiple Registers

1. No response is given with an attempt to write to more than 64 registers at a time.
2. Block starting point cannot exceed the read and write boundaries (40001-41280).
3. If a multiple write includes read only registers, then only the write registers will change.
4. If the write value exceeds the register limit (see Register Table), then that register value changes to its high or low limit.

FC08: Diagnostics

The following is sent upon FC08 request:

Module Address, 08 (FC code), 04 (byte count), "Total Comms" 2 byte count, "Total Good Comms" 2 byte count, checksum of the string

"Total Comms" is the total number of messages received that were addressed to the PAXI. "Total Good Comms" is the total messages received by the PAXI with good address, parity and checksum. Both counters are reset to 0 upon response to FC08 and at power-up.

FC17: Report Slave ID

The following is sent upon FC17 request:

RLC-PAXI_V3 <a><b><0300h><0040h><0040h><0010h>
<a> = SP Card Status. "0"-None, "2"-Dual, "4"-Quad
<b> = Linear Card Status. "0"-Not Installed, "1"-Installed
<0300h> = Software Version Number (e.g. 3.00)
<0040h><0040h> = Max Register Reads/Writes (64)
<0010h> = Number of GUID/Scratch Pad Registers (16)

SUPPORTED EXCEPTION CODES

01: Illegal Function

Issued whenever the requested function is not implemented in the meter.

02: Illegal Data Address

Issued whenever an attempt is made to access a single register that does not exist (outside the implemented space) or to access a block of registers that falls completely outside the implemented space.

03: Illegal Data Value

Issued when an attempt is made to read or write more registers than the meter can handle in one request.

07: Negative Acknowledge

Issued when a write to a register is attempted with an invalid string length.

PAXI MODBUS REGISTER TABLE

This table shows the most commonly used registers for the PAXI. The complete register table listing is available at http://www.redlion.net.

Values less than 65,535 will be in (Lo word). Values greater than 65,535 will continue into (Hi word). Negative values are represented by two's complement of the combined (Hi word) and (Lo word). The PAXI should not be powered down while parameters are being changed. Doing so may corrupt the non-volatile memory resulting in checksum errors.

REGISTER ADDRESS	REGISTER NAME	LOW LIMIT	HIGH LIMIT	FACTORY SETTING	ACCESS	COMMENTS
	FREQUENTLY USED REGISTERS					
40001	Counter A Value (Hi word)	-99999999	999999999	0	Read/Write	1 = 1 Display Unit
40002	Counter A Value (Lo word)					
40003	Counter B Value (Hi word)	-99999999	999999999	0	Read/Write	1 = 1 Display Unit
40004	Counter B Value (Lo word)					
40005	Counter C Value (Hi word)	-99999999	999999999	0	Read/Write	1 = 1 Display Unit
40006	Counter C Value (Lo word)					
40007	Rate Value (Hi word)	0	99999	0	Read/Write	1 = 1 Display Unit
40008	Rate Value (Lo word)					
40009	Min (Lo) Value (Hi word)	0	99999	0	Read/Write	1 = 1 Display Unit
40010	Min (Lo) Value (Lo word)					
40011	Max (Hi) Value (Hi word)	0	99999	0	Read/Write	1 = 1 Display Unit
40012	Max (Hi) Value (Lo word)					
40013	Counter A Scale Factor (Hi word)	1	999999	100000	Read/Write	Active List (A or B)
40014	Counter A Scale Factor (Lo word)					
40015	Counter B Scale Factor (Hi word)	1	999999	100000	Read/Write	Active List (A or B)
40016	Counter B Scale Factor (Lo word)					
40017	Counter C Scale Factor (Hi word)	1	999999	100000	Read/Write	Active List (A or B)
40018	Counter C Scale Factor (Lo word)					
40019	Counter A Count Load (Hi word)	-99999	999999	500	Read/Write	Active List (A or B)
40020	Counter A Count Load (Lo word)					
40021	Counter B Count Load (Hi word)	-99999	999999	500	Read/Write	Active List (A or B)
40022	Counter B Count Load (Lo word)					
40023	Counter C Count Load (Hi word)	-99999	999999	500	Read/Write	Active List (A or B)
40024	Counter C Count Load (Lo word)					
40025	Setpoint 1 Value (Hi word)	-199999	999999	100	Read/Write	Active List (A or B)
40026	Setpoint 1 Value (Lo word)					

REGISTER ADDRESS	REGISTER NAME	LOW LIMIT	HIGH LIMIT	FACTORY SETTING	ACCESS	COMMENTS
40027	Setpoint 2 Value (Hi word)	-199999	999999	200	Read/Write	Active List (A or B)
40028	Setpoint 2 Value (Lo word)					
40029	Setpoint 3 Value (Hi word)	-199999	999999	300	Read/Write	Active List (A or B)
40030	Setpoint 3 Value (Lo word)					
40031	Setpoint 4 Value (Hi word)	-199999	999999	400	Read/Write	Active List (A or B)
40032	Setpoint 4 Value (Lo word)					
	Manual Mode Registers					
40036	Manual Mode Register (MMR)	0	31	0	Read/Write	Bit State: 0 = Auto Mode, 1 = Manual Mode Bit 4 = S1, Bit 3 = S2, Bit 2 = S3, Bit 1 = S4, Bit 0 = Linear Output
40037	Analog Output Register (AOR)	0	4095	0	Read/Write	Linear Output Card written to only if Linear Output is in Manual Mode (MMR bit 0 = 1).
40038	Setpoint Output Register (SOR)	0	15	N/A	Read/Write	Status of Setpoint Outputs. Bit State: 0=Off, 1=On. Bit 3 = S1, Bit 2 = S2, Bit 1 = S3, Bit 0 = S4. Outputs can only be activated/reset with this register when the respective bits in the Manual Mode Register (MMR) are set.
40039	Reset Output Register	0	15	0	Read/Write	Bit State: 1= Reset Output, bit is returned to zero following reset processing; Bit 3 = S1, Bit 2 = S2, Bit 1 = S3, Bit 0 = S4

SERIAL RLC PROTOCOL COMMUNICATIONS

RLC Communications requires the Serial Communications Type Parameter (tYPE) be set to RLC Protocol (rLC).

SENDING SERIAL COMMANDS AND DATA TO THE METER

When sending commands to the meter, a string containing at least one command character must be constructed. A command string consists of a command character, a value identifier, numerical data (if writing data to the meter) followed by a command terminator character * or $. The <CR> is also available as a terminator when Counter C is in the SLAVE mode.

Command Chart

COMMAND	DESCRIPTION	NOTES
N	Node (Meter) Address Specifier	Address a specific meter. Must be followed by a two digit node address. Not required when address = 00.
T	Transmit Value (read)	Read a register from the meter. Must be followed by register ID character
V	Value Change (write)	Write to register of the meter. Must be followed by register ID character and numeric data.
R	Reset	Reset a register or output. Must be followed by register ID character.
P	Block Print Request	Initiates a block print output. Registers are defined in programming.

Command String Construction

The command string must be constructed in a specific sequence. The meter does not respond with an error message to invalid commands. The following procedure details construction of a command string:

1. The first characters consist of the Node Address Specifier (N) followed by a 1 or 2 character address number. The address number of the meter is programmable. If the node address is 0, this command and the node address itself may be omitted. For node address 1 through 9, a leading zero character is not required. (The only exception is a numeric transmission when Counter C is set for slave mode.) This is the only command that may be used in conjunction with other commands.
2. After the optional address specifier, the next character is the command character.
3. The next character is the Register ID. This identifies the register that the command affects. The P command does not require a Register ID character. It prints according to the selections made in print options.
4. If constructing a value change command (writing data), the numeric data is sent next.
5. All command strings must be terminated with the string termination characters *, $ or when Counter C is set for slave mode <CR>. The meter does not begin processing the command string until this character is received. See Timing Diagram figure for differences between terminating characters.

