

# **MKS Type 651D Pressure Controller**

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This manual is for firmware version: pre-release

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## Safety Information

### Symbols Used in This Instruction Manual

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

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**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.

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**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.

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**Note**

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

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## **Symbols Found on the Unit**

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















<b>Definition of Symbols Found on the Unit</b>			
			
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**

**Observe the following general safety precautions during all phases of operation of this controller. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the controller 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 CONTROLLER**

Do not install substitute parts or perform any unauthorized modification to the controller. Return the controller 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.

### **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 controller. All electrical fittings 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<sup>2</sup>. 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 AN EXPLOSIVE ENVIRONMENT**

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



## Chapter One: General Information

### Introduction

The MKS Type 651D Pressure Controller controls and supplies power to MKS type 253 and 653 throttle valves. The unit has a high-powered driver to operate most MKS throttle valves, including valves with vacuum shut-off capability up to 100 mm (4") and non-sealing valves up to 320 mm (13"). The 651 controller, available with a low capacity or optional high capacity power supply, can supply  $\pm 15$  Volts to power and provide a readout for an attached capacitance manometer. The system pressure (in units of Torr, mTorr, mBar,  $\mu$ Bar, Pascal, kPa, cmH<sub>2</sub>O, or inH<sub>2</sub>O) and valve position (as a % of full scale) display in the window on the front panel. The 651D's dual channel input extends the dynamic control range to support widely varying process pressure recipes. This dual channel input allows controlled pump down from atmosphere.

The 651 controller controls a vacuum system using PID. The *PID* mode uses a Proportional, Integral, and Derivative (PID) algorithm which uses two programmable gain parameters to control at different set points over a wide range of pressures.

The 651 unit allows you to control its communication parameters; sensor and valve parameters; five internal programmable set points (each one having the option of being setup for pressure or position control); one external analog set point; an adjustable softstart function (to minimize turbulence in the chamber and contamination of the process); two process limit relays (each with high and low trip levels) to indicate if the pressure deviates from the desired trip point levels; and valve open, close, and stop functions for use in system setup and diagnostics.

You can operate the 651 controller using front panel (Local), or rear panel (Remote RS-232 or digital logic) control. A Key Lock switch located on the front panel is used to select between the two options, and can lock the front panel controls as a safety measure to prevent accidental command entries.

Two types of batteries are used in the 651 controller: a lithium battery and an optional lead-acid battery. The lithium battery (battery-backed memory module) is a standard component of the 651 unit and is used to power memory for storage of configuration and learned system information while power is off. An *optional* lead-acid battery (valve failsafe battery back up) allows you to configure the controller to drive a valve open or closed upon an AC power failure.

All MKS unheated and 45° C temperature-controlled, linear Baratron® transducers are compatible with the low power 651 controller. The 100° C temperature-controlled, linear Baratron transducers are compatible with the high power unit. Refer to *Product Compatibility*, page 11, for a complete listing of the MKS products that are compatible with the 651 controller.

## **How This Manual is Organized**

This manual is designed to provide instructions on how to set up, install, and operate a Type 651 unit.

**Before installing your Type 651 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 controller in your system.

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

Chapter Four, *Local Operation*, describes how to operate the controller using the front panel controls.

Chapter Five, *Remote RS-232 Operation*, describes the protocol and messages used to operate the unit through RS-232 communications.

Chapter Six, *Remote Digital Logic Control*, describes how to control the unit through the Interface connector on the rear panel.

Chapter Seven, *Maintenance and Troubleshooting*, describes basic maintenance procedures and how to troubleshoot a problem should the unit malfunction.

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

Appendix B, *Model Code Explanation*, describes the controller's ordering code.

Appendix C, *Initial Settings*, lists the controller's initial, factory-set operating parameters.

Appendix D, *Gain Conversions*, explains how to convert the gain and lead parameters used with the 651C unit to the integral and gain values used with the 651D unit.

Appendix E, *RS-232 Message Summary*, lists all of the RS-232 commands and requests, alphabetically by command.

## **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 controllers 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 651 controller, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the controller 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 controller.

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

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**Warning**

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

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## Chapter Two: Installation

### How To Unpack the Type 651 Unit

MKS has carefully packed the Type 651 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.

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**Note**

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

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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.

---

**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 controller. Proper handling is essential when working with all highly sensitive precision electronic controllers.**

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### Unpacking Checklist

#### Standard Equipment

- Type 651 Unit
- Type 651 Instruction Manual (this book)
- Key for the front panel Key Lock switch
- Power Cable

***Optional Equipment***

- Electrical Connector Accessory Kit - 651D-K1  
Includes an I/O connector for the rear panel of the unit, a cover for the I/O connector, and a screwlock assembly for the I/O connector cover
- MKS Type 253 (fast or standard) or 653 control valve
- Valve Failsafe Battery Back-Up (factory installed)
- Rack Mounts:  
RM-13 (supports a 9" deep rack - for a standard 651 unit)  
RM-14 (supports a 12" deep rack - required for mounting a unit with the valve failsafe battery back-up)
- System Interface Cables (Table 3)
- Adapter Cables (Table 4)

**Product Location and Requirements**

The Type 651 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)  
15° to 35° C (59° to 95° F) with the optional valve failsafe battery back-up
- Main supply voltage fluctuations must not exceed  $\pm 10\%$  of the nominal voltage
- Ventilation requirements include sufficient air circulation
- Connect the power cord into a grounded outlet

**Safety Conditions**

The 651 controller 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

## **Product Compatibility**

### **Valves**

MKS *downstream* control valves compatible with the 651 unit include:

- Types 253 and 653

### **Transducers**

MKS transducers compatible with the *low power* 651 unit include:

- Types 121, 122, 124, 127, 128<sup>1</sup>, 220, 223, 622, 626, 627, and 628.

MKS transducers compatible with the *high power* 651 unit include:

- Types 120, 121, 122, 124, 127, 128, 220, 223, 621, 622, 626, 627, and 628.

Table 2 lists the current available to a transducer from a 651 controller.

<b>Transducer Current Available</b>			
<b>Valve Configuration</b>	<b>651 Supply Type</b>	<b>Line Voltage Range</b>	<b>Transducer Current Available</b>
253/653	Low power	90 to 99 VAC 50/60 Hz	400 mA
		180 to 198 VAC 50/60 Hz	400 mA
		100 to 132 VAC 50/60 Hz	500 mA
		200 to 264 VAC 50/60 Hz	500 mA
253/653	High power	90 to 132 VAC 48/62 Hz	1.5 A
		180 to 264 VAC 48/62 Hz	1.5 A

Table 2: Transducer Current Available

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<sup>1</sup>To ensure proper operation of the Type 128 transducer in the (90 to 99 or 180 to 198) power line voltage range, it is recommended that the *high power* 651 unit be used. Above 100/200 Volts, the *low power* unit provides adequate power.

## 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, 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 89/336/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.

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 651 unit to a 627 transducer, use part number CB147-1-10; for a metal braided shielded cable, use part number CB147S-1-10.

## Interface Cables

MKS Interface Cables			
To Connect the 651 Unit To...	High Channel, Use Cable		Low Channel
	Standard	Shielded	
122, 124, 223, 225, 622, and 623 transducers	CB112-2-10	CB112S-2-10	Use of the Low Channel connector requires <i>both</i> one of the cables at left and a CB651S-31-1 15 pin high density to standard density adapter.
127, 128, 624, 625, 626, 627, and 628 transducers	CB147-1-10	CB147S-1-10	
120 transducer	CB120-6-10	CB120S-1-10	
220 transducer	CB112-10-10	CB112S-10-10	
121 and 221 transducers	CB112-14-10	CB112S-14-10	
653 valve	CB652-1-10	CB652S-1-10	
253B valve	CB651-30-10	CB651S-30-10	
Computer 9-pin serial port (pins 2 & 3 straight through) 25-pin serial port (pins 2 & 3 reversed)	CB651-10-10 CB651-11-10	CB651S-10-10 CB651S-11-10	

Table 3: MKS Interface Cables



## Adapter Cables

The 651 pressure controller can be used in place of the 152, 252, and 652 controllers. It may, however, be necessary to use an adapter cable to connect the Type “D” connectors on the 651 controller to your unit. The required adapter cables are listed in Table 4.

Adapter Cables			
From	To	Use the MKS Cable...	
		Standard	Shielded
252 252 + VPO	651 I/O	CB651-12-1	CB651S-12-1
252 + MSO	651 I/O	CB651-13-1	CB651S-13-1
252 + PLO 252 + PLO + VPO	651 I/O	CB651-14-1	CB651S-14-1
252 + MSO + PLO 252 + MSO + VPO 252 + MSO + VPO + PLO	651 I/O	CB651-15-1	CB651S-15-1
152 PC/VPO 152 PC/VPO + RS-232	651 I/O	CB651-16-1	CB651S-16-1
152 RZ/VPO RZ/VPO + RS-232	651 I/O	CB651-17-1	CB651S-17-1
152/252/1252 Sensor Cables	651 Sensor	CB651-18-1	CB651S-18-1
25-Pin Serial Cable*	651 Serial	CB651-19-1	CB651S-19-1
652 I/O	651 I/O	CB651-20-1	CB651S-20-1
152/252/1252 Valve Cable	651 Valve	CB652-2-1	CB652S-2-1
*Pins 2 and 3 are not reversed. This cable is a 651 to 652 serial port converter cable. The 25-pin end simulates a 652 controller, and the opposite end connects to the 651 serial port.			

Table 4: Adapter 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 1 and 2, page 15. (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:
  - The voltage ratings
  - The cumulative  $I^2R$  heating of all the conductors (keep them safely cool)
  - The IR drop of the conductors, so that adequate power or signal voltage gets to the device
  - The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables)
  - 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)

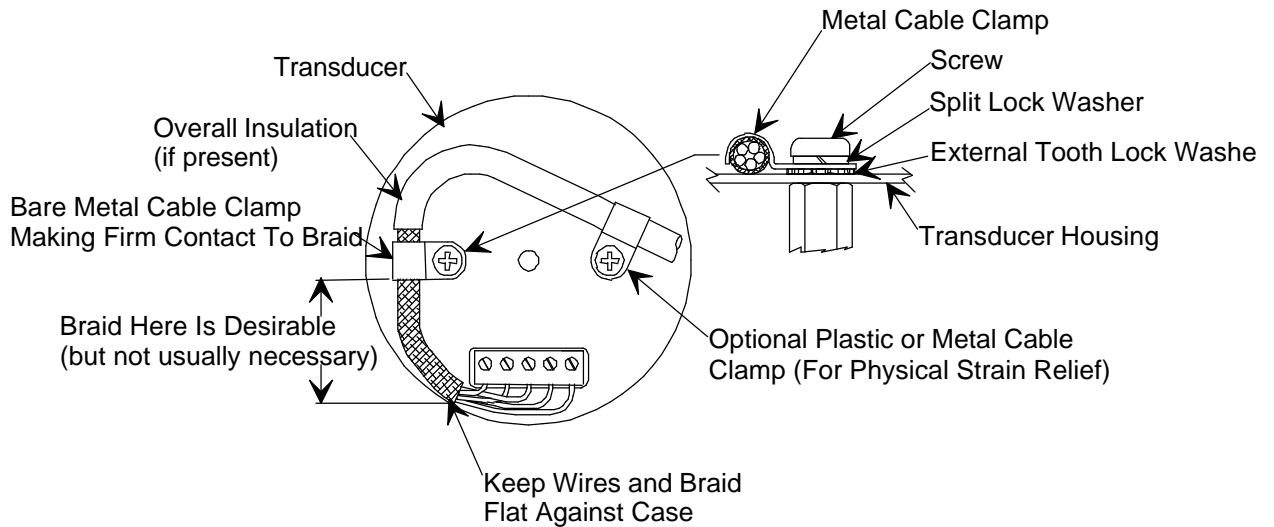


Figure 1: Preferred Method To Connect an Overall Metal Braided Shielded Cable

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

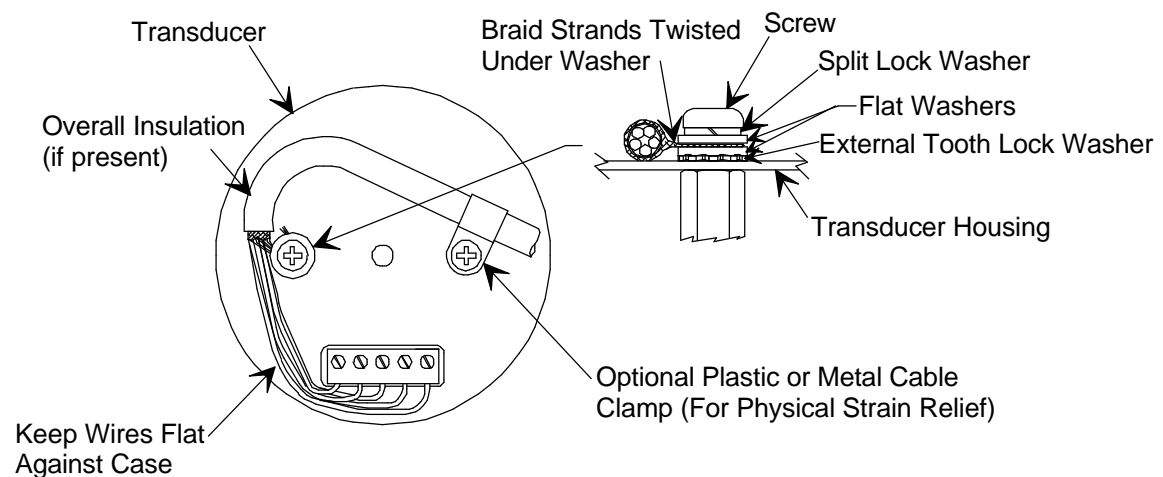


Figure 2: Alternate Method To Connect an Overall Metal Braided Shielded Cable  
*Use this method when cable clamp is not available*

## Setup

### Mounting Instructions

The 651 unit can be mounted in either a panel cutout or in one of the rack mount options (refer to *Optional Equipment*, page 10). Position the unit with proper clearance, to allow air cooling, so that the unit can operate within the specified temperature range. A solid system ground should be maintained for proper operation and safety to personnel.

### Power and Fuse Requirements

The 651 unit is available with either a low or high power option, selected when you placed your order. The unit is shipped with the line voltage set for 115 VAC, although either unit can be operated with 115 VAC or 230 VAC (refer to *How To Set the Line Voltage*, page 23, for more information).

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. Refer to *How to Replace the Fuses*, page 123, for more information.

Power and Fuse Requirements			
Power Supply Option	Nominal Line	Line Voltage Range	Fuse Type
Low power	115 VAC	90 to 132 VAC @50/60 Hz 75 VA (max)	0.63A (T) / 250V / 5 x 20 mm
	230 VAC	180 to 264 VAC @50/60 Hz 75 VA (max)	0.315A (T) / 250V / 5 x 20 mm
High power	115 VAC	90 to 132 VAC @48/62 Hz 150 VA (max)	1.25A (T) / 250V / 5 x 20 mm
	230 VAC	180 to 264 VAC @48/62 Hz 150 VA (max)	0.63A (T) / 250V / 5 x 20 mm

Table 5: Power and Fuse Requirements

#### Caution



Disconnect the power cord from the 651 unit *before* you replace the fuse, to avoid any damage.

Ensure that the fuse type is appropriate for your voltage setting and that voltage setting is correct for your local electrical source.

## Grounding

For protective earthing, plug the power cord into a properly grounded outlet.

## How To Set the Line Voltage

The line voltage selector, located on the rear panel of the 651 unit (refer to Figure 9), configures the 651 unit to accept either 115 or 230 VAC input voltage

### Caution

**The Line Voltage Selector on the 651 unit must be set to the proper input voltage *before* you connect the power cord and turn on the power. Otherwise, the unit will be severely damaged.**

### Note



Be sure to install the correct fuses for the line voltage selected.

To change the line voltage:

1. Be sure that the power cord and all interface cables are disconnected from the 651 controller.
2. Use a blunt instrument, such as a flat head screwdriver, to slide the line voltage selector switch to the left position for operation in the 115 V range, or to the right position for operation in the 230 V range.

Refer to Figure 3. The value of the selected line voltage is visible through the window in the cover of the switch. The voltage and fuse label above the switch shows the corresponding voltage range and fuse requirements for either voltage setting.

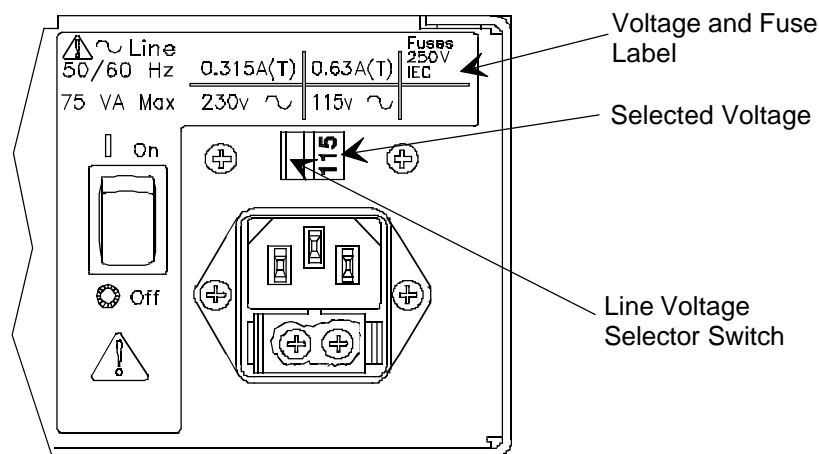


Figure 3: Line Voltage Selector

**Warning**

---

**Be sure that your 651 unit is plugged into the correct AC outlet for the selected line voltage.**

**Plugging a unit with 115V line voltage into a 230 V outlet will damage the controller!**

---

## **Connectors**

### **Rear Panel Connectors**

The 651 controller has five Type “D” connectors on its rear panel (refer to Figure 9, page 32).

The connectors are numbered, from right to left as 1 to 4, as listed in Table 6.

<b>Rear Panel Connector Slot Labels</b>	
<b>Slot Number</b>	<b>Type “D” Connector</b>
1	RS-232 Serial Interface Connector
2	Interface (I/O) Connector
3	Transducer Connectors
4	Valve Connector

Table 6: Rear Panel Connector Slot Labels



**Note** The pinouts for the connectors are listed in Tables 7 to 10, pages 20 to 24. The “Reserved” and “No Connection” pin assignments for the Type “D” connectors are defined as follows:

1. The “Reserved” pin assignment refers to a pin, which has an internal connection and may be assigned a function in the future.
2. The “No Connection” pin assignment refers to a pin with no internal connection.

## RS-232 Serial Interface Connector

The 9-pin male Type “D” Serial Interface connector is used to connect the 651 unit to a computer, providing an interface for RS-232 communications.

### Caution



You *must* use the MKS cable CB651S-10-10 to make the connection from the 651 unit’s 9-pin serial port to a computer’s 9-pin serial port.

Unlisted pins on this connector are not compatible with the current 9-pin Type “D” industry-standard cable.

RS-232 Serial Interface Connector Pinout	
Pin Number	Assignment
1	Reserved
2	Transmit data
3	Receive data
4	No connection
5	Digital ground
6	Reserved
7	Reserved
8	No connection
9	No connection

Table 7: RS-232 Serial Interface Connector Pinout



### Interface (I/O) Connector

The 37-pin female Type “D” Interface (I/O) connector provides access to the set points, process relay limits, softstart control, and the valve control functions.

Interface Connector Pinout			
Pin Number	Assignment	Pin Number	Assignment
1	PLO 1 - NC contact	20	PLO 1 - common contact
2	PLO 1 - NO contact	21	PLO 2 - common contact
3	PLO 2 - NC contact	22	PLO 2 - NO contact
4	Digital ground	23	Valve closed status (hi = closed)
5	Reserved	24	Learn Valve (low)
6	Analog set point <i>position</i> control Hold <i>both</i> pins 6 and 11 low.	25	Remote zero (low)
7	Softstart (low)	26	Stop valve (low)
8	Close valve (low)	27	Open valve (low)
9	Analog input channel select hi = Channel 1; low = Channel 2	28	(output) PLO 2 status (low = out of limit)
10	Analog set point $\div 10$	29	(output) PLO 1 status (low = out of limit)
11	Analog set point control Hold <i>only</i> pin 11 low to select pressure control. Hold <i>both</i> pins 6 and 11 low to select position control	30	+15 V Output
12	Select set point E (low)	31	-15 V Output
13	Select set point D (low)	32	Power ground
14	Select set point C (low)	33	+ Set point input
15	Select set point B (low)	34	- Set point input*
16	Select set point A (low)	35	Analog ground*
17	Zeroed pressure output voltage for low range transducer (Channel 2)	36	Zeroed pressure output voltage for high range transducer (Channel 1)
18	Reserved	37	Position output voltage
19	Valve open status (hi = open)		

\* The analog set point must be referenced to analog ground. If you are using an absolute

<i>transducer, connect the negative analog set point (pin 34) to analog ground (pin 35).</i>
--

Table 8: Interface Connector Pinout

### Transducer Connector

The 15-pin female Type “D” connector is used to connect the 651 unit to a transducer.

The upper, 15-pin ‘D’ connector, is for the High Range pressure sensor.

The lower, 15-pin Hi-Density ‘D’, is for the Low Range pressure sensor

Both pressure sensor connectors use the same pinout shown below.

Transducer Connector Pinout	
Pin Number	Assignment
1	+15 V Supply
2	+ Pressure input
3	Reserved
4	Reserved
5	Power ground
6	-15 V Supply
7	+15 V Supply
8	Reserved
9	-15 V Supply
10	Reserved
11	Digital ground
12	- Pressure input
13	Reserved
14	Reserved
15	Chassis ground

Table 9: Transducer Connector Pinout

## Valve Connector

The 9-pin female Type “D” Valve connector allows you to connect the 651 controller to either a 653 or 253 throttle valve.

Valve Connector Pinout	
Pin Number	Assignment
1	Motor winding A low
2	Motor winding A high
3	Limit switch ground
4	Open limit switch signal
5	Closed limit switch signal
6	Motor winding B high
7	Motor winding B low
8	+15V @25 mA (for Opto switches)
9	Motor ground

Table 10: Valve Connector Pinout

### Note



If you are making your own cables, you must properly shield the Open, Closed, and Limit switch ground wires.

## Chapter Three: Overview

### **Control Mode**

The 651 controller can control a vacuum system using the PID control mode.

In the *PID mode*, the 651 controller uses a Proportional, Integral, and Derivative (PID) algorithm for control, which requires you to input two (gain and phase) values. Each set point uses its own gain and phase value to optimize the response from set point to set point. Although there are default values for the gains, you should adjust the values for optimum control.

### **Gain and Phase**

The 651 unit uses a PID compensator to control pressure in a vacuum system. When using PID control, two values (gain and phase) can be manually adjusted to provide the best response to the set point. By careful adjustment of each value, it is possible to achieve optimum control throughout a wide range of pressure regions.

### *Phase*

The phase provides a control signal that is proportional to the integral of the error signal. This phase is responsible for allowing the controller to track the set point with zero steady state error. If the phase is too low, the pressure will overshoot the set point before settling in (refer to Figure 5). If the phase is too high, the pressure will respond slowly to a set point change (refer to Figure 4) or a change in flow rate.

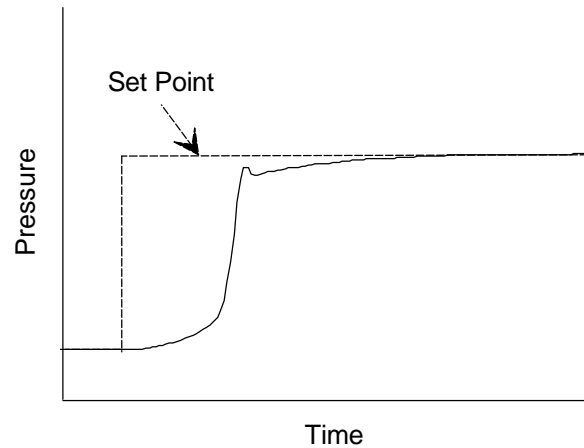


Figure 4: Phase Set Too High

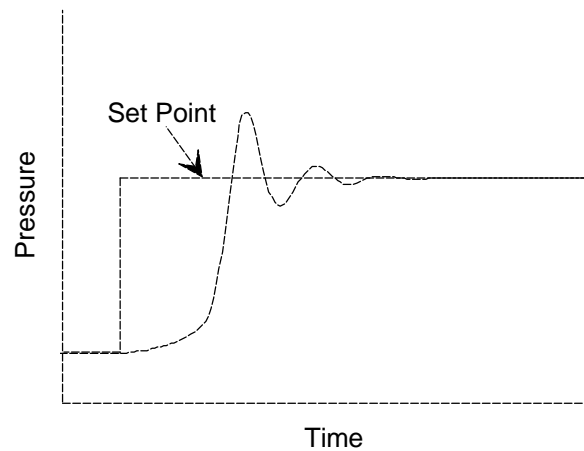


Figure 5: Phase Set Too Low

**Gain**

Gain provides a control signal that is directly proportional to the error signal. The error signal is the difference between the actual pressure and the set point. This gain is responsible for controlling how quickly the pressure responds to a change in set point. A large gain generally results in a faster response to set point. However, if the gain is too small, the system will be slow in responding to set point (refer to Figure 7). If the gain is too high, the pressure will overshoot and then oscillate around the set point before settling in (refer to Figure 6).

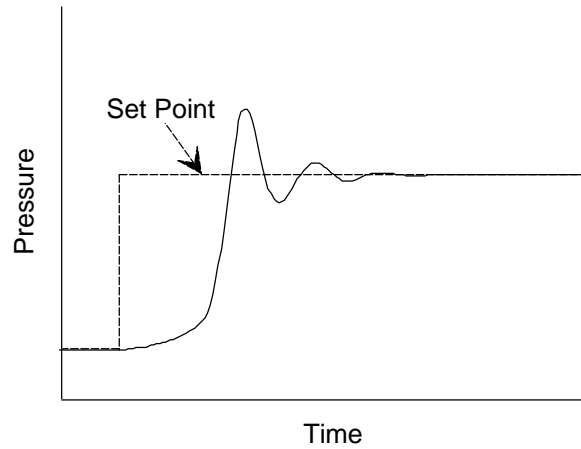


Figure 6: Gain Set Too High

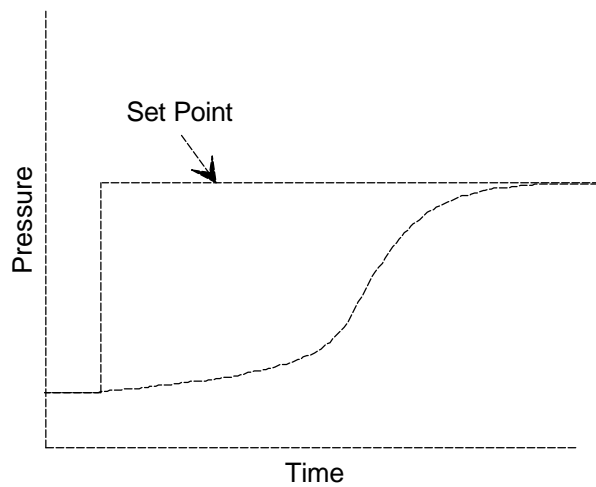


Figure 7: Gain Set Too Low

## **Set Points**

The 651 controller has five internal set points (A to E) and is capable of accepting one analog set point through the Interface connector on the rear panel. The unit controls the system based on the value of the “active” set point; only one set point can be active at a time. LEDs on the front panel indicate which internal set point is active. There is no LED to indicate that the system is under analog set point control (in fact, all LEDs on the front panel go out).

You can configure the 651 controller so that an internal set point is configured to represent a pressure or position. Pressure set points are reported in user-defined units of Torr, mTorr, mBar,  $\mu$ Bar, Pascal, or kPa. Position set points are reported as a percentage of open.

The analog set point can be configured for 5 Volt or 10 Volt full scale input. The analog set point value is expressed as a percentage of full scale, using the following formula:

$$\text{ANALOG SET POINT} = (\text{ANALOG SET POINT VOLTAGE} / \text{FULL SCALE VOLTAGE})$$

You can also operate the analog set point at a different full scale input, for example 4.5 Volts, by recalibrating the full scale of the analog set point. Refer to *How To Calibrate the Full Scale of the Analog Set Point*, page 72 (Local operation), or *Chapter 5 Remote RS-232 Operation* on page 75 for more information.

## **Softstart Rates**

The softstart feature is used to define the rate at which a control valve initially moves toward a new set point. The rate is given as a percent of full *speed* and can be used on either a pressure or position set point. Softstart control can be applied to all of the set points, as well as the valve open, and valve close commands. Once set point is achieved under softstart control, the valve is free to move at full speed.



## **Process Limit Relays**

There are two process limit (PLO) relays in the 651 controller. Each relay has a high and a low trip limit. Refer to Table 8, for the Interface connector pinout, to determine which pins are for relay 1, and which are for relay 2. Use the appropriate pins to configure the relays for normally-open or normally-closed operation. While the pressure remains within PLO limits, the 651 pressure controller actuates the relay (a normally-open contact closes, and a normally-closed contact opens). When the pressure crosses *below* the *low* trip point or *above* the *high* trip point, the 651 pressure controller de-actuates the relay (a normally-open contact opens, and a normally-closed contact closes).

## Front Panel Components

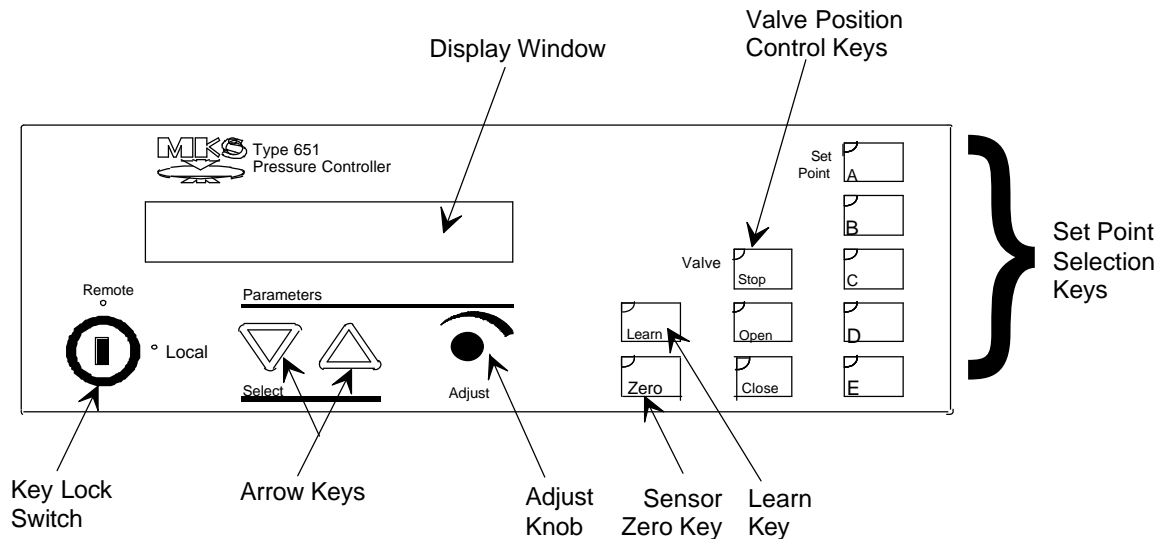


Figure 8: Front Panel of the 651 Controller

### Display Window

The Display Window shows the system pressure and position of the valve during operation. It also displays the various software menus.