Sending Numeric Data

Numeric data sent to the meter must be limited to the digit range shown under transmit details in the Register Identification Chart. Leading zeros are ignored. Negative numbers must have a minus sign. The meter ignores any decimal point and conforms the number to the scaled resolution. (For example: the meter's scaled decimal point position = 0.0 and 25 is written to a register. The value of the register is now 2.5.

Note: Since the meter does not issue a reply to value change commands, follow with a transmit value command for readback verification.

Register Identification Chart

ID	VALUE DESCRIPTION	MNEMONIC	COMMAND	TRANSMIT DETAILS
A	Count A	CTA	T, V, R	6 digit (V), 8 digit (T)
B	Count B	CTB	T, V, R	6 digit (V), 8 digit (T)
C	Count C	CTC	T, V, R	6 digit (V), 8 digit (T)
D	Rate	RTE	T, V	5 digit, positive only
E	Min (Lo) Value	MIN	T, V, R	6 digit, positive only
F	Max (Hi) Value	MAX	T, V, R	6 digit, positive only
G	Scale Factor A	SFA	T, V	6 digit, positive only
H	Scale Factor B	SFB	T, V	6 digit, positive only
I	Scale Factor C	SFC	T, V	6 digit, positive only
J	Counter Load A	LDA	T, V	5 negative / 6 positive
K	Counter Load B	LDB	T, V	5 negative / 6 positive
L	Counter Load C	LDC	T, V	5 negative / 6 positive
M	Setpoint 1	SP1	T, V, R	5 negative / 6 positive
O	Setpoint 2	SP2	T, V, R	5 negative / 6 positive
Q	Setpoint 3	SP3	T, V, R	5 negative / 6 positive
S	Setpoint 4	SP4	T, V, R	5 negative / 6 positive
U	Auto/Manual Register	MMR	T, V	0 – auto, 1 - manual
W	Analog Output Register	AOR	T, V	0 – 4095 normalized
X	Setpoint Register	SOR	T, V	0 – not active, 1 – active

Command String Examples:

1. Address = 17, Write 350 to Setpoint 1.
   String: N17VM350$
2. Address = 5, Read Count A value.
   String: N5TA*
3. Address = 0, Reset Setpoint 4 output.
   String: RS*

RECEIVING DATA FROM THE METER

Data is transmitted by the meter in response to either a transmit command (T), a print block command (P) or User Function print request. The response from the meter is either a full field transmission or an abbreviated transmission. The meter response mode is established in Module 7.

Full Field Transmission (Address, Mnemonic, Numeric data)

Byte	Description
1, 2	2 byte Node (meter) Address field [00-99]
3	<SP> (Space)
4-6	3 byte Register Mnemonic field
7-18	12 byte data field, 10 bytes for number, one byte for sign, one byte for decimal point
19	<CR> carriage return
20	<LF> line feed
21	<SP>* (Space)
22	<CR>* carriage return
23	<LF>* line feed

** These characters only appear in the last line of a block print.*

The first two characters transmitted (bytes 1 and 2) are the unit address. If the address assigned is 00, two spaces are substituted. A space (byte 3) follows the unit address field. The next three characters (bytes 4 to 6) are the register mnemonic. The numeric data is transmitted next.

The numeric field (bytes 7 to 18) is 12 characters long. When the requested value exceeds eight digits for count values or five digits for rate values, an * (used as an overflow character) replaces the space in byte 7. Byte 8 is always a space. The remaining ten positions of this field (bytes 9 to 18) consist of a minus sign (for negative values), a floating decimal point (if applicable), and eight positions for the requested value. The data within bytes 9 to 18 is right-aligned with leading spaces for any unfilled positions.

The end of the response string is terminated with <CR> (byte 19), and <LF> (byte 20). When a block print is finished, an extra <SP> (byte 21), <CR> (byte 22), and <LF> (byte 23) are used to provide separation between the transmissions.

Abbreviated Transmission (Numeric data only)

Byte	Description
1-12	12 byte data field, 10 bytes for number, one byte for sign, one byte for decimal point
13	<CR> carriage return
14	<LF> line feed
15	<SP>* (Space)
16	<CR>* carriage return
17	<LF>* line feed

** These characters only appear in the last line of a block print.*

Meter Response Examples:

1. Address = 17, full field response, Count A = 875
   17 CTA 875 <CR><LF>
2. Address = 0, full field response, Setpoint 2 = -250.5
   SP2 -250.5<CR><LF>
3. Address = 0, abbreviated response, Setpoint 2 = 250, last line of block print
   250<CR><LF><SP><CR><LF>

AUTO/MANUAL MODE REGISTER (MMR) ID: U

This register sets the controlling mode for the outputs. In Auto Mode (0) the meter controls the setpoint and analog output. In Manual Mode (1) the outputs are defined by the registers SOR and AOR. When transferring from auto mode to manual mode, the meter holds the last output value (until the register is changed by a write). Each output may be independently changed to auto or manual. In a write command string (VU), any character besides 0 or 1 in a field will not change the corresponding output mode.

U abcde
e = Analog Output
d = SP4
c = SP3
b = SP2
a = SP1

Example: VU00011* places SP4 and Analog in manual.

ANALOG OUTPUT REGISTER (AOR) ID: W

This register stores the present signal value of the analog output. The range of values of this register is 0 to 4095, which corresponds to the analog output range per the following chart:

Register Value	Output Signal*		
	0-20 mA	4-20 mA	0-10 V
0	0.00	4.00	0.000
1	0.005	4.004	0.0025
2047	10.000	12.000	5.000
4094	19.995	19.996	9.9975
4095	20.000	20.000	10.000

**Due to the absolute accuracy rating and resolution of the output card, the actual output signal may differ 0.15% FS from the table values. The output signal corresponds to the range selected (0-20 mA, 4-20 mA or 0-10 V).*

Writing to this register (VW) while the analog output is in the Manual Mode causes the output signal level to update immediately to the value sent. While in the Automatic Mode, this register may be written to, but it has no effect until the analog output is placed in the manual mode. When in the Automatic Mode, the meter controls the analog output signal level. Reading from this register (TW) will show the present value of the analog output signal.

Example: VW2047* will result in an output of 10.000 mA, 12.000 mA or 5.000V depending on the range selected.

SETPOINT OUTPUT REGISTER (SOR) ID: X

This register stores the states of the setpoint outputs. Reading from this register (TX) will show the present state of all the setpoint outputs. A "0" in the setpoint location means the output is off and a "1" means the output is on.

X abcd
d = SP4
c = SP3
b = SP2
a = SP1

In Automatic Mode, the meter controls the setpoint output state. In Manual Mode, writing to this register (VX) will change the output state. Sending any character besides 0 or 1 in a field or if the corresponding output was not first in manual mode, the corresponding output value will not change. (It is not necessary to send least significant 0s.)

Example: VX10* will result in output 1 on and output 2 off.

COUNTER C SLAVE COMMUNICATIONS

Counter C may be programmed for SLAVE, to act as a serial slave display. By doing this, the carriage return <CR> is added as a valid command terminator character for all serial command strings. The <CR> as a terminator may be very useful for standard serial commands, even if Counter C is never displayed or sent a slave message. The $ terminator should not be used in the slave mode. If numeric values are not to be saved to memory, then send the value as a literal transmission with <CR> terminator.

The Counter C slave display is right aligned. It has a capacity of displaying six characters. When less than six characters are received, blank spaces will be placed in front of the characters. If more than six characters are sent, then only the last six are displayed. The meter has a 192 character buffer for the slave display. If more than 192 characters are sent, the additional characters are discarded until a terminator is received. Counter C processes numeric and literal transmissions differently.

Numeric Transmissions

When a string that does not begin with #, T, V, P or R is received, the meter processes it as a Numeric transmission. In this case, only the recognized numbers and punctuation are displayed. All other characters in the string are discarded. If a negative sign appears anywhere in the string the resulting number will be negative. Only the most significant decimal point is retained. If no numerical characters are received, then the numeric value will be zero. The numeric display can be used for setpoint (boundary action only) and analog output functions. When using this display for setpoint and analog output values, the decimal point position must match the programming entered through the front panel. The numeric value is retained in Counter C memory until another Numeric transmission is received.