### Key Lock Switch

The Key Lock switch is used to select either Local (front panel) or Remote (rear panel) control.

#### Note




The switch must be set to Remote to remove the key.

When set to Local, all control command inputs must be entered using the front panel controls. Informational requests, however, may be sent using RS-232 commands.

When set to Remote, the front panel is locked out. All communication with the 651 unit is achieved through RS-232 commands or through digital logic levels at the I/O connector.

You can, however, scroll through the displays to view existing parameters using the [▽] and [△] keys.

**Arrow Keys**

The up arrow key [  ] is used to display the *next* screen in the open menu.

The down arrow key [  ] is used to display the *previous* screen in the open menu.

**Adjust Knob**

The adjust knob, which turns clockwise and counterclockwise, is used to select a parameter value.

**Learn Key**

This key currently has no function.

**Zero Key**

This key is used to zero an attached sensor.

**Valve Position Control Keys**

The three position control keys are used to select the position of the valve.

**Set Point Selection Keys**

The five set point keys are used to activate one of the internal set points.

## Rear Panel Components

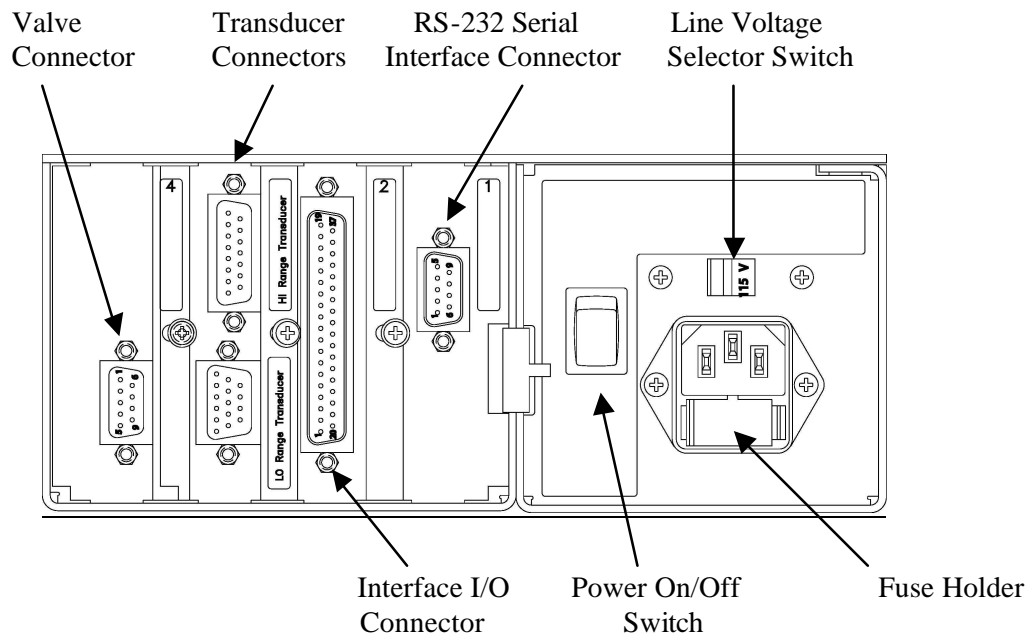


Figure 9: Rear Panel of the 651 Controller

### Valve Connector - Slot 4

The 9-pin female Type "D" connector is used to attach either a 653 or 253 throttle valve to the 651 controller. Refer to Table 10 on page 23, for the Valve connector pinout.

### Transducer Connectors - Slot 3

The 15-pin female Type "D" connectors are used to attach transducers to the 651 controller. Refer to Table 9, on page 22 for the Transducer connector pinout.

### Interface Connector - Slot 2

The 37-pin female Type "D" Interface (I/O) connector provides access to the set points, process limit relays, softstart control, and the valve control functions. Refer to Table 8, for the Interface connector pinout.

### RS-232 Serial Interface Connector - Slot 1

The 9-pin male Type "D" RS-232 Serial Interface connector provides an interface for RS-232 communications. Refer to Table 7, on page 20, for the RS-232 Serial Interface connector pinout.

### Power ON/OFF Switch

This switch turns power to the 651 unit on and off.

### Line Voltage Selector Switch

This switch sets the unit to operate at either 115 VAC or 230 VAC. Refer to *How To Set the Line Voltage*, for more information.

### Fuse Holder

This housing holds the unit's two fuses. The fuse values are listed in Table 5, page 16. Refer to *How to Replace the Fuses*, page 127, for more information.

---

#### Caution



**Disconnect the power cord from the 651 unit *before* you replace the fuse, to avoid any damage.**

**Be sure the fuse type is appropriate for your voltage setting, and that the voltage setting is correct for your local electrical source.**

---

## Optional Valve Failsafe Battery Back-Up

The optional valve failsafe battery back-up provides full valve drive capability for about 30 seconds after an AC power failure. The 651 controller can be set to drive the valve open, closed, or disabled. When in a disabled state, backup power is not provided. In most cases this means that the valve doesn't move, but this is not guaranteed.

This battery is a rechargeable, 12 Volt, 2 amp-hour, sealed lead-acid battery (MKS part no. 003-1109451). If the battery backup is installed, an **ATTENTION** label is affixed to the side of the 651 unit stating that it contains a lead-acid battery.

### Note



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The lead-acid battery is also available from the following sources:

- Power Sonics (PS-1220)
  - Panasonic (LCR 12 V2.2P)
- 

### Battery Voltage

The normal voltage level of the battery ranges from 11 V to 15.5 V. A voltage level *below* 11 V indicates a discharged battery. A voltage level *above* 15.5 V indicates an open fuse, a disconnected battery, or a defective charger.

The battery is continually recharged while the 651 unit is powered and operating. Therefore, the battery is typically maintenance free and only needs attention when it must be replaced. Refer to 1, page for more information.

### Valve Positions

The controller can be configured so that the valve will be driven fully open, fully closed, or will be disabled upon an AC power failure.

**Open:** The controller opens the valve at power down. In the event that the valve is already open, the module provides power for approximately 1 second before turning off.

**Closed:** The controller closes the valve at power down. In the event that the valve is already closed, the module provides power for approximately 1 second before turning off.

**Disable:** The option is disabled and will not perform any function at power down. The controller turns off in a normal manner.

When the controller is configured to open or close the valve, it will perform the operation whenever power to the controller is turned off, regardless of whether the power is turned off via the power switch or by a power failure.

**Note**

If for any reason the controller cannot open or close the valve within 30 seconds of a power failure, the battery back-up module automatically turns off. This prevents the battery from discharging when no valve is present or if the valve is defective in some way.

**Threshold Voltage Check**

When the 651 controller is turned on, it measures the voltage at the input port assigned to the battery back-up module. When the voltage level at the port exceeds a factory set minimum threshold value, the controller recognizes that the battery back-up is present, and the software menus which support the module are installed. Should the voltage level be below the threshold, the controller does not recognize the module and the software menus are not installed.

Once the 651 unit has been powered up and the battery back-up module has been recognized, the actual voltage of the battery is measured. Refer to *How To Check the Battery Voltage*, page 42 (Local operation), and *How To Report the Voltage Status of the Valve Battery Back-Up*, page 112 (RS-232 operation), for more information.

**Expected Battery Life**

An AC power failure typically results in a 30% discharge of the battery. Under this condition, the battery life is at least 1000 cycles, and should be able to recharge within a few hours after power returns. Battery life under several conditions is listed in Table 11.

<b>Expected Battery Life</b>	
<b>Expected Cycles</b>	<b>% Discharge with each Battery Use</b>
1000	30
400	50
200	100
2-3 years if unused and charge is maintained	

Table 11: Expected Battery Life

When AC power returns, the battery recharges, provided that the 651 controller is turned on. From a full discharge condition, the voltage typically increases from about 11 V to 15.5 V over a five-hour period. The voltage is maintained at about 14.5 V for another five hours then gradually drops to 13.5 V. The 13.5 Volt charge is maintained in a trickle charge state (a top charged state) until there is an AC power failure. The recharge time for a completely discharged battery is a maximum of 12 hours.

## Battery Storage

The lead-acid battery loses its capacity if it is stored with no power connected. In fact, the higher the ambient temperature, the faster the capacity is lost. Table 12 lists the time it takes for the battery to fall to fifty percent of its full capacity at various ambient temperatures.

<b>Capacity Loss of Stored Battery</b>	
<b>Ambient Temperature (° C)</b>	<b>No. Days to 50% Capacity</b>
20	500
30	250
40	150
50	75

Table 12: Capacity Loss of Stored Battery



## Labels

### Voltage and Fuse Label

The voltage and fuse label, located on the rear panel of the 651 controller (refer to Figure 9), lists the voltage and fuse requirements for the unit.

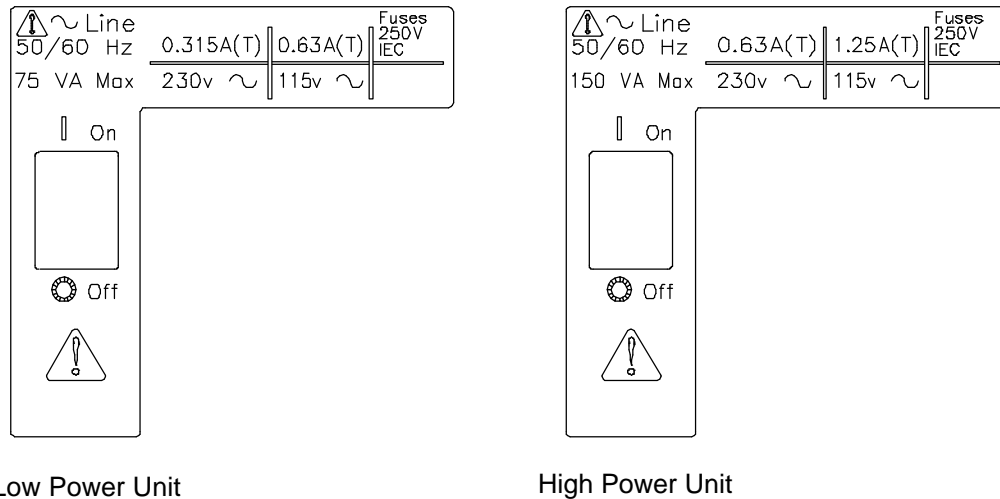


Figure 10: Voltage and Fuse Labels

### Serial Number Label

The serial number label, located on the side of the unit, lists the serial number and the product model code, and displays the CE mark signifying compliance with the European CE regulations.



Figure 11: Serial Number Label

The model code is identified as “651DXYZCD.” Refer to *Appendix B: Model Code Explanation*, page 133, for more information.

### Attention Label

If the battery backup is installed, an **ATTENTION** label is affixed to the side of the 651 unit stating that it contains a lead-acid battery.





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## Chapter Four: Local Operation

### General Information

Local operation of the 651 controller is achieved by using the controls on the front panel of the controller. There are three main software menus, accessed through the front panel that allow you to configure the system. The menus allow you to select the valve, set the operating parameters, and set the set point parameters. It is not necessary to open the unit to set any switches.

During Local operation:

- Press the  key to scroll to the *next* configuration parameter
- Press the  key to scroll to the *previous* configuration parameter
- Use the Adjust knob to select the desired setting
- Press any key (other than  or  ) at any time to return to the default *Pressure and Position* display screen

The Key Lock Switch on the front panel must be set to *Local* in order to input any operating parameters using the front panel controls. Informational requests, however, may still be sent using RS-232 commands.

Even if you are using local control, it is useful to read *Chapter Five: Remote RS-232 Operation.*, since requests and responses can always be sent using RS-232 commands. It is also useful to read *Chapter Six: Remote Digital Logic Control*, which describes digital logic control through the Interface connector on the rear panel.

## **Startup**

At initial power up, the display screen appears for about five seconds, listing the current software/firmware version (refer to Figure 12).

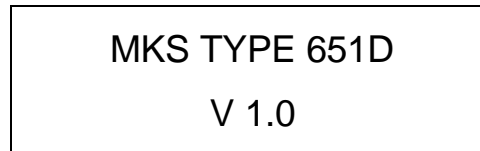


Figure 12: Initial Display Screen

The system then advances to its default *Pressure and Position* display (refer to Figure 13) and is ready for valve connection and setup (or normal operation once the system has been configured).

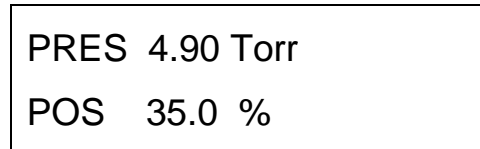


Figure 13: Pressure and Position Display Screen

### **Optional Valve Failsafe Battery Back-Up**

At power up, units configured with the optional valve failsafe battery back-up measure the voltage at the input port assigned to the battery back-up module. Once the battery back-up is recognized, the actual voltage of the battery is measured. If the battery back-up module is *not* recognized, the screen reverts to the initial display screen (refer to Figure 12). Press any key to return to the default *Pressure and Position* display screen. Refer to *Threshold Voltage Check*, page 35, for more information.

### ***Battery Voltage Within Range***

If the battery voltage is within the acceptable range of 11 V to 15.5 V, the controller revision and the current software/firmware version appears on the front panel display for about five seconds, before advancing to the default *Pressure and Position* display screen, as shown in Figures 12 and 13.

The controller is now ready for valve connection and setup (or normal operation once the system has been configured). The 651 unit does not display a status screen to indicate that the battery voltage is within range.

***Battery Voltage Out-of-Range***

If the battery voltage is out-of-range, the controller revision and the current software/firmware version appear on the front panel display for about five seconds (refer to Figure 12), followed by the appropriate error message, rather than advancing to the default *Pressure and Position* display screen). Refer to Figure 13.

If the battery voltage is below 11 V, the screen displays:

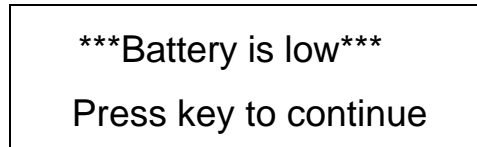


Figure 14: Battery Voltage Low Message

If the battery voltage is above 15.5 V, the screen displays:

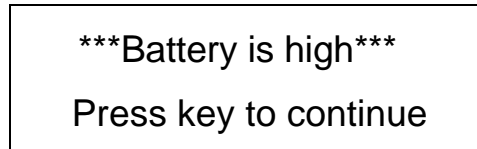


Figure 15: Battery Voltage High Message

The system allows for continued operation when the battery voltage is out-of-range, since your process may not require that the battery voltage level be addressed immediately. To continue operation, press any key to advance to the default *Pressure and Position* display screen.

**Note**

---

It is important to note that in addition to supporting the controller's valve position, the battery back-up feature powers the controller, and any pressure transducer or valve connected to it.

---

## How To Check the Battery Voltage

**Note**

Refer to *Optional Valve Failsafe Battery Back-Up* for more information.