Recognized Numbers = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Recognized Punctuation = period, comma, minus

Literal Transmissions

When a string that begins with # is received, the meter processes it as a Literal transmission. In this case, any unrecognized characters will be replaced with a space. A Literal display will replace a Numeric value in the Counter C display. However, it will not remove a previous Numeric value from Counter C memory or prevent the Counter C outputs from functioning with the Numeric value. Literal transmissions are only possible when using RS232 or RS485 cards.

Recognized Characters = a, b, c, d, e, f, g, h, i, j, l, n, o, p, q, r, s, t, u, y, z (in upper or lower case)
Recognized Numbers = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Recognized Punctuation = period, comma, minus, blank

COMMAND RESPONSE TIME

The meter can only receive data or transmit data at any one time (half-duplex operation). During RS232 transmissions, the meter ignores commands while transmitting data, but instead uses RXD as a busy signal. When sending commands and data to the meter, a delay must be imposed before sending another command. This allows enough time for the meter to process the command and prepare for the next command.

At the start of the time interval t_1, the computer program prints or writes the string to the com port, thus initiating a transmission. During t_1, the command characters are under transmission and at the end of this period, the command terminating character (*, $ or slave only <CR>) is received by the meter. The time duration of t_1 is dependent on the number of characters and baud rate of the channel.

$$t_1 = (10 \text{ times the \# of characters}) / \text{baud rate}$$

At the start of time interval t_2, the meter starts the interpretation of the command and when complete, performs the command function. This time interval t_2 varies from 2 msec to 15 msec. If no response from the meter is expected, the meter is ready to accept another command.

If the meter is to reply with data, the time interval t_2 is controlled by the use of the command terminating character and the Serial Transmit Delay parameter (dELAY). The '*' or '<CR>' terminating character results in a response time window of the Serial Transmit Delay time (dELAY) plus 15 msec. maximum. The dELAY parameter should be programmed to a value that allows sufficient time for the release of the sending driver on the RS485 bus. Terminating the command line with "$" results in a response time window (t_2) of 2 msec minimum and 15 msec maximum. The response time of this terminating character requires that sending drivers release within 2 msec after the terminating character is received.

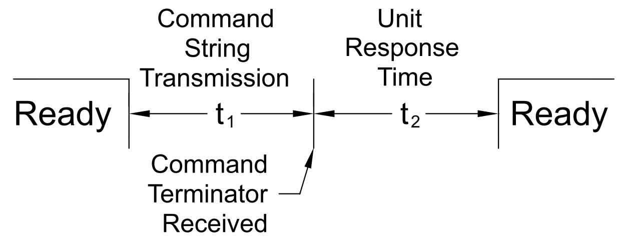
At the beginning of time interval t_3, the meter responds with the first character of the reply. As with t_1, the time duration of t_3 is dependent on the number of characters and baud rate of the channel. At the end of t_3, the meter is ready to receive the next command.

$$t_3 = (10 \text{ times the \# of characters}) / \text{baud rate}$$

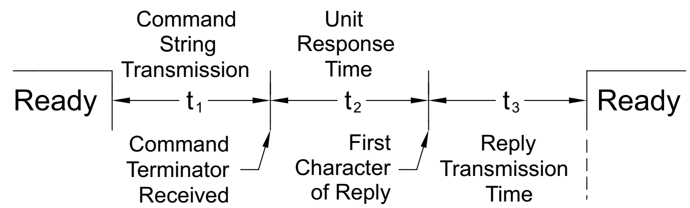
The maximum serial throughput of the meter is limited to the sum of the times t_1, t_2 and t_3.

Timing Diagrams

NO REPLY FROM METER



RESPONSE FROM METER



COMMUNICATION FORMAT

Data is transferred from the meter through a serial communication channel. In serial communications, the voltage is switched between a high and low level at a predetermined rate (baud rate) using ASCII encoding. The receiving device reads the voltage levels at the same intervals and then translates the switched levels back to a character.

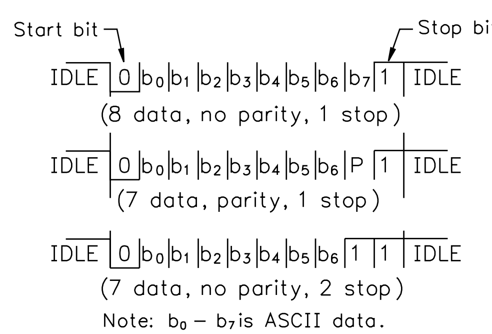
The voltage level conventions depend on the interface standard. The table lists the voltage levels for each standard.

LOGIC	INTERFACE STATE	RS232*	RS485*
1	mark (idle)	TXD,RXD; -3 to -15 V	a-b < -200 mV
0	space (active)	TXD,RXD; +3 to +15 V	a-b > +200 mV
* Voltage levels at the Receiver			

Data is transmitted one byte at a time with a variable idle period between characters (0 to ∞). Each ASCII character is "framed" with a beginning start bit, an optional parity bit and one or more ending stop bits. The data format and baud rate must match that of other equipment in order for communication to take place. The figures list the data formats employed by the meter.

Start bit and Data bits

Data transmission always begins with the start bit. The start bit signals the receiving device to prepare for reception of data. One bit period later, the least significant bit of the ASCII encoded character is transmitted, followed by the remaining data bits. The receiving device then reads each bit position as they are transmitted.



Character Frame Figure

Parity bit

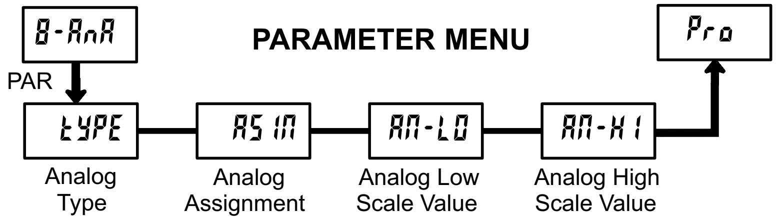
After the data bits, the parity bit is sent. The transmitter sets the parity bit to a zero or a one, so that the total number of ones contained in the transmission (including the parity bit) is either even or odd. This bit is used by the receiver to detect errors that may occur to an odd number of bits in the transmission. However, a single parity bit cannot detect errors that may occur to an even number of bits. Given this limitation, the parity bit is often ignored by the receiving device. The PAX meter ignores the parity bit of incoming data and sets the parity bit to odd, even or none (mark parity) for outgoing data.

Stop bit

The last character transmitted is the stop bit. The stop bit provides a single bit period pause to allow the receiver to prepare to re-synchronize to the start of a new transmission (start bit of next byte). The receiver then continuously looks for the occurrence of the start bit. If 7 data bits and no parity is selected, then 2 stop bits are sent from the PAXI.

6.8 MODULE 8 - ANALOG OUTPUT PARAMETERS (8-AnA)

PAXI ONLY



Module 8 is the programming for the analog output parameters. To have an analog output signal, an analog output option card needs to be installed (See Ordering Information). For analog output hardware and wiring details, refer to the bulletin shipped with the option card.

ANALOG TYPE

tYPE
4-20

SELECTION	RANGE
0-20	0 to 20 mA
4-20	4 to 20 mA
0-10	0 to 10 V

Enter the analog output type. For voltage output use terminals 16 and 17. For current output use terminals 18 and 19. Only one range can be used at a time.

ANALOG ASSIGNMENT

AS IN
rAtE

A CNt b CNt C CNt
rAtE LO HI

Select the display that the analog output is to follow:

A CNt = Counter A Value
b CNt = Counter B Value
C CNt = Counter C Value
rAtE = Rate Value
LO = Minimum Value
HI = Maximum Value

ANALOG LOW SCALE VALUE

An-LO
0

-99999 to 999999

Enter the display value within the selected Analog Assignment that corresponds to the low limit of the type selected.

The decimal point is determined by the decimal point setting of the assigned counter or rate. The scale value can not be set to read values with more than 6 digits. Reverse acting output is possible by reversing the scaling values.

ANALOG HIGH SCALE VALUE

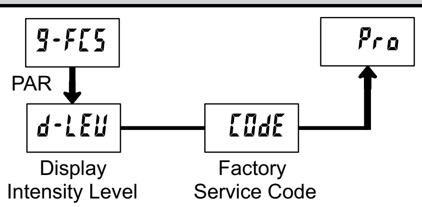
An-HI
1000

-99999 to 999999

Enter the display value within the selected Analog Assignment that corresponds to the high limit of the type selected.

The decimal point is determined by the decimal point setting of the assigned counter or rate. The scale value can not be set to read values with more than 6 digits. Reverse acting output is possible by reversing the scaling values.

6.9 MODULE 9 - FACTORY SERVICE OPERATIONS (9-FCS)



DISPLAY INTENSITY LEVEL

d-LEV
3

Enter the desired Display Intensity Level (0-15) by using the arrow keys. The display will actively dim or brighten as the levels are changed. This parameter also appears in Quick Programming Mode when enabled.

RESTORE FACTORY DEFAULTS

CODE
66

Use the arrow keys to display CODE 66 and press **PAR**. The meter will display rESEt and then returns to CODE 50. Press **DSP** key to return to the Display Mode. This will overwrite all user settings with the factory settings.

Pressing the **PAR** and **DSP** keys at the same time on power-up will load the factory settings and display Err4. This allows operation in the event of a memory failure or corrupted data. Immediately press **RST** key and reprogram the meter. If the meter is powered down again before pressing the **RST** key, the existing dynamic data will not be overwritten.

UNIT TYPE AND VERSION

CODE
51

The meter briefly displays the unit type followed by the current firmware version (VEr x.x), and then returns to CODE 50. This information is also displayed during the meter power-up sequence.

INPUT A AND B LOGIC SELECTION

CODE
55

The Count Inputs A and B are factory configured for falling edge triggered (active low) operation in single edge count modes. The Counter Operating Mode descriptions in the Input programming section reflect this logic. If an application is better suited to use rising edge triggered (active high) operation, the Input Logic for Input A and/or Input B can be changed by entering Code 55.

INP A
LO-ACt   LO-ACt   HI-ACt

Selecting HI-ACt sets the Input A logic to rising edge triggered (active high) operation. Be advised that all references to Input A falling edge and Input A rising edge will be reversed for the Counter Operating Mode descriptions.

INP b
LO-ACt   LO-ACt   HI-ACt

Selecting HI-ACt sets the Input B logic to rising edge triggered (active high) operation. Be advised that all references to Input B falling edge and Input B rising edge will be reversed for the Counter Operating Mode descriptions.

PAXI: CALIBRATION

CODE
48

The only item in the PAXI meter that can be calibrated is the Analog Output. The Count A and B values are scaled using the parameters in Module 1, Counter C value is scaled using Module 5 and the Rate value is scaled using Module 4. If the meter appears to be indicating incorrectly or inaccurately, refer to the Troubleshooting section.

When Analog Out recalibration is required (generally every 2 years), it should be performed by qualified technicians using appropriate equipment. Calibration does not change any user programmed parameters.

Calibration may be aborted by disconnecting power to the meter before exiting Module 9. In this case, the existing calibration settings remain in effect.

***Note**: Allow a 30 minute warm-up period before staring calibration.*

Analog Output Card Calibration

Before starting, verify that a precision meter with an accuracy of 0.05% or better (voltmeter for voltage output and/or current meter for current output) is connected and ready. Then perform the following procedure:

1. Use the arrow keys to display CODE 48 and press **PAR**.
2. CALOUt is displayed. Use the arrow keys to select YES and press **PAR**.
3. Using the chart below, step through the five selections to be calibrated. At each prompt, use the PAXI arrow keys to adjust the output so that the external meter display matches the selection being calibrated. When the external reading matches, or if the range is not being calibrated, press **PAR**.

SELECTION	EXTERNAL METER	ACTION
0.0_A	0.00	Adjust if necessary, press **PAR**
4.0_A	4.00	Adjust if necessary, press **PAR**
20.0_A	20.00	Adjust if necessary, press **PAR**
0.0u	0.00	Adjust if necessary, press **PAR**
10.0u	10.00	Adjust if necessary, press **PAR**

4. When CodE 50 appears, press **PAR** twice and remove the external meters.

TROUBLESHOOTING

For further assistance, contact technical support at the appropriate company numbers listed.

PROBLEM	REMEDIES
NO DISPLAY	**CHECK**: Power level, power connections
PROGRAM LOCKED-OUT	**CHECK**: Active (lock-out) user input **ENTER**: Security code requested
CERTAIN DISPLAYS ARE LOCKED OUT	**CHECK**: Module 3 programming
INCORRECT DISPLAY VALUE or NOT COUNTING	**CHECK**: Input wiring, DIP switch setting, input programming, scale factor calculation, input signal level, user input jumper, lower input signal frequency
USER INPUT NOT WORKING CORRECTLY	**CHECK**: User input wiring, user input jumper, user input being used for signal, Module 2
OUTPUT DOES NOT WORK	**CHECK**: Corresponding option card installation, output configuration, output wiring
JITTERY DISPLAY	**CHECK**: Wiring is per EMC installation guidelines, input signal frequency, signal quality, scaling, update time, DIP switch setting
"r OLOL" **RATE**	**CHECK**: Lower input signal frequency, reduce rate scaling
MODULES or PARAMETERS NOT ACCESSIBLE	**CHECK**: Corresponding option card installation, related controlling parameter selected
ERROR CODE (Err 1-4)	**PRESS**: Reset key (if unable to clear contact factory.)
SERIAL COMMUNICATIONS	**CHECK**: Wiring, connections, meter and host settings

Shaded areas are model dependent.

PARAMETER VALUE CHART

PAX Model Number ________ Programmer ________________ Date ________

Meter# ______________ Security Code __________

1-INP Counter A & B Input Parameters - PAXC & I only

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
A CNt	COUNTER A OPERATING MODE	cnt	
ArESEt	COUNTER A RESET ACTION	ZErO	
AdECPt	COUNTER A DECIMAL POSITION	0	
ASCFAC	COUNTER A SCALE FACTOR (A)	1.00000	
	COUNTER A SCALE FACTOR (B) *	1.00000	
ASCALr	COUNTER A SCALE MULTIPLIER	1	
ACNtLd	COUNTER A COUNT LOAD VALUE (A)	500	
	COUNTER A COUNT LOAD VALUE (B)*	500	
A P-UP	COUNTER A RESET POWER-UP	NO	
PrSEN	PRESCALER OUTPUT ENABLE	NO	
PrUAL	PRESCALER SCALE VALUE	1.0000	
b CNt	COUNTER B OPERATING MODE	NONE	
brESEt	COUNTER B RESET ACTION	ZErO	
bdECPt	COUNTER B DECIMAL POSITION	0	
bSCFAC	COUNTER B SCALE FACTOR (A)	1.00000	
	COUNTER B SCALE FACTOR (B)*	1.00000	
bSCALr	COUNTER B SCALE MULTIPLIER	1	
bCNtLd	COUNTER B COUNT LOAD VALUE (A)	500	
	COUNTER B COUNT LOAD VALUE (B)*	500	
b P-UP	COUNTER B RESET POWER-UP	NO	

** See Module 2, Exchanging Parameter Lists, for details on programming this value.*

Shaded areas are model dependent.