To be sure that the 651 unit has recognized the optional battery back-up module, or to view the actual battery voltage and the current valve configuration without entering the software menus (regardless of whether you are using Local or Remote operation):

1. Be sure that the default *Pressure and Position* display screen appears on the display:

PRES	4.90 Torr
POS	35.0 %

2. Press the [▽] key one time.

If the battery back-up module has been recognized, the screen displays:

BATTERY	13.5V
BACK-UP:	OPEN

This screen allows you to view the actual battery voltage and the current valve configuration. The valve configuration cannot be changed from this screen. Refer to *How To Set the Operating Parameters*, step 18, for instructions on how to change the valve configuration; the battery voltage cannot be adjusted. Press any key to return to the default *Pressure and Position* display screen.

If the battery back-up module has *not* been recognized, the screen reverts to the initial display screen, which lists the controller revision and the current software/firmware version:

651D
V 1.0

Press any key to return to the default *Pressure and Position* screen.

## Setup

### How to Select and Calibrate the Valve

The 651 controller works with the 253 or 653 valve. Choose the appropriate valve and connect it to the 651 unit (refer to the valve manual if necessary).


#### Caution



The procedure for calibrating (learning) the valve involves cycling the valve from the open to the close position. Be certain that the system can withstand valve cycling *before* proceeding.

This test can be performed prior to installing the valve in your system.

To select and calibrate the valve:

1. Be sure that the valve is connected to the 651 unit and the Key Lock switch on the front panel is set to *Local*.
2. Press the  and the valve [CLOSE] keys simultaneously for about three seconds.

The screen displays:

VALVE TYPE:  
253 STD

Select the valve type from the options of 253 STD (initial), 253 FAST, and 653.

#### Note



Be sure to select the correct valve; otherwise the 651 pressure controller will not function correctly.

3. Press the [STOP] key to select and calibrate the valve.

The valve opens and closes as it is being calibrated, then stops at completion. The screen returns to the default *Pressure and Position* display screen.

### How To Set the Operating Parameters

Your 651 controller is shipped with the initial configuration settings shown in Appendix C Initial Settings, Table 20.

#### Note





The initial configuration is not a default configuration, since the 651 controller stores most of its 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 651 unit “remembers” the latest configuration, not the initial configuration.

---

To enter the Setup Menu to configure the operating parameters:


1. Press the  and  keys simultaneously for about three seconds.

The screen displays:

CONTROL

MODE      PID


Select the desired pressure control mode, PID.

2. Press the  key to advance to the next screen.

The screen displays:

BAUD RATE: 9600

Select the baud rate from the options of 300, 1200, 2400, 4800, 9600 (initial), and 19200.


3. Press the  key to advance to the next screen.

The screen displays:

PARITY: NONE

Select the parity from the options of NONE (no parity / 8 data bits - initial) or EVEN (even parity / 7 data bits).




4. Press the  key to advance to the next screen.

The screen displays:

DELIMITER: CRLF


Select the delimiter from the options of CRLF (carriage return/line feed - initial) or CR (carriage return).

5. Press the  key to advance to the next screen.

The screen displays:

HIGH SENSOR RANGE:  
100.00

Identify the full scale range for the sensor connected to your unit. The acceptable sensor ranges are shown in Table 13 on the next page.

6. Press the  key to advance to the next screen.

The screen displays:

LOW SENSOR RANGE:  
.10000

Identify the full scale range for the sensor connected to your unit. The acceptable sensor ranges are shown in Table 13 on the next page.


Note: The range selection on one channel restricts the available ranges on the other channel.

Full Scale Sensor Ranges	
Torr	mBar
.10000	
.20000	
.5000	
1.0000	1.3332
2.0000	2.6664
5.000	
10.000	13.332
20.000	
50.00	
100.00*	133.32
200.00	
500.0	
1000.0	1333.2
5000	6666
10000	13332
*Initial setting	

Table 13: Full Scale Sensor Ranges

To view the range of a sensor in pressure units of *mBar* for a sensor calibrated in *Torr*, select the equivalent mBar unit of measure. For example, select 13.332 for a sensor calibrated to 10.000 Torr.


To display a 1 Torr sensor in *mTorr*, the appropriate sensor range and pressure unit must be entered during setup. For example, 1000 *mTorr* must be entered to display a 1 Torr sensor in *mTorr*.

7. Press the  key to advance to the next screen.

The screen displays:

<p>PRESSURE UNITS:</p> <p>Torr</p>
------------------------------------


Select the pressure units for the 651 controller display from the options of Torr (initial), mTorr, mBar,  $\mu$ Bar, kPa, Pa, cmH<sub>2</sub>O, and inH<sub>2</sub>O.

8. Press the  key to advance to the next screen.

The screen displays:

CHANNEL SELECT:  
AUTO


Select the pressure sensor to be used. “Auto” will automatically switch between the High and Low sensors. “High” will always use the High channel sensor and “Low” always the low channel sensor.

9. Press the  key to advance to the next screen.

The screen displays:

SENSOR SIGNAL:  
10 VOLTS

Select the full scale voltage range for the pressure sensor input from the options of 1 Volt, 5 Volts, and 10 Volts (initial).

10. Press the  key to advance to the next screen.

The screen displays:

ANALOG SETPT ANGE:  
5 VOLTS


Select the full scale voltage range for the analog set point from the options of 5 Volts (initial) and 10 Volts full scale.

---

**Note**

You can operate the 651 controller at a different full scale input, for example 4.5 V, by recalibrating the full scale of the analog set point. Refer to *How To Calibrate the Full Scale of the Analog Set Point*.


---

11. Press the  key to advance to the next screen.

The screen displays:

VALVE SIGNAL OUTPUT:  
10 VOLTS

Select the full scale voltage range for the valve position signal (analog) output from the options of 5 Volts or 10 Volts (initial).

12. Press the  key to advance to the next screen.

The screen displays:

SETPOINT A TYPE:  
PRESSURE


Identify whether set point A will be a pressure value or the position of the valve. Choose from the options of pressure (initial) or position.

13. Repeat step 12 for set points B to E.

---

**Note**

1. Refer to *How to Adjust the Set Point Parameters*, for information on how to define the set point values.
  2. The analog set point control (pressure or position) is controlled by the digital logic level on Pin 6 of the I/O connector. Refer to Table 8, for the I/O connector pinout.
- 


14. Press the  key to advance to the next screen.

The screen displays:

SOFT START RATE  
SETPT A: 100.0 %

Set the softstart rate for set point A to any value from 0.1% (slowest) to 100% (fastest - initial) of full scale. If it is not necessary to use softstart control in your process, leave the softstart rate at the initial setting of 100%.

15. Repeat step 14 for set points B to E.


16. Press the  key to advance to the next screen.

The screen displays:

SOFT START RATE

ANLG SETPT: 100%

Set the softstart rate for the analog set point to any value from 0.1% (slowest) to 100% (fastest - initial) of full scale. If it is not necessary to use softstart control in your process, leave the softstart rate at the initial setting of 100%.


17. Press the  key to advance to the next screen.

The screen displays:

SOFT START RATE

OPEN: 100%

Set the softstart rate for the valve open command to any value from 0.1% (slowest) to 100% (fastest - initial) of full scale. If it is not necessary to use softstart control in your process, leave the softstart rate at the initial setting of 100%.

18. Press the  key to advance to the next screen.

The screen displays:

SOFT START RATE

CLOSE: 100%


Set the softstart rate for the valve close command to any value from 0.1% (slowest) to 100% (fastest - initial) of full scale. If it is not necessary to use softstart control in your process, leave the softstart rate at the initial setting of 100%.

---

**Note**

*When controlling either the set point or the valve via TTL logic , Activating the softstart rate, that is, determining whether the softstart rate is used, depends on the state of the softstart line (input pin 7) on the I/O connector. Refer to *How To Activate the Softstart Rate*, for more information.*

---

19. Press the  key to advance to the next screen.

The screen displays:

BATTERY	13.5V
BACK-UP:	OPEN

---

**Note**

This screen only appears if the valve failsafe battery back-up option is installed in your 651 controller.

---

The screen displays the actual voltage level of the battery along with the position the valve is currently set to drive to upon a power loss.

Select whether the valve will be driven fully open, fully closed, or will be disabled upon an AC power failure. Choose from the options of open, closed, or disable (initial).

---

**Note**

The system setup is now complete. Press the STOP key to exit the Setup Menu and return to the default *Pressure and Position* display screen.

---

## How To Adjust the Set Point Parameters

The set point parameters include the internal set points (A to E), gains and phases, two process limit relays (each with high and low trip levels), and the external analog set point.

The software menu screens for setting the set point parameters varies slightly, depending on your system's configuration. Specifically, the order and number of software screens depends on the set point control (pressure or position) chosen in the Setup Menu.

For example:

- If you are using PID control with pressure set points, you have access to the gain and phase values.  
Refer to *PID Control with Pressure Set Points*, to set the gain and phase values.
- If your set points are under position control, there are no gain or phase parameters.  
Refer to *Position Set Point Control* to set the internal set point values.

The software screens for setting the process limit relays and the analog set point follow those for the internal set points and the gains (if applicable), and are the same for any system configuration. Refer to *Process Limit Relays and the Analog Set Point*, for more information.

---

**Note**

When a set point is changed, the system immediately stores the new value. The system *pressure* will not change, however, unless the displayed set point is the active set point.

---


## PID Control with Pressure Set Points

*To enter the Main Menu to access the set point and gain parameters:*

**Note**

When using PID control, the gains can be adjusted to provide the best response to the set point.


1. Be sure that the default *Pressure and Position* display appears on the screen.

2. Press the  key to advance to the first set point menu screen.

The screen displays both the set point and the current system pressure (in the selected units):

SP A	100 mTorr	
PRES	100 mTorr	L


Adjust the set point value to the desired pressure. In this example, set point A is a pressure value of 100 mTorr, and the system pressure is 100 mTorr.

3. Press the  key to advance to the next screen.

The screen displays:

GAIN A	1.000	
PRES	1.64 Torr	L


The screen displays the value for the gain (Gain A) and the current system pressure. Adjust the gain to any value from 0 to 100%.

4. Press the  key to advance to the next screen.

The screen displays:

PHASE A	0.0%	
PRES	100.00 mTorr	L

The screen displays the phase value and the current system pressure. Adjust the phase to any value from 0 to 100%.

- 5.\* Press the  key to advance to the next screen.



The screen displays:


GAIN COMP FACTOR:

100.0 %

The Gain Compensation Factor (GCF) modifies the gain value so that the controller gives the best response to the **low** range setpoints. When the 651 controller receives a set point in the range of the High range sensor, it uses the Gain value. When the controller receives a set point in the range of the low range sensor, it uses this percentage of the high range gain.

Enter the Gain Comp Factor value, range from 0 to 100 % of High range sensor Gain

For example, if:	Gain value = 90.0
And:	GCF = 50
Then:	<i>Gain used for low range = 45.0</i>

6.\* Press the  key to advance to the next screen.

The screen displays:


PHASE COMP FACTOR:

100.0 %

The Phase Compensation Factor (PCF) modifies the phase value so that the controller gives the best response to the low range set points.

Enter the Phase Comp Factor value, range from 0 to 100 % of the high range phase.

For example, if:	Phase value = 20.0
And:	PCF = 75
Then:	<i>Phase used for low range = 15.0</i>

7.\* Press the  key to advance to the next screen.

The screen displays:


BACKFILL / RELAY2:

ENAB      DISAB

The Backfill Valve Control feature can open a pneumatic valve to assist in raising the system pressure to a new setpoint.

Note: When the backfill valve control feature is enabled, process relay 2 is disabled. When backfill valve control feature is disabled, relay 2 is enabled. These features share the same pins on the I/O connector.

Select the Backfill and Relay2 configuration. (ENAB/DISAB or DISAB/ENAB)

8.\* Press the  key to advance to the next screen.


The screen displays:

MINIMUM DELTA P:

.10000      Torr

This value is the required difference between the new set point and the current pressure in the system before the backfill control feature operates. Set point changes less than the backfill threshold value do not trigger the backfill function.

Enter the Minimum Delta P value, range is 0 to High Sensor range.

9.\* Press the  key to advance to the next screen.

The screen displays:

SETPNT BACKFILL LIM:

50.0 % of SETPNT

This parameter sets the point at which the backfill valve closes (the relay deactivates) and the feature turns off. When the feature is turned off, a new setpoint must be entered before the feature can be enabled. The value of this entry is defined as a percent of the new setpoint value.

Enter the Setpoint backfill limit value, range from 10 to 100 %.

10. Repeat steps 2 to 4 for set points B to E.

\* These menu screens only appear when Setpoint A is in Pressure control mode.

### ***Position Set Point Control***


To enter the Main Menu to access the set point parameters:

**Note**

---

There are no gain values associated with set points under position control.

---

1. Be sure that the default *Pressure and Position* display appears on the screen.
2. Press the  key to advance to the first set point menu screen.


The screen displays:

SP A	60.0 Pos
PRES	2.000 Torr L

Adjust the set point to the desired valve position, as a percentage of full scale. In this example, set point A is a valve position of 60% of full scale, and the system pressure is 2 Torr.

3. Repeat step 2 for set points B to E.
4. Proceed to Process *Limit Relays and the Analog Set Point*.

### Process Limit

*The following series of screens are accessible by pressing the  key after you have configured the set point and gain parameters (if applicable). These screens are the same regardless of your system's configuration.*

Be sure that the default *Pressure and Position* display appears on the screen.


1. Press the  key to scroll to the display shown below.

The screen displays:

PROCESS LIMIT 1

LOW:      -99.00 Torr

Select the desired pressure value for the low trip point of process limit 1.


2. Press the  key to advance to the next screen.

The screen displays:

PROCESS LIMIT 1

HIGH:      0.00 Torr

Select the desired pressure value for the high trip point of process limit 1.


3. Press the  key to advance to the next screen.

The screen displays:

PROCESS LIMIT 2

LOW:      -99.99 Torr

Select the desired pressure value for the low trip point of process limit 2.

4. Press the  key to advance to the next screen.

The screen displays:

PROCESS LIMIT 2

HIGH:      0.00 Torr


Select the desired pressure value for the high trip point of process limit 2.

**Note**

1. To disable a low limit trip point, set it to negative full scale.
2. To disable a high limit trip point, set it to full scale.

**Analog Setpoint Value**

Be sure that the default *Pressure and Position* display appears on the screen.

Press the  key to advance to the analog setpoint screen.

The screen displays:

ANALOG SETPOINT

VALUE: 50.0 %      H

The analog set point display reports the voltage percent of the actual input applied; *this is an informational screen only*.

For example, if the analog set point is configured for 5 V full scale input, and the actual input applied is 5 V, the analog set point display shows a value of 100%. However, if the actual input applied is 2.5 V, the analog set point display indicates that input by showing a value of 50%.

You can operate the 651 controller at a different full scale input, for example 4.5 V, by recalibrating the full scale of the analog set point. Refer to *How To Calibrate the Full Scale of the Analog Set Point*, for more information.

**Note**

The set point parameter setup is now complete. Press the stop key to exit the Main Menu and return to the default *Pressure and Position* display screen.

## Operation

### How To Activate a Set Point

Activating a set point commands the 651 unit to control to that set point. Only one set point can be active at a time.

#### *How To Activate an Internal Set Point*

The internal set points (A to E) are activated by pressing the appropriate key on the front panel of the 651 controller (refer to Figure 8.).

To activate an internal set point:

1. Press the appropriate set point key (A to E) on the front panel.

The LED in the upper left corner of the activated set point key illuminates and the display changes to reflect the activated set point. Once the key is pressed, the *Pressure and Position* display screen appears and displays either the set point pressure or valve position, and the actual pressure. The LED remains lit until another set point (or valve function) is chosen.

#### *How To Activate the Analog Set Point*

The analog set point is activated through the Interface connector on the rear panel of the 651 controller (refer to Figure 9).