2-FNC User Input and Function Key Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
USr-1	USER INPUT 1	NO	
USr-2	USER INPUT 2	NO	
USr-3	USER INPUT 3	NO	
F1	FUNCTION KEY 1	NO	
F2	FUNCTION KEY 2	NO	
rSt	RESET KEY	dSPrSt	
Sc-F1	2nd FUNCTION KEY 1	NO	
Sc-F2	2nd FUNCTION KEY 2	NO	

3-LOC Display and Program Lockout Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
A CNt	COUNTER A DISPLAY LOCK-OUT	rEd	
b CNt	COUNTER B DISPLAY LOCK-OUT	LOC	
C CNt	COUNTER C DISPLAY LOCK-OUT	LOC	
rAtE	RATE DISPLAY LOCK-OUT	rEd	
HI	MAX DISPLAY LOCK-OUT	LOC	
LO	MIN DISPLAY LOCK-OUT	LOC	
SP-1	SETPOINT 1 ACCESS LOCK-OUT	LOC	
SP-2	SETPOINT 2 ACCESS LOCK-OUT	LOC	
SP-3	SETPOINT 3 ACCESS LOCK-OUT	LOC	
SP-4	SETPOINT 4 ACCESS LOCK-OUT	LOC	
ACNtLd	COUNT LOAD A ACCESS	LOC	
bCNtLd	COUNT LOAD B ACCESS	LOC	
CCNtLd	COUNT LOAD C ACCESS	LOC	
ASCFAC	SCALE FACTOR A ACCESS	LOC	
bSCFAC	SCALE FACTOR B ACCESS	LOC	
CSCFAC	SCALE FACTOR C ACCESS	LOC	
d-LEU	DISPLAY INTENSITY ACCESS	LOC	
COdE	SECURITY CODE	0	

Shaded areas are model dependent.

4-rtE Rate Input Parameters - PAXI & R only

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
rAtEEN	RATE ASSIGNMENT	rAtE-A	
LO-Udt	LOW UPDATE TIME	1.0	
HI-Udt	HIGH UPDATE TIME	2.0	
rtE dP	RATE DECIMAL POINT	0	
SEGS	LINEARIZER SEGMENTS	0	
rdSP 0	SCALING PT. 1 - DISPLAY VALUE	0	
r INP 0	SCALING PT. 1 - INPUT VALUE	0.0	
rdSP 1	SCALING PT. 2 - DISPLAY VALUE	1000	
r INP 1	SCALING PT. 2 - INPUT VALUE	1000.0	
rdSP 2	SCALING PT. 3 - DISPLAY VALUE	2000	
r INP 2	SCALING PT. 3 - INPUT VALUE	2000.0	
rdSP 3	SCALING PT. 4 - DISPLAY VALUE	3000	
r INP 3	SCALING PT. 4 - INPUT VALUE	3000.0	
rdSP 4	SCALING PT. 5 - DISPLAY VALUE	4000	
r INP 4	SCALING PT. 5 - INPUT VALUE	4000.0	
rdSP 5	SCALING PT. 6 - DISPLAY VALUE	5000	
r INP 5	SCALING PT. 6 - INPUT VALUE	5000.0	
rdSP 6	SCALING PT. 7 - DISPLAY VALUE	6000	
r INP 6	SCALING PT. 7 - INPUT VALUE	6000.0	
rdSP 7	SCALING PT. 8 - DISPLAY VALUE	7000	
r INP 7	SCALING PT. 8 - INPUT VALUE	7000.0	
rdSP 8	SCALING PT. 9 - DISPLAY VALUE	8000	
r INP 8	SCALING PT. 9 - INPUT VALUE	8000.0	
rdSP 9	SCALING PT. 10 - DISPLAY VALUE	9000	
r INP 9	SCALING PT. 10 - INPUT VALUE	9000.0	
rOUNd	RATE DISPLAY ROUNDING	1	
LOCUt	MINIMUM LOW CUT OUT	0	
HI-t	MAX CAPTURE DELAY TIME	2.0	
LO-t	MIN CAPTURE DELAY TIME	2.0	

Shaded areas are model dependent.

5-CtrC Counter C Input Parameters - PAXC & I only

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
C CNt	COUNTER C OPERATING MODE	NONE	
CrESEt	COUNTER C RESET ACTION	ZErO	
CdECPt	COUNTER C DECIMAL POSITION	0	
CSCFAC	COUNTER C SCALE FACTOR (A)	1.00000	
	COUNTER C SCALE FACTOR (B)*	1.00000	
CSCALr	COUNTER C SCALE MULTIPLIER	1	
CCNtLd	COUNTER C COUNT LOAD VALUE (A)	500	
	COUNTER C COUNT LOAD VALUE (B)*	500	
C P-UP	COUNTER C RESET POWER-UP	NO	

** See Module 2, Exchanging Parameter Lists, for details on programming this value.*

6-SPt Setpoint (Alarm) Parameters

		SP-1		SP-2		SP-3		SP-4	
DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING	FACTORY SETTING	USER SETTING	FACTORY SETTING	USER SETTING	FACTORY SETTING	USER SETTING
LIt-n	SETPOINT ANNUNCIATORS	NOr		NOr		NOr		NOr	
OUt-n	SETPOINT OUTPUT LOGIC	NOr		NOr		NOr		NOr	
SUP-n	SETPOINT POWER UP STATE	OFF		OFF		OFF		OFF	
ACt-n	SETPOINT ACTION	OFF		OFF		OFF		OFF	
ASN-n	SETPOINT ASSIGNMENT	A CNt		A CNt		A CNt		A CNt	
SP-n	SETPOINT VALUE (A)	100		100		100		100	
	SETPOINT VALUE (B)*	100		100		100		100	
trC-n	SETPOINT TRACKING	NO		NO		NO		NO	
tYP-n	SETPOINT BOUNDARY TYPE	HI		HI		HI		HI	
Stb-n	STANDBY OPERATION	NO		NO		NO		NO	
HYS-n	SETPOINT HYSTERESIS (rate)	0		0		0		0	
tOFF-n	SETPOINT OFF DELAY	0.00		0.00		0.00		0.00	
tON-n	SETPOINT ON DELAY	0.00		0.00		0.00		0.00	
tOUt-n	SETPOINT TIME OUT	1.00		1.00		1.00		1.00	
AUtO-n	COUNTER AUTO RESET ACTION	NO		NO		NO		NO	
rSd-n	SETPOINT RESET WITH DISPLAY	NO		NO		NO		NO	
rSAS-n	RESET WHEN SPn+1 ACTIVATES	NO		NO		NO		NO	
rSAE-n	RESET WHEN SPn+1 DEACTIVATES	NO		NO		NO		NO	

** See Module 2, Exchanging Parameter Lists, for details on programming this value.*

Shaded areas are model dependent.

7-SrL Serial Communication Parameters - PAXI only

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
tYPE	COMMUNICATIONS TYPE	MbrtU	
bAUd	BAUD RATE	38400	
dAtA	DATA BIT	8	
PAr	PARITY BIT	NO	
Addr	METER ADDRESS	247	
dELAY	TRANSMIT DELAY	0.010	
AbrV	ABBREVIATED PRINTING	NO	
A CNt	PRINT COUNTER A	YES	
b CNt	PRINT COUNTER B	NO	
C CNt	PRINT COUNTER C	NO	
rAtE	PRINT RATE	NO	
HILO	PRINT MAX & MIN	NO	
SCFAC	PRINT SCALE FACTORS	NO	
CNtLd	PRINT COUNT LOAD VALUES	NO	
SPNt	PRINT SETPOINT VALUES	NO	

8-AnA Analog Output Parameters - PAXI only

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
tYPE	ANALOG TYPE	4-20	
ASIN	ANALOG ASSIGNMENT	rAtE	
AN-LO	ANALOG LOW SCALE VALUE	0	
AN-HI	ANALOG HIGH SCALE VALUE	1000	

9-FCS Factory Service Parameters

DISPLAY	PARAMETER	FACTORY SETTING	USER SETTING
d-LEV	DISPLAY INTENSITY LEVEL	3	

LIMITED WARRANTY

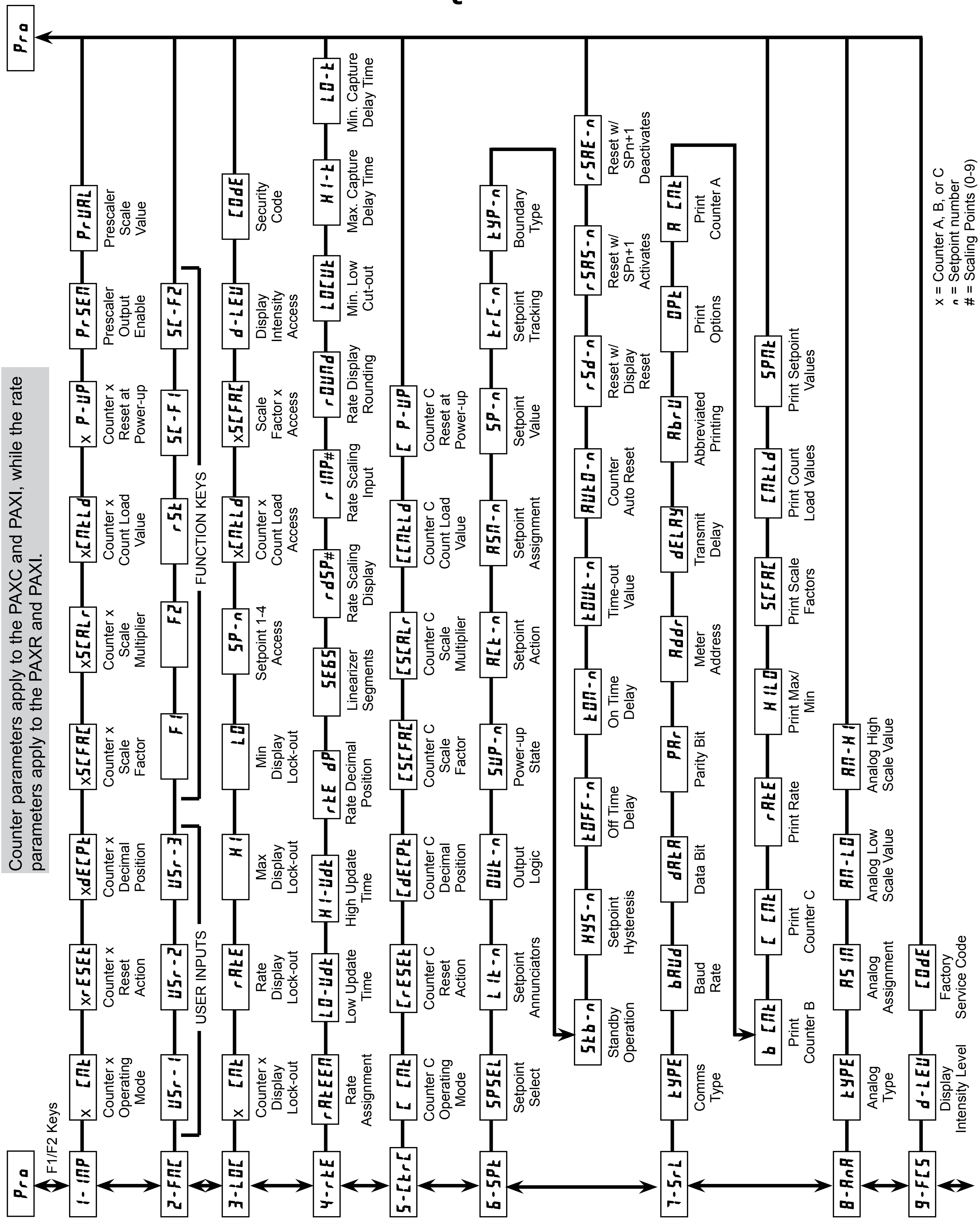
(a) Red Lion Controls Inc., Sixnet Inc., N-Tron Corporation, or Blue Tree Wireless Data, Inc. (the "Company") warrants that all Products shall be free from defects in material and workmanship under normal use for the period of time provided in "Statement of Warranty Periods" (available at www.redlion.net) current at the time of shipment of the Products (the "Warranty Period"). **EXCEPT FOR THE ABOVE-STATED WARRANTY, COMPANY MAKES NO WARRANTY WHATSOEVER WITH RESPECT TO THE PRODUCTS, INCLUDING ANY (A) WARRANTY OF MERCHANTABILITY; (B) WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE; OR (C) WARRANTY AGAINST INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS OF A THIRD PARTY; WHETHER EXPRESS OR IMPLIED BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE OR OTHERWISE.** Customer shall be responsible for determining that a Product is suitable for Customer's use and that such use complies with any applicable local, state or federal law.

(b) The Company shall not be liable for a breach of the warranty set forth in paragraph (a) if (i) the defect is a result of Customer's failure to store, install, commission or maintain the Product according to specifications; (ii) Customer alters or repairs such Product without the prior written consent of Company.

(c) Subject to paragraph (b), with respect to any such Product during the Warranty Period, Company shall, in its sole discretion, either (i) repair or replace the Product; or (ii) credit or refund the price of Product provided that, if Company so requests, Customer shall, at Company's expense, return such Product to Company.

(d) **THE REMEDIES SET FORTH IN PARAGRAPH (c) SHALL BE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDY AND COMPANY'S ENTIRE LIABILITY FOR ANY BREACH OF THE LIMITED WARRANTY SET FORTH IN PARAGRAPH (a).**

PROGRAMMING QUICK OVERVIEW



VAISALA

PTU300 Combined Pressure, Humidity and Temperature Transmitter

For Demanding Applications

Features

- Barometric pressure, humidity, and temperature measurement in one transmitter
- RS-232C serial interface with NMEA protocol for GPS use
- Graphical display and keypad for convenient operation
- Analog outputs, RS-232/485, LAN
- Modbus protocol support (RTU/TCP)
- Traceable to international standards

Vaisala Combined Pressure, Humidity and Temperature Transmitter PTU300 is a unique instrument measuring three parameters simultaneously.

Options

- Available with up to two barometric pressure sensors for added reliability
- Optional universal power supply module
- HMT330MIK installation kit for outdoor use

You can choose from the following probe options: PTU301 for wall mounting for example in laboratories or engine rooms, PTU303 for general use, PTU307 warmed probe for outdoor and demanding meteorology applications, and PTU30T for pressure and temperature measurement only.

Proven Vaisala Sensor Technology

PTU300 incorporates sensors known for their high accuracy and excellent long-term stability: Vaisala BAROCAP® for pressure measurement and Vaisala HUMICAP® for humidity measurement. The temperature sensor is a platinum RTD sensor.

Graphical Display of Measurement Data and Trends for Convenient Operation

PTU300 features a large numerical and graphical display with a multilingual menu and keypad. It allows users to easily monitor operational data, measurement trends, and access measurement history for the past 12 months.

The optional data logger, with real-time clock, makes it possible to generate over four years of measurement history and zoom in on any desired time or time frame.

The display alarm allows any measured parameter to be tracked, with freely configurable low and high limits.

Versatile Outputs and Data Collection

PTU300 comes with a standard RS-232 serial interface. The output format is compatible with major GPS receivers and NMEA-coded messages. An isolated RS-485 interface is available as an option.

PTU300 is also capable of applying the Modbus communication protocol and, together with an appropriate connection option, provides either Modbus RTU (RS-485) or Modbus TCP/IP (Ethernet) communication.

The data logger records data that can be viewed on the local display or transferred to a PC with Microsoft® Windows® software. The transmitter can also be connected to a network with an optional LAN interface, which enables an Ethernet connection. A USB service cable makes it easy to connect PTU300 to a PC via the service port.

Outdoor Installation Kit

Outdoor installation is possible using the optional HMT330MIK installation kit, for applications requiring reliable measurements for meteorological purposes.

Flexible Calibration

Quick, one-point field calibration for humidity is easy using Vaisala Hand-Held Humidity Meter HM70.