#### **Note**



When the 651 unit is configured for PID control, two gain parameters are maintained for each pressure set point. When an analog set point is used with PID control, the gain parameters associated with any of the pressure set points (A to E) may be used. The unit uses the gain values for set point A by default.

To specify which set point's gain parameters to use:

1. Apply a TTL low level signal to the I/O connector pin assigned to the desired set point.

Refer to Table 8, for the I/O connector pinout.

The TTL low level signal (0 to 0.8 Volts) is "level sensitive" meaning that once the signal is held low, the 651 unit may take up to 50 milliseconds to recognize the command. The line must be held low *continuously* for the 651 unit to use the selected parameters. Once the signal goes high, the controller will default back to set point A parameters within 50 milliseconds.

For example, to apply the gain parameters associated with set point C to the analog set point, apply a 0 to 0.8 Volt signal to pin 14 on the I/O connector for as long as you wish to use those parameters. There is no LED on the front panel to indicate that the system is under analog set point control (in fact, all LEDs on the front panel go out).

## How To Control the Valve

The 651 unit can drive the throttle valve to full open or full close, or halt at its current position.

### Note



---

The commands to open, close, or halt the valve override the active set point control of the valve.

---

### *How To Drive the Valve to Full Open*

To drive the valve to full open:

1. Press the [OPEN] key.

The system responds by illuminating the LED in the upper left corner of the [OPEN] key, driving the throttle valve to full open, and displaying the default *Pressure and Position* display screen.

### *How To Drive the Valve to Full Close*

To drive the valve to full close:

1. Press the [CLOSE] key.

The system responds by illuminating the LED in the upper left corner of the [CLOSE] key, driving the throttle valve to full close, and displaying the default *Pressure and Position* display screen.

### *How To Stop the Valve*

To stop (hold) the valve in its current position:

1. Press the [STOP] key.

The system responds by illuminating the LED in the [STOP] key, halting the throttle valve in its current position, and displaying the default *Pressure and Position* display screen.



## How To Use the Sensor Zero

The sensor zero function corrects any sensor zero offsets.

To zero the currently displayed sensor

(indicated on the display by a ‘H’ for the **H**igh pressure sensor or an ‘L’ for the **L**ow pressure sensor)

1. Turn the gas flow off.
2. Open the control valve fully by pressing the [OPEN] key.

Refer to *How To Drive the Valve to Full Open*.

3. Pump the system down to base pressure.

In order to achieve a proper zero, the pressure of the system must be *lower* than the resolution of the sensor used to measure system pressure.

4. Press the [ZERO] key for at least three seconds.


The LED in the upper left corner of the [ZERO] key remains on as the sensor is zeroed. The front panel display shows a pressure reading of zero, and changes to reflect changes in system pressure as soon as a change occurs.

### Note



If the pressure reading (at base pressure) is greater than 4% of full range, the sensor will not be zeroed.


To change the displayed sensor

Enter setup mode (see setup section), press the  key to advance to the Channel Select screen, and select the desired channel (High or Low). Press the STOP key to return to the default *Pressure and Position* display screen and follow steps 1 through 4 above.

## How To Use the Special Zero

The special zero function zeros the base pressure in systems where the known base pressure is not *at*, but *near* zero (as measured by another transducer in the system).

To use the special zero:

1. Press the  and the [ZERO] keys simultaneously for about three seconds.

The screen displays:

ZERO BASE PRESSURE:

0.0

2. Adjust the pressure reading on the display until it matches the known base pressure reading (as measured by another transducer in the system).
3. Press any key to return to the default *Pressure and Position* display screen.

### How To Remove the Zero Correction Factors

This function removes the sensor and special zero correction factors stored in memory, and is used to determine the uncorrected signal from the pressure transducer. Each time a sensor is zeroed, the offset changes and the pressure display is updated. In some applications it may be important to keep the zero offset within a specific range.

To remove the zero corrections:

1. Press the [STOP] key and the [ZERO] key simultaneously for about three seconds until the front panel display changes from a zero pressure reading to the uncorrected signal level.
2. Press the [STOP] key to return to the default *Pressure and Position* display screen.

### How To Zero the Analog Set Point

This function instructs the controller to take the current value of the external analog set point for its zero value. Zeroing the analog set point allows you to correct any controller zero offsets.

To zero the analog set point:


1. Apply zero input voltage to Interface connector pins 33 and 34.

#### Note



Pin 34 should be connected to Pin 35 to properly ground the analog input.

Refer to Table 8, for the Interface connector pinout.

2. Press the  and [STOP] keys simultaneously for about three seconds.

The screen displays:

**CAUTION**

**CALIBRATION MODE**

3. Press the [SETPOINT B] key.

The screen displays:

**ANLG SP: 100.00 %**

**LEARN+ZERO to CAL**

4. Press the [LEARN] and [ZERO] keys simultaneously for about three seconds.

The 651 controller *learns* the input voltage that corresponds to the analog set point zero value, then the screen returns to the default *Pressure and Position* display screen.

### How To Calibrate the Full Scale of the Analog Set Point

The analog set point can be configured for 5 V (initial) or 10 V full scale input (refer to step 9). You can operate the 651 controller, however, at a different full scale input, for example, 4.5 V, by recalibrating the full scale of the analog set point. Although the actual voltage input to the unit must be measured, you can report the voltage input applied as a percentage of the analog set point full scale, using the analog set point display.

For example, if the analog set point is configured for 5 V full scale input, and the actual input applied is 5 V, the analog set point display shows a value of 100%. However, if the actual input applied is 2.5 V, the analog set point display indicates that input by showing a value of 50%.

To recalibrate the full scale of the analog set point:


1. Be sure that the default *Pressure and Position* display appears on the screen.
2. Apply the full scale input voltage (for example, 4.5 V) to pins 33 and 34 on the Interface connector. (Pin 34 should be connected to Pin 35 to properly ground the analog input.)

Refer to Table 8, for the Interface connector pinout.

#### Note



Pin 34 should be connected to Pin 35 to properly ground the analog input.

3. Press the  and [STOP] keys simultaneously for about three seconds.

The screen displays:

**CAUTION**

**CALIBRATION MODE**

4. Press the [SETPOINT D] key.

The screen displays:

**ANLG SP: 95.00 %**

**FULL SPAN: 20015**

5. Adjust the value of the analog set point to 100%.

The 4.5 Volt input to the Interface connector is now the full scale value. To be sure that the analog set point is adjusted correctly, turn the adjust knob until the reading flickers between 99.99 and 100.00%.

**Note**

- 
1. The display reads 100.00% for an overrange reading as well as a true 100% reading.
  2. If the current value of the analog set point exceeds  $\pm 15\%$  of full scale, the controller will not change the full scale value.
- 

6. Press the [STOP] key to return to the default *Pressure and Position* display screen.



## Chapter Five: Remote RS-232 Operation

### **General Information**

Remote (or rear panel) control of the 651 pressure controller is achieved either through digital RS-232 communications through the Serial Interface connector, or through analog or digital logic control at the rear panel Interface connector (refer to Table 8).

The RS-232 communication parameters (baud rate, parity, end-of-line delimiter) are configured using the front panel menu; there are no RS-232 commands for these settings. Refer to *How To Set the Operating Parameters*, for information on setting the communication parameters.

When the Key Lock switch on the front panel is set to Remote, the front panel locks and all communication to the 651 unit must be sent through either the RS-232 Serial or the Interface connector. You can, however, still use the front panel to scroll through and view the current system information as described in *Chapter Four: Local Operation*.

The RS-232 communication commands are separated into four functional groups: Setup, Set Point, Control, and Information. A summary of the RS-232 messages is listed in Appendix E, Table 20.

## **RS-232 Protocol**

Messages sent *to the 651 controller* from a remote computer are either commands that instruct the controller to perform a task or change an operating parameter, or *requests* that prompt the controller to report information.

The format of the commands sent to the 651 controller appear as:

**command** *value*

where **command** is a label that allows you to identify the command, and *value* identifies the task or parameter to be changed.

Requests (R) are numbered chronologically from 1 to 52, each with a different function, and appear as:

**R** #

Messages sent *by the 651 controller* to a remote computer are *responses*. The responses are replies to requests sent by the host computer.

The format of responses sent by the 651 controller to the computer appear as:

*response* *value*

where *response* is a label that allows you to identify the response, and *value* is the requested information.



## Message Syntax

The RS-232 message syntax uses the following conventions:

### Note



1. Commands and requests are *not* case sensitive.
2. Spaces are included in the syntax for clarity only. Do not include spaces in actual messages.

<b>bold</b>	Messages that you must enter exactly as shown in the manual. Do not include any spaces in the message string.
<i>italics</i>	Placeholder that represents text or numeric values that you must supply.
response	Format of message sent from the 651 controller.
ENTER	Represents the end-of-line delimiter. All messages must use a carriage return-line feed (CRLF) or carriage return (CR) as the end-of-line delimiter. Use your host computer's communications software to assign the desired action to the ENTER key. The 651 controller appends an end-of-line delimiter to the end of every response.

## Priority and Timing of Command Execution

Each RS-232 command is executed in the order that it is received. There is no prioritization of RS-232 commands as is the case with digital logic commands (refer to *Chapter Six: Remote Digital Logic Control*). However, the appropriate RS-232 command will *override* a high priority digital logic command. For example, a valve being held closed with a digital logic command can be commanded to control to the level of Set Point A with the appropriate RS-232 command.

The RS-232 commands generally execute within 25 milliseconds or less with the following exceptions:

- **J** (valve type and calibration) command can take several seconds to execute
- **Y2** (Calibrate Analog Set Point Full Scale) can take up to 20 seconds.
- **F** (pressure unit) and **T** (set point type) commands can take up to 100 milliseconds to execute

## Setup Messages

The Setup messages configure the operating parameters for the 651 unit.

Table 14

RS-232 Setup Messages			
Description	Command	Request	Response
Select and Calibrate the Valve	<b>J type</b> <i>type:</i> 1 = Std 253* 2 = Fast 253 3 = 653	<b>R 23</b>	<i>J type</i> <i>type:</i> 1 = Std 253 2 = Fast 253 3 = 653
Pressure Control Mode	<b>V value</b> <i>value:</i> 1 = PID*	<b>R 51</b>	<i>V value</i> <i>value:</i> 1 = PID
Pressure Units	<b>F value</b> <i>value:</i> 00 = Torr* 01 = mTorr 02 = mBar 03 = $\mu$ Bar 04 = kPa 05 = Pa 06 = cm H <sub>2</sub> O 07 = in H <sub>2</sub> O	<b>R 34</b>	<i>F value</i> <i>value:</i> 00 = Torr 01 = mTorr 02 = mBar 03 = $\mu$ Bar 04 = kPa 05 = Pa 06 = cm H <sub>2</sub> O 07 = in H <sub>2</sub> O
Backfill Valve Control Enable	<b>BE0</b> = Disabled* <b>BE1</b> = Enabled	<b>RBE</b>	BE0 = Disabled BE1 = Enabled
Backfill Limit	<b>BLvalue</b>	<b>RBL</b>	<i>Blvalue</i> <i>BL95.0*</i>  <i>value:</i> pressure at which the feature turns off, in % of active setpoint
Backfill Threshold Pressure	<b>MDvalue</b> <i>value:</i> minimum difference between the new setpoint and the system pressure required to turn on the backfill feature (entered as a % of the high range pressure transducer full scale)	<b>RMD</b>	MD+ <i>value</i>  <i>value:</i> minimum pressure difference required to turn on the backfill feature (reported as a % of the high range pressure transducer full scale)

Table 14: RS-232 Setup Messages (Continued)			
Valve Position Signal Output Range	<b>B value</b> <i>value:</i> 0 = 5 V 1 = 10 V*	<b>R 31</b>	B <i>value</i> <i>value:</i> 0 = 5 V 1 = 10 V
Valve Battery Back-Up Control	<b>K value</b> <i>value:</i> 0 = Disable option* 1 = Open valve at power failure 2 = Close valve at power failure	<b>R 40</b>	K <i>value</i> <i>value:</i> 0 = Option disabled 1 = Valve opens at power failure 2 = Valve closes at power failure
Sensor Type	<b>U value</b> <i>value:</i> 0 = Absolute*	<b>R 36</b>	U <i>value</i> <i>value:</i> 0 = Absolute
Sensor Signal Input Range	<b>G value</b> <i>value:</i> 0 = 1 V 1 = 5 V 2 = 10 V*	<b>R 35</b>	G <i>value</i> <i>value:</i> 0 = 1 V 1 = 5 V 2 = 10 V
Sensor Range LOW	<b>EL value</b> <i>value:</i> 00 = 0.1 Torr 01 = 0.2 02 = 0.5 03 = 1 04 = 2 05 = 5 06 = 10* 21 = 20 07 = 50 08 = 100 22 = 200 09 = 500 10 = 1000 11 = 5000 12 = 10000 13 = 1.33 mBar 14 = 2.66 15 = 13.33 16 = 133.3 17 = 1333 18 = 6666 19 = 13332	<b>R 55</b>	EL <i>value</i> <i>value:</i> 00 = 0.1 Torr 01 = 0.2 02 = 0.5 03 = 1 04 = 2 05 = 5 06 = 10 21 = 20 07 = 50 08 = 100 22 = 200 09 = 500 10 = 1000 11 = 5000 12 = 10000 13 = 1.33 mBar 14 = 2.66 15 = 13.33 16 = 133.3 17 = 1333 18 = 6666 19 = 13332

Sensor Range High	<b>EH value</b>	<b>R 33</b>	<b>EH value</b>
	<i>value:</i> 00 = 0.1 Torr		<i>value:</i> 00 = 0.1 Torr
	01 = 0.2		01 = 0.2
	02 = 0.5		02 = 0.5
	03 = 1		03 = 1
	04 = 2		04 = 2
	05 = 5		05 = 5
	06 = 10		06 = 10
	21 = 20		21 = 20
	07 = 50		07 = 50
	08 = 100		08 = 100
	22 = 200		22 = 200
	09 = 500		09 = 500
	10 = 1000*		10 = 1000*
	11 = 5000		11 = 5000
	12 = 10000		12 = 10000
	13 = 1.33 mBar		13 = 1.33 mBar
	14 = 2.66		14 = 2.66
	15 = 13.33		15 = 13.33
	16 = 133.3		16 = 133.3
	17 = 1333		17 = 1333
	18 = 6666		18 = 6666
	19 = 13332		19 = 13332
<i>* Initial setting</i>			

Table 14: RS-232 Setup Messages

## How To Select and Calibrate the Valve

The 651 unit can control Type 253 and Type 653 valves. Be sure that the valve is connected to the 651 unit.

### Caution



The procedure for selecting the valve involves cycling the valve from the open to the close position. Be certain that the system can withstand valve cycling before proceeding.

This test can be performed prior to installing the 651 controller and the valve in your system.

The command `[J type]` identifies the type of valve you want to control, where:

<i>type:</i>	1	=	Standard 253 valve (initial)
	2	=	Fast 253 valve
	3	=	653 valve

To check the type of valve selected, issue the request:

**R 23**

The controller responds with the message `[J type]`, where:

<i>type:</i>	1	=	Standard 253 valve
	2	=	Fast 253 valve
	3	=	653 valve

An example response, if the unit is connected to a standard 253 valve, is:

`J 1`

To change the valve selection to a 653 valve, enter:

**J 3**

*Entering the command to select a valve also calibrates the valve.* The valve moves from fully open to fully closed, and then stops at the completion of the calibration procedure.

### Note



Be sure to select the correct valve, otherwise the 651 pressure controller will not function properly.

## How To Read the Pressure Control Mode

To query the current control mode setting, issue the request:

**R 51**

The controller responds with the message [V *value*], where:

*value*: 1 = PID

### How to Set the Pressure Units

The command **[F *value*]** identifies the units for the 651 controller display, where:

*value*: 00 = Torr (initial)  
01 = mTorr  
02 = mBar  
03 =  $\mu$ Bar  
04 = kPa  
05 = Pa  
06 = cm H<sub>2</sub>O  
07 = in H<sub>2</sub>O

To query the current pressure units, enter:

**R 34**

The controller responds with the message **[F *value*]**, where:

*value*: 00 = Torr (initial)  
01 = mTorr  
02 = mBar  
03 =  $\mu$ Bar  
04 = kPa  
05 = Pa  
06 = cm H<sub>2</sub>O  
07 = in H<sub>2</sub>O

An example response, if the pressure units are Torr, is:

**F 00**

To change the units to mTorr, enter:

**F 01**

#### Note



---

The **[F *value*]** command assigns a *label* to the pressure units; it does not convert pressure readings. Pressure readings are reported as a percentage (%) of full scale.

---

## How To Enable Backfill Valve Control

The Backfill Valve Control feature can open a pneumatic valve to assist in raising the system pressure to a new setpoint. The messages described here enable and disable the feature, and check which of those states is in force.

### Note



---

When the backfill valve control feature is enabled, process relay 2 is disabled. When the backfill valve control feature is disabled, relay 2 is enabled. These features share the same pins on the I/O connector.

---

The value of the command [**BEvalue**] determines whether the backfill valve control feature is enabled or disabled:

**BE0** = Disabled (default)

**BE1** = Enabled

To report the status of the feature, enter:

**RBE**

The controller responds with the message [**BEvalue**], where:

BE0 = Disabled

BE1 = Enabled

## How To Set the Set Point Backfill Limit

This parameter sets the point at which the backfill valve closes (the relay deactivates) and the feature turns off. When the feature is turned off, a new setpoint must be entered before the feature can be enabled. The value of this entry is defined as a percent of the new set point value. The messages described here set and report the backfill limit value.

The command [**BLvalue**] sets the value of the backfill limit, where:

*Value* is a percentage of the new set point, from 0 to 100%

Default value is 95%

To report the value of the backfill limit, enter:

**RBL**

The Controller responds with the message [**BLvalue**], where:

*value* is a percentage of the new set point, from 0 to 100%



### How To Set the Backfill Threshold Pressure Value

This value is the required difference between the new set point and the current pressure in the system before the backfill control feature operates. Set point changes less than the backfill threshold value do not trigger the backfill function. The entry is defined as a percent of the full scale value for the high pressure transducer. The messages described here change and report the threshold value.

The command [**MD***value*] sets the minimum delta pressure value, where:

*value* is a percent of the high range pressure transducer full scale, from 0 to 100 %

The default is 5% of full scale of the high range transducer.

To report the minimum delta pressure value, enter:

**RMD**

The controller responds with the message [**MD***value*], where:

*value* is a percentage of the high range pressure transducer full scale, 0 to 100%

### How To Set the Valve Position Signal Output Range

The command [**B** *value*] configures the full scale voltage range for the valve position signal (analog) output, where:

*value:* 0 = 5 Volts  
1 = 10 Volts (initial)

To check the current range of the valve signal output, issue the request:

**R 31**

The controller responds with the message [**B** *value*], where:

*value:* 0 = 5 Volts  
1 = 10 Volts

An example response, if the valve output has a full scale range of 10 Volts, is:

**B 1**

To change the valve signal output range to 5 Volts, enter:

**B 0**

### How To Set the Valve Battery Back-Up Control

The 651 controller has an optional valve failsafe battery back-up. If your 651 unit has this option, it can be configured so the valve battery back-up drives the valve to fully open or fully closed within 30 seconds of an AC power failure. The option can also be disabled.

The command [**K** *value*] defines the direction of valve control upon power failure, where:

*value:* 0 = Disable option

- 1 = Open valve at power failure
- 2 = Close valve at power failure

To check the direction of the valve battery back-up control, issue the request:

**R 40**

The controller responds with the message [K *value*], where:

- value*: 0 = Option disabled
- 1 = Valve opens at power failure
- 2 = Valve closes at power failure

An example response, if the valve is set to open upon a power failure, is:

K 1

To change the valve control so that it closes upon a power failure, enter:

**K 2**

## How To Read the Sensor Type

To query the current sensor type, issue the request:

**R 36**

The controller responds with the message [U *value*], where:

*value*: 0 = Absolute

An example response is:

U 0

## How To Set the Sensor Signal Input Range

### Note



Be sure that the sensor is connected to the 651 controller before changing the sensor signal input range.

The command `[G value]` sets the full scale voltage range for the pressure sensor input, where:

<i>value:</i>	0	=	1 Volt
	1	=	5 Volts
	2	=	10 Volts (initial)

To query the current range of the sensor signal input, issue the request:

**R 35**

The controller responds with the message `[G value]`, where:

<i>value:</i>	0	=	1 Volt
	1	=	5 Volts
	2	=	10 Volts

An example response, if the sensor input has a full scale range of 10 Volts, is:

G 2

To change the sensor signal input range to 5 Volts, enter:

**G 1**

## How To Set the Sensor Range

### Note



Be sure that the sensor is connected to the 651 controller before changing the sensor range.

The command **[Ex *value*]** identifies the range of the sensor, in units, where **x** corresponds to either 'H' or 'L' for the High or Low pressure sensor, and ***value*** corresponds to a valid sensor range, as listed in Table 14.

The 651 controller is initially configured to work with a 10 and a 1000 Torr pressure sensor. If your sensors cover different pressure ranges, use this command to identify the range of your sensor.

Sensor Range Values			
Value	Sensor Range	Value	Sensor Range
00	0.1 Torr	10	1000 Torr
01	0.2	11	5000
02	0.5	12	10000
03	1	13	1.33 mBar
04	2	14	2.66
05	5	15	13.33
06	10	16	133.3
07	50	17	1333
08	100 (initial)	18	6666
09	500	19	13332
21	20	22	200

Table 14: Sensor Range Values

### Note



1. Pressure readings are reported as a percentage (%) of full scale (FS), where full scale is the sensor range shown in Table 14.
2. For example, if the actual pressure is 10 Torr for a 10 Torr FS unit, the 651 controller reports a pressure value of 100 (for 100%). If the pressure is 10 Torr for a 100 Torr FS unit, the 651 controller reports a pressure value of 10 (for 10%).

To check the sensor range of your unit, issue the request:

**R 55** for the Low range sensor

**R 33** for the High range sensor

The controller responds with the message `[Ex value]`, where x corresponds to either 'H' or 'L' for High or Low sensor range and *value* corresponds to a valid sensor range shown in Table 14, page 81.

An example response, if the Low range sensor has a range of 100 Torr, is:

`EL 08`

To change the Low range to 5 Torr, enter:

**EL 05**

To change the High range to 1000 Torr, enter:

**EH 10**

## **Set Point Messages**

The Set Point messages define the set point parameters which include the set point values, the gains and phases, and two process limit relays (each with high and low trip point levels).

All of the set point messages (except for the gain and phase parameters) function the same, regardless of your system's configuration. The way your unit responds to the gain or phase messages depends on the type of pressure control (PID) and set point control (pressure or position) chosen in the Setup menu.

For example:

- When you are using PID control with pressure set points, you can adjust both the gain and phase values. The unit accepts and responds to both commands and queries.
- If you are using position set point control, there are no gain or phase parameters. The unit will not accept or respond to these queries or commands.

RS-232 Set Point Messages			
Description	Command	Request	Response
Set Point Control	<b>T x value</b> <b>x:</b> 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Analog Set Pt  <b>value:</b> 0 = Position 1 = Pressure*	<b>R xx</b> <b>xx:</b> 25 = Analog Set Pt 26 = Set Point A 27 = Set Point B 28 = Set Point C 29 = Set Point D 30 = Set Point E	T x value <b>x:</b> 0 = Analog Set Pt 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E  value: 0 = Position 1 = Pressure
Analog Set Point Range	<b>A value</b> <b>value:</b> 0 = 5 V 1 = 10 V*	<b>R 24</b>	A value value: 0 = 5 V 1 = 10 V
Set Point Values	<b>S x value</b> <b>x:</b> 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Analog Set Pt  <b>value:</b> Set points A to E = % FS pressure or % open  Analog set point = 0 = 100% of controlling transducer's range 1 = 10% of controlling transducer's range	<b>R x</b> <b>x:</b> 0 = Analog Set Pt 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 10 = Set Point E	S x value <b>x:</b> 0 = Analog Set Pt 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E  <b>value:</b> Set points A to E: % FS pressure or % open  Analog set point: % of the analog set point FS voltage range

Table 15: RS-232 Set Point Messages  
(Continued on next page)

RS-232 Set Point Messages (Continued)



Description	Command	Request	Response
Gain	<b>M x value</b> <b>x:</b> 1 = Gain SP A 2 = Gain SP B 3 = Gain SP C 4 = Gain SP D 5 = Gain SP E <b>value:</b> 0 to 100%	<b>R xx</b> <b>xx:</b> 46 = Gain SP A 47 = Gain SP B 48 = Gain SP C 49 = Gain SP D 50 = Gain SP E	M x value <b>x:</b> 1 = Gain SP A 2 = Gain SP B 3 = Gain SP C 4 = Gain SP D 5 = Gain SP E <b>value:</b> 0 to 100%
Phase	<b>X x value</b> <b>x:</b> 1 = Phase SP A 2 = Phase SP B 3 = Phase SP C 4 = Phase SP D 5 = Phase SP E <b>value:</b> 0 to 100%	<b>R xx</b> <b>xx:</b> 41 = Phase SP A 42 = Phase SP B 43 = Phase SP C 44 = Phase SP D 45 = Phase SP E	X x value <b>x:</b> 1 = Phase SP A 2 = Phase SP B 3 = Phase SP C 4 = Phase SP D 5 = Phase SP E <b>value:</b> 0 to 100%
Gain Compensation Factor	<b>GCvalue</b> value: 0 to 100.0%	<b>RGC</b>	GCvalue value: 0 to 100.0%
Phase Compensation Factor	<b>PCvalue</b> value: 0 to 100.0%	<b>RPC</b>	PCvalue value: 0 to 100.0%
Softstart Rates	<b>I x value</b> <b>x:</b> 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Analog Set Pt 7 = Valve open 8 = Valve close <b>value:</b> 0.1 to 100% full speed	<b>R xx</b> <b>xx:</b> 15 = Set Point A 16 = Set Point B 17 = Set Point C 18 = Set Point D 19 = Set Point E 20 = Analog Set Pt 21 = Valve open 22 = Valve close	I x value <b>x:</b> 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Analog Set Pt 7 = Valve open 8 = Valve close <b>value:</b> 0.1 to 100% full speed
Process Limit Relays	<b>P x value</b> <b>x:</b> 1 = Low - PL1 2 = High - PL1 3 = Low - PL2 4 = High - PL2 <b>value:</b> pressure limit	<b>R xx</b> <b>xx:</b> 11 = Low - PL1 12 = High - PL1 13 = Low - PL2 14 = High - PL2	P x value <b>x:</b> 1 = Low - PL1 2 = High - PL1 3 = Low - PL2 4 = High - PL2 <b>value:</b> pressure limit
Table 15: RS-232 Set Point Messages <span style="float: right;">* Initial setting</span>			

## How To Set the Type of Set Point Control

Each set point can be configured so that it represents a pressure value or position value.

The command `[T x value]` configures the unit for set point control, where:

<b>x:</b>	1	=	Set point A control
	2	=	Set point B control
	3	=	Set point C control
	4	=	Set point D control
	5	=	Set point E control
	6	=	Analog set point control
<b>value:</b>	0	=	Position control
	1	=	Pressure control (initial)

To configure set point A for pressure control, enter:

**T 1 1**

### Note



The RS-232 command `[T6 value]` overrides the digital logic control for the analog set point.

To report the type of valve control for a particular set point, issue the request:

**R xx**

where <b>xx:</b>	25	=	Analog set point control
	26	=	Set point A control
	27	=	Set point B control
	28	=	Set point C control
	29	=	Set point D control
	30	=	Set point E control

The controller responds with the message `[T x type]`, where:

<b>x:</b>	0	=	Set point A control
	1	=	Set point A control
	2	=	Set point B control
	3	=	Set point C control
	4	=	Set point D control
	5	=	Set point E control
<b>value:</b>	0	=	Position control
	1	=	Pressure control

To report the type of control for set point A, enter:

**R 26**

An example response, if set point A is configured for pressure control, is:

**T 1 1**

### How To Set the Analog Set Point Range

The command `[A value]` sets the full scale voltage range for the analog set point, where:

*value*: 0 = 5 Volts (initial)  
1 = 10 Volts

To query the voltage range of the analog set point, issue the request:

**R 24**

The controller responds with the message `[A range]`, where:

*value*: 0 = 5 Volts  
1 = 10 Volts

An example response, if the analog set point has a full scale range of 5 Volts, is:

A 0

To change the full scale range of the analog set point to 10 Volts, enter:

**A 1**

#### Note



---

You can operate the 651 controller at a different full scale input, for example, 4.5 V, by recalibrating the full scale of the analog set point. Refer to *How To Calibrate the Full Scale of the Analog Set Point*, for more information.

---

## How To Set the Set Point Values

The command `[S x value]` sets the values for the set points, where:

**x:**

1	=	Set point A value
2	=	Set point B value
3	=	Set point C value
4	=	Set point D value
5	=	Set point E value
6	=	Analog set point value

***value:***

*set points A to E:*

% of full scale (with pressure control)
% of open (with position control)

*analog set point:* 0 = 0 to 100% of the controlling transducer's range (normal resolution - initial)

1 = 0 to 10% of the controlling transducer's range (10x normal resolution)

To set the value of set point A to 50% of full scale pressure, enter:

**S 1 50**

To report the value of a set point, issue the request:

 $\mathbf{R} \ x$ 

where  $\mathbf{x}$ :

- 0 = Analog set point value
- 1 = Set point A value
- 2 = Set point B value
- 3 = Set point C value
- 4 = Set point D value
- 10 = Set point E value

The controller responds with the message `[S x value]`, where:

<code>x:</code>	<code>0</code>	<code>=</code>	Analog set point value
	<code>1</code>	<code>=</code>	Set point A value
	<code>2</code>	<code>=</code>	Set point B value
	<code>3</code>	<code>=</code>	Set point C value
	<code>4</code>	<code>=</code>	Set point D value
	<code>5</code>	<code>=</code>	Set point E value

`value:`

<i>set points A to E:</i>	% of full scale (with pressure control)
	% of open (with position control)

<i>analog set point:</i>	% of the analog set point FS voltage range
--------------------------	--

To report the value for set point A, enter:

**R 1**

An example response, if set point A is set to 50% of full scale pressure, is:

S 1 50

To report the value for the analog set point, enter:

**R 0**

An example response, is:

S 0 100

## Note



The request **[R 0]** reports the analog set point value as *a percentage of the analog set point full scale range voltage*; it does not report the percentage of the controlling transducer's range.

Refer to *How To Calibrate the Full Scale of the Analog Set Point*, for more information.

## How To Set the Gain Values

The command **[M x value]** sets the gain values for the internal set points, where:

**x:**     1 = Set point A gain  
          2 = Set point B gain  
          3 = Set point C gain  
          4 = Set point D gain  
          5 = Set point E gain  
  
**value:**     0 to 100%

To set the gain for set point A to 50%, enter:

**M 1 50**

To report the gain value for any set point, issue the request:

**R xx**

where **xx:** 46 = Set point A gain  
          47 = Set point B gain  
          48 = Set point C gain  
          49 = Set point D gain  
          50 = Set point E gain

To report the gain value for set point A, enter:

**R 46**

The controller responds with the message **[M x value]**, where:

**x:** 1 = Set point A gain  
     2 = Set point B gain  
     3 = Set point C gain  
     4 = Set point D gain  
     5 = Set point E gain  
  
**value:**     0 to 100%

An example response, if the gain for set point A is set to 45, is:

**M 1 45**

## How To Set the Gain Compensation Factor

The gain compensation factor (GCF) modifies the gain value so that the controller gives the best response to the low range set points.