With Vaisala Barometric Pressure Transfer Standard PTB330TS, including optional humidity and temperature probe, field check and calibration can be performed for all three parameters.

Applications

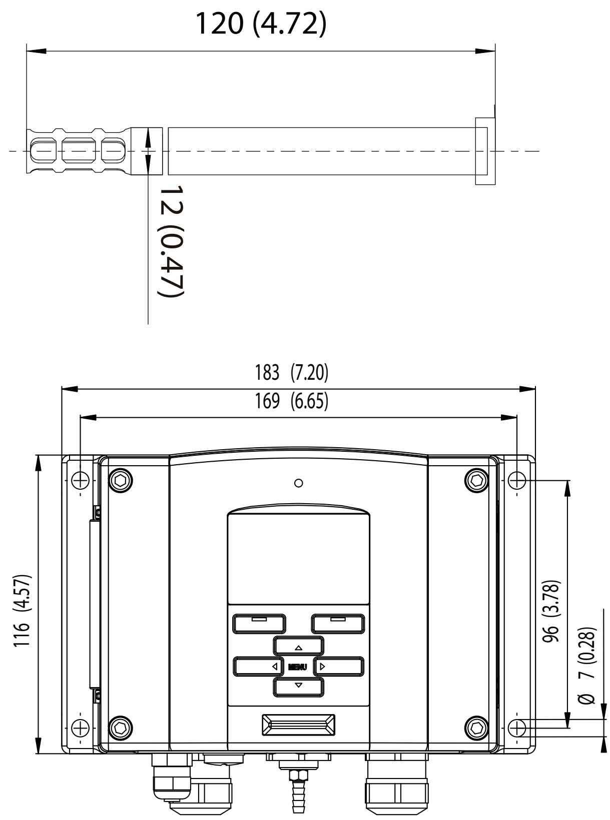
- Environmental monitoring in calibration laboratories
- Industrial applications in semiconductor industry, engine testing and maritime sector
- GPS meteorology: estimating precipitable water vapor in the atmosphere, weather stations

The display also shows the WMO pressure trend ΔP 3h and tendency of 0 ... 8.

Model

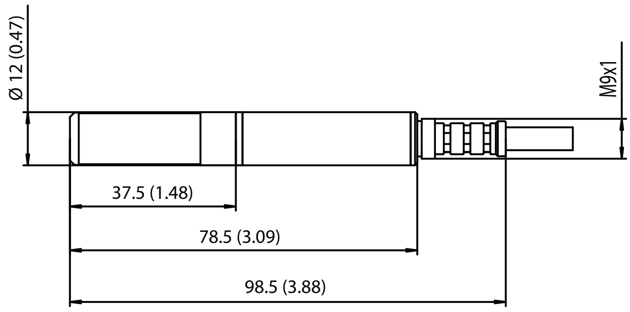
PTU301 for wall mounting

Dimensions in mm

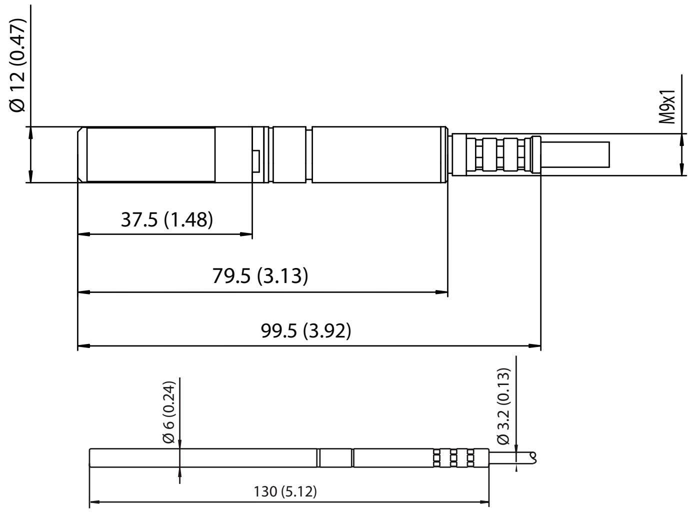


Model	**Dimensions in mm**

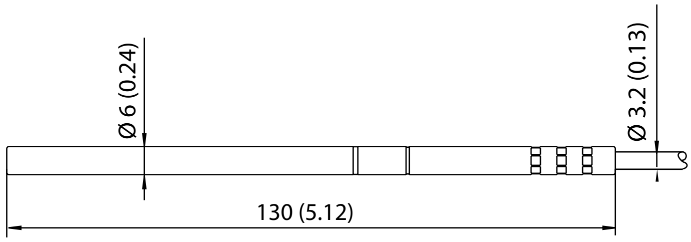
PTU303 probe for outdoor use

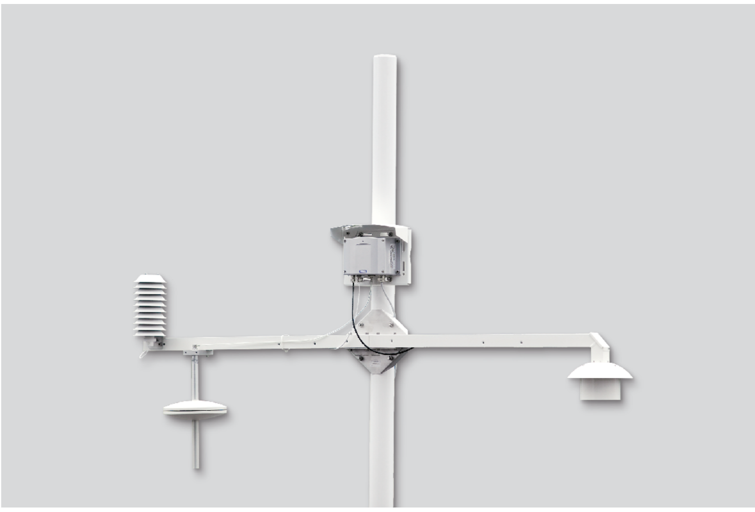


PTU307 warmed probe for demanding meteorological installations



PTU30T for pressure and temperature only measurement





HMT330MIK Meteorological Installation Kit enables PTU307 to be installed outdoors to obtain reliable measurements for meteorological purposes.

Technical Data

Measurement Performance

Barometric Pressure

Pressure range		500 ... 1100 hPa	50 ... 1100 hPa
Accuracy	500 ... 1100 hPa	500 ... 1100 hPa	50 ... 1100 hPa
	Class A	Class B	
Linearity	±0.05 hPa	±0.10 hPa	±0.20 hPa
Hysteresis	±0.03 hPa	±0.03 hPa	±0.08 hPa
Repeatability	±0.03 hPa	±0.03 hPa	±0.08 hPa
Calibration uncerainty	±0.07 hPa	±0.15 hPa	±0.20 hPa
Accuracy at +20 °C / +68 °F	±0.10 hPa	±0.20 hPa	±0.30 hPa
Temperature dependence	±0.1 hPa	±0.1 hPa	±0.3 hPa
Total accuracy (-40 ... +60 °C / -40 ... +140 °F)	±0.15 hPa	±0.25 hPa	±0.45 hPa
Long-term stability/year	±0.1 hPa	±0.1 hPa	±0.2 hPa
Response Time (100 % Response):			
One sensor	2 s	1s	1 s
Pressure units	hPa, mbar, kPa, Pa, inHg, mmH20, mmHg, torr, psia		