When the 651 controller receives a set point in the range of the high sensor (Channel 1), it uses the gain value entered with the [**Mxvalue**] command. When the controller receives a set point in the range of the low range sensor (Channel 2), it uses a percentage of the high range gain determined by the GCF.

The messages described here set and report the gain compensation factor.

The command [**GCvalue**] sets the gain compensation factor, where:

*value* = 0 to 100% of high range gain

To report the value of the gain compensation factor, enter:

**RGC**

The controller responds with the message [**GCvalue**], where:

*value* = 0 to 100% of high range gain

For example, if:

**Mxvalue** = 90.0

and:

**GCF** = 50

then:

Gain used for low range = 45.0

## How To Set the Phase Values

The command **[X x value]** sets the Phase values for the internal set points, where:

<b>x:</b>	1	=	Set point A Phase
	2	=	Set point B Phase
	3	=	Set point C Phase
	4	=	Set point D Phase
	5	=	Set point E Phase
<b>value:</b>	0 to 100%		

To set the Phase for set point A to 5%, enter:

**X 1 5**

To report the Phase value for any set point, issue the request:

**R xx**

where <b>xx:</b>	41	=	Set point A Phase
	42	=	Set point B Phase
	43	=	Set point C Phase
	44	=	Set point D Phase
	45	=	Set point E Phase

To report the Phase value for set point A, enter:

**R 41**

The controller responds with the message **[X x value]**, where:

<b>x:</b>	1	=	Set point A Phase
	2	=	Set point B Phase
	3	=	Set point C Phase
	4	=	Set point D Phase
	5	=	Set point E Phase
<b>value:</b>	0 to 100%		

An example response, if the Phase for set point A is set to 10% , is:

**X 1 10**



### How To Set the Phase Compensation Factor

The phase compensation factor (PCF) modifies the phase value so that the controller gives the best response to the low range set points.

When the 651 controller receives a set point in the range of the high sensor, it uses the phase value entered with the [**Xxvalue**] command. When the controller receives a set point in the range of the low sensor, it uses a percentage of the high range phase determined by the PCF.

The messages described here set and report the phase compensation factor.

The command [**PCvalue**] sets the gain compensation factor, where:

*value* = 0 to 100% of the high range phase

To report the value of the phase compensation factor, enter:

**RPC**

The controller responds with the message [**PCvalue**], where:

*value* = 0 to 100% of the high range phase

For example, if:

*Xx value* = 20.0

and:

PCF = 75

then:

Phase used for low range = 15.0

## How To Set the Softstart Rates

The softstart rate controls the rate at which flow moves toward the desired set point. Different softstart rates can be assigned to each set point as well as to the valve open and valve close commands. The softstart rate is expressed as a percentage of the valve's full *speed*, ranging from 0.1 to 100%. If it is not necessary to utilize softstart control in your process, leave the softstart rate at 100% of full speed.

The command **[I x value]** sets the softstart rate for each set point, where:

**x:**

1	=	Set point A rate
2	=	Set point B rate
3	=	Set point C rate
4	=	Set point D rate
5	=	Set point E rate
6	=	Analog set point rate
7	=	Valve open rate
8	=	Valve close rate

**value:** 0.1 (slowest) to 100% (fastest) of valve full speed

To report the softstart rate for any set point, issue the request:

**R xx**

where **xx:**

15	=	Set point A rate
16	=	Set point B rate
17	=	Set point C rate
18	=	Set point D rate
19	=	Set point E rate
20	=	Analog set point rate
21	=	Valve open rate
22	=	Valve close rate

To report the softstart rate for set point A, enter:

**R 15**

The controller responds with the message **[I x value]**, where:

**x:**

1	=	Set point A rate
2	=	Set point B rate
3	=	Set point C rate
4	=	Set point D rate
5	=	Set point E rate
6	=	Analog set point rate
7	=	Valve open rate
8	=	Valve close rate

**value:** 0.1 (slowest) to 100% (fastest) of valve full speed

An example response, if the softstart rate for set point A is set to 100%, is:

**I 1 100**

To change the softstart rate for set point A to 50% enter:

**I 1 50**

## How To Set the Process Limit Relays

The command **[P x value]** sets the process limit relay thresholds, where:

**x:**     1 = Low threshold - Process Limit 1  
           2 = High threshold - Process Limit 1  
           3 = Low threshold - Process Limit 2  
           4 = High threshold - Process Limit 2  
  
**value:**     Pressure limit

To report a process limit threshold, issue the request:

**R xx**  
  
 where **xx:**    11 = Low threshold - Process Limit 1  
                   12 = High threshold - Process Limit 1  
                   13 = Low threshold - Process Limit 2  
                   14 = High threshold - Process Limit 2

The controller responds with the message **[P x value]**, where:

**x:**     1 = Low threshold - Process Limit 1  
           2 = High threshold - Process Limit 1  
           3 = Low threshold - Process Limit 2  
           4 = High threshold - Process Limit 2  
  
**value:**     Pressure limit

To report the low threshold for process limit 1, enter:

**R 10**

An example response, if the low threshold for process limit 1 is 100 Torr, is:

P 1 100

### Note



To disable a low threshold process limit, set the **P x value** to negative full scale.

To disable a high threshold process limit, set the **P x value** to full scale.

## Control Messages

The control messages directly control the actions of the valve and the system.

RS-232 Control Messages			
Description	Command	Request	Response
Activate Set Point	<b>D x</b> <b>x:</b> 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 0 = Analog Set Pt	<b>R7</b>	M x y z w <b>X:</b> Active Set Point 0 = Analog Set Pt 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Valve Open 7 = Valve Closed 8 = Valve Stop <b>Y:</b> Valve Status 0 = Controlling 2 = Valve open 4 = Valve close <b>Z:</b> Pressure 0 = $\leq 10\%$ FS 1 = $> 10\%$ FS <b>W:</b> Active Sensor/Channel Select/Zero Adjust 0 = L/A/D 1 = H/A/D 3 = H/H/D 4 = L/A/E 5 = H/A/E 7 = H/H/E 8 = L/L/D : = L/L/E
Valve Open • drives valve fully open	<b>O*</b>	None	None
Valve Close • drive valve fully closed	<b>C*</b>	None	None

RS-232 Control Messages			
Valve Stop • stops valve in current position	<b>H*</b>	None	None
Sensor Zero • corrects sensor zero offsets	<b>Z 1</b>	None	None
Special Zero • zeros base pressure	<b>Z 2 value</b> <i>value: % FS pressure</i>	None	None
Remove Sensor and Special Zeros • removes [ <b>Z1</b> ] and [ <b>Z2 value</b> ]	<b>Z 3</b>	None	None
Zero Analog Set Point	<b>Z 4</b>	None	None
Calibrate Analog Set Point Full Scale	<b>Y2</b>	<b>R 0</b>	<i>S 0 value</i> <i>value:</i> % of the analog set point FS voltage range
*The RS-232 commands to open, close, or halt the valve override the active set point control of the valve.			

Table 17: RS-232 Control Messages

## How To Activate a Set Point

The command **[D x]** activates one of the set points, where:

- x:**
- 1 = Set point A
  - 2 = Set point B
  - 3 = Set point C
  - 4 = Set point D
  - 5 = Set point E
  - 0 = Analog set point

To activate set point A, enter:

**D 1**

To report which set point is active, issue the request:

**R 7**

The controller responds with the message:

**M x y z w**

where Status	<b>x:</b> Active Set Point	<b>y:</b> Valve
	0 = Analog set point	0=Controlling
	1 = Set point A	1=Valve open
	2 = Set point B	2=Valve close
	3 = Set point C	
	4 = Set point D	<i>z: Pressure</i>
	5 = Set point E	
	6 = Valve open	0=Pressure ≤10% of FS
	7 = Valve closed	1=Pressure >10% of FS
	8 = Valve stop	

**w:** Active Sensor Range /Channel Select Status /Zero Adjust Status

- 0 = Low / Auto/ Disabled
- 1 = High / Auto / Disabled
- 3 = High / High / Disabled
- 4 = Low / Auto / Enabled
- 5 = High / Auto / Enabled
- 7 = High / High / Enabled
- 8 = Low / Low / Disabled
- : = Low / Low / Enabled

An example response, if set point A is active, the valve is open, and the pressure is ≤10% FS, is:

**M 1 1 0 0**

## How To Control the Valve

The 651 unit can drive the throttle valve to full open or full close, or to stop at its current position. There are no requests associated with these functions.

### Note



---

The RS-232 commands to open, close, or stop the valve *override* the active set point control of the valve.

---

### *How to Drive the Valve to Full Open*

To drive the valve to full open, issue the command:

**O**

The system responds by illuminating the LED in the upper left corner of the [OPEN] key on the front panel, driving the throttle valve to full open, and displaying the default *Pressure and Position* display screen.

### *How to Drive the Valve to Full Close*

To drive the valve to full close, issue the command:

**C**

The system responds by illuminating the LED in the upper left corner of the [CLOSE] key on the front panel, driving the throttle valve to full close, and displaying the default *Pressure and Position* display screen.

### *How to Stop the Valve*

To stop (hold) the valve in its current position, issue the command:

**H**

The system responds by illuminating the LED in the upper left corner of the [STOP] key on the front panel, halting the throttle valve in its current position, and displaying the default *Pressure and Position* display screen.



## How To Use the Sensor Zero

The command **[Z 1]** corrects for any sensor zero offsets. There is no request associated with this function. This command will zero the currently selected pressure sensor range.

To use the sensor zero:

1. Turn the gas flow off.
2. Drive the valve to full open by issuing the command:

**O**

Refer to *How to Drive the Valve to Full Open*, page.

3. Pump the system down to base pressure.

In order to achieve a proper zero, the pressure of the system must be *lower* than the resolution of the sensor used to measure system pressure.

4. Enter the command:

**Z 1**

The LED in the upper left corner of the **[ZERO]** key illuminates as the sensor is zeroed. The front panel display shows a pressure reading of zero, and changes to reflect changes in system pressure as soon as a change occurs. To remove the sensor zero correction, refer to *How To Remove the Sensor and Special Zeros*.

### Note



If the pressure reading (at base pressure) is greater than 4% of full range, the sensor will not be zeroed.

## How To Use the Special Zero

The special zero command **[Z 2 value]** zeros the base pressure in systems where the known base pressure is not *at*, but *near* zero (as measured by another transducer in the system). There is no request associated with this function.

To use the special zero:

1. Set your system to base pressure.
2. Send the command:

**Z 2 value**

Where **value** is expressed as a percentage of full scale pressure (% FS pressure):

$$\text{value} = \frac{\text{known base pressure reading}}{\text{transducer's full scale}}$$

To remove the special zero correction, refer to *How To Remove the Sensor and Special Zeros*, page 101.

## How To Remove the Sensor and Special Zeros

The command **[Z 3]** removes the sensor zero **[Z 1]** and the special zero **[Z2 value]** correction factors stored in memory, and is used to determine the uncorrected signal from the pressure transducer. Each time a sensor is zeroed, the offset changes and the pressure display is updated. In some applications it may be important to keep the zero offset within a specific range. There is no request associated with this function.

To remove the zero corrections, send the command:

**Z 3**

### How To Zero the Analog Set Point

The command **[Z 4]** instructs the controller to take the current value of the external analog set point for its zero value. Zeroing the analog set point allows you to correct any controller zero offsets. There is no request associated with this function.

To zero the analog set point:

1. Apply zero input voltage to Interface connector pins 33 and 34. (Connect pin 34 to 35 to properly ground.)

Refer to Table 8, page 22, for the Interface connector pinout.

2. Enter the command:

**Z 4**

The 651 controller *learns* the input voltage that corresponds to the analog set point zero value.

## How To Calibrate the Full Scale of the Analog Set Point

The analog set point can be configured for 5 Volt (initial) or 10 Volt full scale input (refer to *How To Set the Analog Set Point Range*). You can, however, operate the 651 controller at a different full scale input, for example, 4.5 V, by recalibrating the full scale of the analog set point. Although the actual voltage input to the unit must be measured, you can report the voltage input applied as a percentage of the analog set point full scale by using the **[R 0]** command (refer to *How To Set the Set Point Values*).

For example, if the analog set point is configured for 5 V full scale input and the actual input applied is 5 V, the unit reports a value of 100%. However, if the actual input applied is 2.5 V, the unit reports a value of 50%.

To recalibrate the full scale of the analog set point:

1. Apply full scale input voltage (for example, 4.5 V) to pins 33 and 34 on the Interface connector. If suitable ground is not available at source of set point, connect pin 34 to pin 35.

Refer to Table 8, for the Interface connector pinout.

2. Send the command:

**Y 2**

The 4.5 V input to the Interface connector is now the full scale value.

This command instructs the controller to assign the voltage applied in step 1 as the new full scale value for the analog set point, in this example, 4.5 V. This command also allows you to correct any full scale offsets.

### Note



If the value of the analog set point exceeds  $\pm 15\%$  of full scale, the controller will not change the full scale value.

To report the applied input voltage for the analog set point as a percentage of full scale, send the command:

**R 0**

An example response, if the actual voltage input is 100% of the analog set point FS range, is:

S 0 100

## Informational Messages

Informational messages report data on the 651 controller. There are no commands associated with these functions.

RS-232 Informational Messages		
Description	Request	Response
Pressure Reading <ul style="list-style-type: none"> <li>reports pressure reading as % of FS</li> </ul>	<b>R 5</b>	P value value: % FS
Valve Position Value <ul style="list-style-type: none"> <li>reports valve position as % of Open</li> </ul>	<b>R6</b>	V value Value: % Open
System Status reports: <ul style="list-style-type: none"> <li>type of operation</li> <li>state of learning</li> <li>valve control</li> </ul>	<b>R 37</b>	M x y z X: Type of Operation 0 = Local 1 = Remote Y: State of the Learn Function 0 = Not learning 2 = Learning valve Z: Valve Control 0 = Open 1 = Close 2 = Stop 3 = Set point A 4 = Set point B 5 = Set point C 6 = Set point D 7 = Set point E 8 = Analog set point

Table 16: RS-232 Informational Messages  
*(Continued on next page)*

RS-232 Informational Messages ( <i>Continued</i> )		
Description	Request	Response
Valve Battery Back-Up Status <ul style="list-style-type: none"> <li>reports the voltage status of the optional valve failsafe battery back-up</li> </ul>	<b>R 39</b>	BT <i>x</i> <i>x</i> : 0 = Battery voltage is out of range 1 = Battery voltage is within acceptable range 2 = Battery back-up option is not installed
Firmware Version <ul style="list-style-type: none"> <li>reports the installed version of firmware</li> </ul>	<b>R 38</b>	H <i>model / version number</i>
Checksum Status <ul style="list-style-type: none"> <li>reports the status of the A/D converter calibration</li> </ul>	<b>R 52</b>	CS <i>value</i> <i>value</i> : 0 = OK 1 = Error condition

Table 16: RS-232 Informational Messages

## How To Report the Pressure Reading

To report the currently selected pressure reading as a percentage (%) of full scale (FS) of your pressure sensor, issue the request:

**R 5**

The controller responds with the message `[P value]`, where:

*value*: % of sensor full scale

### Note



Pressure readings are reported as a percentage of full scale, where full scale is the sensor range set with the **[Ex value]** command. Refer to *How To Set the Sensor Range*, for more information.