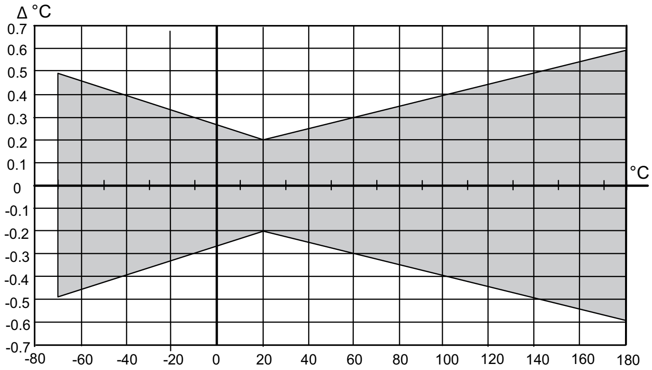
Relative Humidity

Measurement range	0 ... 100 %RH
Accuracy (Including Non-linearity, Hysteresis, and Repeatability):	
At +15 ... +25 °C / +59 ... +77 °F	±1 %RH (0 ... 90 %RH) ±1.7 %RH (90 ... 100 %RH)
At -20 ... +40 °C / - 4... +104 °F	±(1.0 + 0.008 x reading) %RH
At -40 ... +60 °C / -40 ... +140 °F	±(1.5 + 0.015 x reading) %RH
Factory calibration uncertainty (+20 °C / +68 °F) (Defined as ±2 standard deviation limits. Small variations possible, see also calibration certificate.)	±0.6 %RH (0 ... 40 %RH) ±1.0 %RH (40 ... 97 %RH)
Sensor for typical applications	Vaisala HUMICAP 180 or 180R
Sensor for applications with chemical purge/warmed probe	Vaisala HUMICAP 180C or 180RC
Response Time (90 %) at +20 °C (+68 °F) in Still Air:	
With grid filter	8 s / 17 s [1)]
With grid + steel netting filter	20 s / 50 s [1)]
With sintered filter	40 s / 60 s [1)]

Temperature

Measurement range, housing (barometric pressure measurement limit) [2)]	-40 ... +60 °C (-40 ... +140 °F)
Measurement range, probes (operational limit when measuring RH or T)	PTU301: -40 ... +60 °C (-40 ... +140 °F) PTU303: -40 ... +80 °C (-40 ... +176 °F) PTU307: -40 ... +180 °C (-40 ... +356 °F) PTU30T: -70 ... +180 °C (-94 ... +356 °F) [3)]
Accuracy at +20 °C (+68 °F)	PTU301, PTU303, PTU307: ±0.2 °C (±0.4 °F) PTU30/T: ±0.1 °C (±0.18 °F)
Temperature units	°C, °F
Temperature sensor	Pt100 RTD Class F0.1 IEC 60751

1) With HUMICAP 180R or 180RC sensor
2) Note that the operational temperature limits of the PTU303, PTU307, and PTU30T probes are higher than for the PTU300 transmitter itself. The transmitter's temperature limit is based on the upper temperature limit for barometric pressure measurement, +60 °C (+140 °F)
3) PTU30T is used for T and P measurements only, RH measurement not in use.



Accuracy over Temperature Range

Operating Environment

Operating temperature	-40 ... +60 °C (-40 ... +140 °F)
Operating temperature with optional display	0 ... +60 °C (+32 ... +140 °F)
Humidity range	Non-condensing
EMC compliance	EN61326-1, Industrial Environment

Note: Transmitter with display test impedance of 40 Ω is used in IEC61000-4-5 (Surge immunity)

Mechanical Specifications

Cable bushing	M20 x 1.5 for cable diameter 8 ... 11 mm / 0.31 ... 0.43"
Conduit fitting	1/2" NPT
User cable connector (optional) Option 1 Option 2	M12 series 8-pin (male) Female plug with 5 m (16.4 ft) black cable Female plug with screw terminals
Cable diameter, PTU303	6.0 mm
Cable diameter, other probes	5.5 mm
Standard probe cable lengths	2 m, 5 m or 10 m [1)]
Housing material	G-AlSi 10 Mg (DIN 1725)
IP rating	IP66 IP65 (NEMA4X) with local display
Weight (depending on selected probe)	1.0 - 3.0 kg / 2.2 - 6.6 lb

1) Additional cable lengths available, please see order form for details.

Optional Data Logger with Real-time Clock

Logged parameters	Max. four with trend/min/max values
Logging interval	10 s (fixed)
Maximum logging period with maximum temporal resolution	4 years 5 months
Logged points	13.7 million points per parameter
Battery lifetime	Min. 5 years

Display

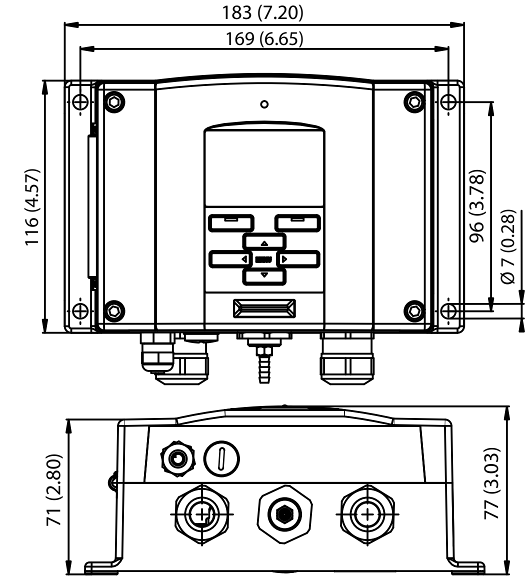
Material	LCD with backlight, graphical trend display of any parameter
Menu languages	English, Chinese, Finnish, French, German, Japanese, Russian, Spanish, Swedish

Inputs and Outputs

Operating voltage With optional power supply module	10 ... 35 VDC, 24 VAC ±20 % 100 ... 240 VAC, 50/60 Hz
Settling time at power-up (one sensor)	Class A: 4 s Class B: 3 s
Recommended wire size	0.5 mm^2 (AWG 20) stranded wires
Digital outputs	RS-232, RS-485 (optional)
Protocols	ASCII commands, Modbus RTU
Service connection	RS-232, USB
Relay outputs (optional)	0.5 A, 250 VAC
Power Consumption at +20 °C (+68 °F) (U_{in} 24 VDC)	
RS-232	Max. 28 mA
U_{out} 3 x 0 ... 1 V / 0 ... 5 V / 0 ... 10 V	Max. 33 mA
I_{out} 3 x 0 ... 20 mA	Max. 63 mA
Display and backlight	+20 mA
During chemical purge	Max. +110 mA
During probe heating	+120 mA
External Loads	
Current outputs	R_L < 500 Ω
0 ... 1 V output	R_L > 2 kΩ
0 ... 5 V and 0 ... 10 V outputs	R_L > 10 kΩ
Ethernet Interface (Optional)	
Supported standards	10BASE-T, 100BASE-TX
Connector	8P8C (RJ45)
IPv4 address assignment	DHCP (automatic), static
Protocols	Telnet, Modbus TCP/IP
Analog Outputs (Optional)	
Current output	0 ... 20 mA, 4 ... 20 mA
Voltage output	0 ... 1 V, 0 ... 5 V, 0 ... 10 V
Humidity and Temperature:	
Accuracy of analog outputs at +20 °C (+68 °F)	±0.05 °% full scale
Temperature dependence of analog outputs	±0.005 %/°C (0.003 %/°F) full scale
Pressure:	
Accuracy of analog outputs at +20 °C (+68 °F)	±0.30 hPa (500 ... 1100 hPa) ±0.40 hPa (50 ... 1100 hPa)
Accuracy of analog outputs at -40 ... +60 °C / -40 ... +140 °F	±0.60 hPa (500 ... 1100 hPa) ±0.75 hPa (50 ... 1100 hPa)

Spare Parts and Accessories

PC software and cable	215005
USB-RJ45 Serial Connection Cable	219685
Connection cable for HM70	211339
Wall mounting plate (plastic)	214829
Pole installation kit with rain shield	215109
DIN rail installation set	211477
Duct installation kit, PTU303/307	210697
Cable gland and AGRO, PTU303/307	HMP247CG
Solar radiation shield, PTU303/307/30T	DTR502B
Meteorological installation kit	HMT330MIK
Duct installation kit (T probe)	215003



Dimensions in mm (inches)

Published by Vaisala | B210954EN-G © Vaisala 2018

VAISALA
www.vaisala.com