An example response, if the pressure is 10 Torr for a *10 Torr FS* unit, is:

`P 100`

The pressure reading is 100% of the sensor's full scale.

An example response, if the pressure is 10 Torr for a *100 Torr FS* unit, is:

`P 10`

The pressure reading is 10% of the sensor's full scale.

## How To Calculate the Absolute Pressure

Calculate the absolute pressure using the formula:

$$\text{ABSOLUTE PRESSURE} = (\text{P value} / 100) \times (\text{FULL SCALE})$$

For example, if the pressure reading (P value) for a 1000 Torr FS unit was reported as 65 (65%), the absolute pressure is:

$$\begin{aligned} \text{ABSOLUTE PRESSURE} &= (65 / 100) \times (1000) \\ &= 650 \text{ Torr} \end{aligned}$$

**How To Report the Valve Position Value**

To report the valve position value as a percentage (%) of full Open, issue the request:

**R 6**

The controller responds with the message `[V value]`, where:

***value*: % of full Open**

Example: if the valve is at 50, the response is:

V+0050.0

The valve position is 50% of full open.

## How To Report the System Status

The system status request reports the type of operation, the state of the learn function, and the state of the valve control.

To report the system status, issue the request:

**R 37**

The controller responds with the message:

M x y z

where X: Type of Operation

0 = Local

1 = Remote

Y: State of the Learn Function

0 = Not learning

2 = Learning valve

Z: Valve Control

0 = Open

1 = Close

2 = Stop

3 = Set point A

4 = Set point B

5 = Set point C

6 = Set point D

7 = Set point E

8 = Analog set point

An example response, if the 651 is set for remote operation, the valve is not learning, and the valve is under set point A control, is:

M 1 0 3



### How To Report the Voltage Status of the Valve Battery Back-Up

To report the voltage status of the optional valve failsafe battery back-up, issue the command:

**R 39**

The controller responds with the message:

BT *x*

where *x*:

0	=	Battery voltage is out of range
1	=	Battery voltage is within acceptable range
2	=	Battery back-up option is not installed

#### Note



---

The normal voltage range of the battery ranges from 11 V to 15.5 V.

- A voltage level *below* 11 V indicates a discharged battery.
  - A voltage level *above* 15.5 V indicates a open fuse, a disconnected battery, or a defective charger.
- 

An example response, if the valve failsafe battery back-up is within the acceptable voltage range of 11 to 15.5 Volts, is:

BT 1

## How To Report the Firmware Version

To report the version of firmware that is installed in your 651 controller, issue the command:

**R 38**

The controller responds with the message:

H *model version number*

An example response, is:

H 651DD2S1N2/DUAL VERSION 1.20

## How To Report the Checksum Status

The checksum indicates the status of the unit's A/D converter calibration. To report the status of the checksum, issue the command:

**R 52**

The controller responds with the message:

CS *value*

where *value*:    0   =   OK  
                     1   =   Error Condition

An example response, if the A/D calibration is OK, is:

CS 0

An example response, if the A/D calibration is out of range, is:

CS 1

If the controller detects a checksum error, perform a full calibration to correct the problem. Refer to *How To Respond to a Checksum Error*, for more information.

If your unit issues a checksum error when you power up the controller, or if the transducer's readings are incorrect, you may need to recalibrate the span of the A/D converter. Refer to *How To Calibrate the Span of the A/D Converter*, for more information.

If the checksum error persists after you perform a full system calibration, followed by a recalibration of the span of the A/D converter, the error indicates a hardware failure of the EEPROM. Contact any MKS Service Center, listed on the inside back cover of this manual, for assistance.

## Chapter Six: Remote Digital Logic Control

### General Information

Digital and analog control of the 651 unit is accomplished via the Interface connector located on the rear panel. Refer to Table 8, for the Interface connector pinout.

#### Note



Any RS-232 command takes priority over digital logic commands. For example, a valve being held closed with a digital logic command can be commanded to control to the level of set point A with the **D1** command (refer to *How To Activate a Set Point* for more information).

Digital *inputs* and *outputs* are designed to interface with low power TTL and CMOS logic families. They also include additional components to protect against damage from ESD or transient voltages.

### How To Select the Digital Input Functions

The Interface (I/O) board contains 16 type 74HC *inputs*. The specific function of each digital input is listed in Table 17, page 112. To select an input function, pull the appropriate input pin to a TTL low level (0 to 0.8 Volts) for a minimum of 50 milliseconds. If a higher priority function has not already been selected, the requested function will be activated.

The TTL low signal is “level sensitive” meaning that once the signal is held low, the 651 unit may take up to 50 milliseconds to recognize the command. The line must be held low *continuously* for the 651 unit to use the selected parameters. Once the signal goes high, the controller will default back to the state associated with the high signal within 50 milliseconds. Each input consists of a single pole filter and pull-up resistor as shown in Figure 16.

When the input is brought high (+2.4 to +5 Volts), any lower priority functions that have been selected will be activated. If no lower priority functions have been selected, the function most recently requested remains in effect.

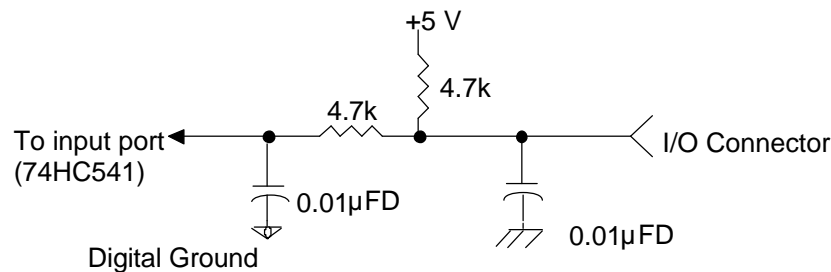


Figure 16: I/O Board Digital Input Circuitry

Refer to Table 8, for the complete Interface connector pinout.

<b>Digital Input Functions</b>		
<b>I/O Pin No.</b>	<b>State</b>	<b>Digital Input Function</b>
6	Low	Analog set point to <i>position</i>
	High	Analog set point to <i>pressure</i>
7	Low	Softstart is <i>active</i> for selected command function
	High	Softstart is <i>inactive</i> for selected command function (used in conjunction with another valve control function)
8	Low	Close the valve
	High	No function
9	Low = Ch. 2	Analog Input
	Hi = Ch. 1	Channel Select
10	Low	FS analog set point yields 1/10 the FS pressure of the controlling transducer or 10% position
	High	FS analog set point yields FS pressure of the controlling transducer or 100% position (Pressure/position function controlled by input 6)
11	Low	Selects analog set point
	High	No function
12	Low	Selects set point E
	High	No function
13	Low	Selects set point D
	High	No function
14	Low	Selects set point C
	High	No function

Table 17: Digital Input Functions  
(Continued on next page)

<b>Digital Input Functions (Continued)</b>		
<b>I/O Pin No.</b>	<b>State</b>	<b>Digital Input Function</b>
15	Low	Selects set point B
	High	No function
16	Low	Selects set point A
	High	No function
24	Low	No function
	High	No function
25	Low	Performs the <i>remote zero</i> function
	High	No function
26	Low	Stop the valve
	High	No function
27	Low	Open the valve
	High	No function

Table 17: Digital Input Functions

### How To Set the Analog Set Point Inputs

The analog set point inputs, (+) set point and (-) set point (pins 33 and 34 respectively on the Interface connector), are fully differential. The (-) set point must be connected to a ground to work correctly, and it is recommended that it be connected to ground at the source of the set point signal. If suitable ground is not available at source of set point, connect pin 34 to pin 35., Refer to Table 8, for the complete Interface connector pinout.

## Digital Input Priorities

Digital inputs are scanned and selected in a prioritized manner, enabling a higher priority request to override a lower one. The order of priority is shown in Table 18.

Priority of Digital Inputs		
Order of Priority	I/O Pin No.	Digital Input Function
1	6	Analog set point (pressure or position)
2	10	Control range of analog set point
<b>Note:</b> Below this point, if any of the digital inputs are held low, lower priority signals are blocked; that is, they are not recognized until the higher priority signal is released.		
3	25	Remote zero
4	5	No function
5	8	Close valve
6	27	Open valve*
7	26	Stop valve*
8	11	Select analog set point
9	16	Select set point A
10	15	Select set point B
11	14	Select set point C
12	13	Select set point D
13	12	Select set point E
* Activating both the <i>open</i> and <i>close</i> commands simultaneously causes the valve to <i>stop</i> .		

Table 18: Priority of Digital Inputs

The order of priority of digital inputs is based on the analog set point line (pin 11) being tied low to continuously select it, thus blocking set points A through E, except to use their gains.

## How To Select the Digital Output Functions

The I/O board contains 6 type 74HC digital *outputs*, each having the capacity to drive one standard TTL load. The specific function of each output is listed in Table 19, page 116. The approximate time constant of the outputs are 2.5 microseconds. Each output includes a 240 ohms series resistor to protect it against line surges and spikes. Additionally, there is a 0.01  $\mu$ FD capacitor connected to the chassis.

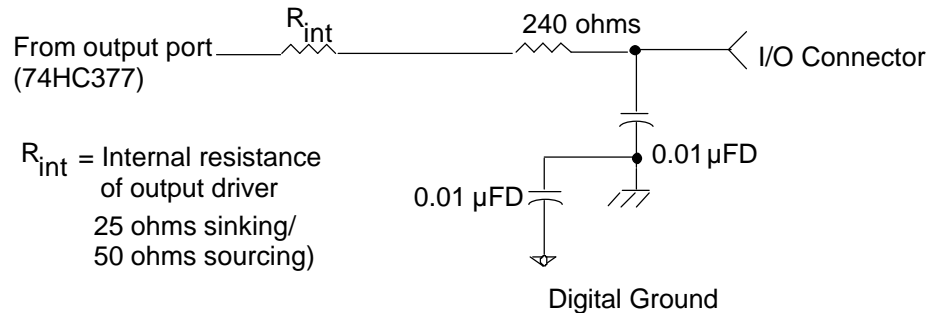


Figure 17: I/O Board Digital Output Circuitry

Refer to Table 8, for the complete Interface connector pinout.

<b>Digital Output Functions</b>		
<b>I/O Pin No.</b>	<b>State</b>	<b>Digital Output Function</b>
19	Low	Valve is not open
	High	Valve is open
23	Low	Valve is not closed
	High	Valve is closed
28	Low	Pressure outside of PLO 2 band (relay is <i>not</i> energized)
	High	Pressure inside of PLO 2 band (relay <i>is</i> energized)
29	Low	Pressure outside of PLO 1 band (relay is <i>not</i> energized)
	High	Pressure inside of PLO 1 band (relay <i>is</i> energized)

Table 19: Digital Output Functions



## **How To Activate the Softstart Rate**

When using the front panel controls or RS-232 to Open the valve, Close the valve, or use a setpoint, the softstart rate is automatically activated. Having a softstart rate setting of 100% is the same as not applying any softstart rate.

The following section applies to the use of TTL commands to Open the valve, Close the valve, or use a setpoint.

The softstart rate for the active set point is controlled by the state of digital logic input pin 7 on the Interface connector. This line must be held low to activate the softstart rate.

To activate softstart control of the active set point:

1. Hold the softstart line low (pin 7 on the Interface connector).

Refer to Table 8, for the Interface connector pinout. Hold the TTL low signal for a minimum of 50 milliseconds. If the line is *not* held low, the valve will move at 100% full speed.

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## Chapter Seven: Maintenance and Troubleshooting

### General Information

If the 651 controller fails to operate properly upon receipt, check for shipping damage, 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.

---

**Warning**

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

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### Maintenance

Periodically check for wear on the cables and inspect the enclosure for visible signs of damage.

#### **How to Replace the Fuses**

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
- Bussmann GDC-T1.25 A or equivalent for the 1.25 A fuse

To replace the fuses:

1. Identify and the proper fuses for the selected line voltage.

All units should have two fuses installed to *fuse both sides* of the line. Refer to Table 5, for information on the line voltage and fuses.

2. Disconnect the power cord from the 651 controller.

**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 rear panel of the unit.
4. Insert a small device such as a screwdriver in the fuse holder clip on the right side of the fuse holder.

Refer to Figure 18 below for the location of the fuse holder clip.

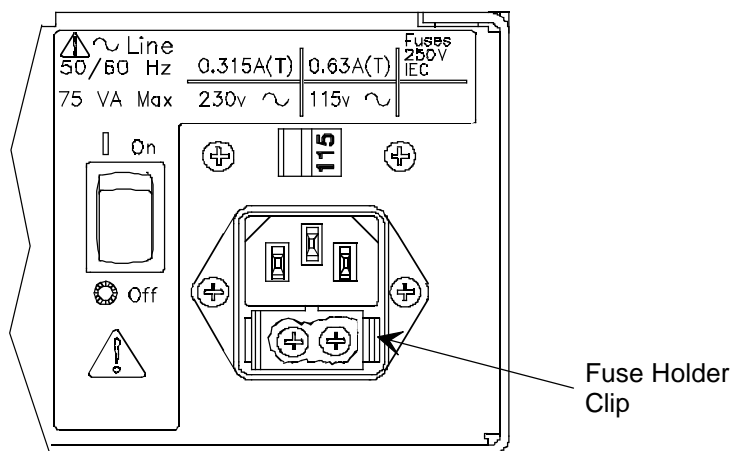


Figure 18: Fuse Holder

5. Gently press against the clip and push up with the screwdriver until the plastic fuse holder pops out.  
It may be necessary to repeat steps 4 and 5 on the left side in order to get the fuse holder to release.
6. Remove the existing fuses.
7. Place the new fuses into the unit.
8. Gently snap the fuse holder back into place.
9. Connect any cables removed from the back of the 651 controller in step 3.
10. Connect the AC power cord.

## How To Replace the Memory (RAM) Module

The 651 pressure controller has a battery-backed memory (RAM) module on the CPU board which stores configuration and *learned* system information while power is off. This memory module (MKS part no. 037-9227) is specified to provide at least seven years of memory storage under all operating conditions. Maintenance is normally not required during this period. The memory module may need to be replaced if the 651 unit continually loses set up information at each power cycle (power off then on again).



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The module is also available from the following sources:

- Bench MarqBench Marq BQ 4011MA-100)
  - SGS-Thompson (MK 48Z32B-10
  - Dallas Semiconductor (DS 1230AB-100)
- 

## How To Remove the CPU Board

### Warning

---

**The 651 unit has lethal voltages inside. Servicing of the unit must be performed by qualified personnel only.**

**To avoid an electrical shock, disconnect the power line *before* opening the unit.**

---

1. Turn the power off.
2. Disconnect the AC power cord.

### Caution



---

**To avoid damage to sensitive internal components, personnel should be grounded through a safety impedance while working inside the 651 unit, and the unit itself must be static-free.**

---

3. Remove the three Phillips head screws on the top of the rear panel and the one on the side.
4. Disengage the cover from the rear chassis by lifting it up from the clips.
5. Remove the top cover by firmly pulling it up and back to clear the top of the connector plates.
6. Locate the CPU board.

The board is located in slot 1 (Serial Interface connector) on the rear panel of the 651 unit (refer to Figure 9).

7. Remove the Phillips head screw to the left of the Serial Interface connector.
8. Remove the CPU board from the 651 controller.

It may be necessary to remove the clamping spring that holds the card cage to the power supply. If so, use needle-nose pliers or a screwdriver to pull the clamping spring straight back and out.

9. Grasp each end of the board and rock it until it loosens from its position and lift the board up and out of the unit.

### ***How To Replace the RAM Module***

1. Locate the battery-backed RAM module on the CPU board.

Refer to Figure 19.

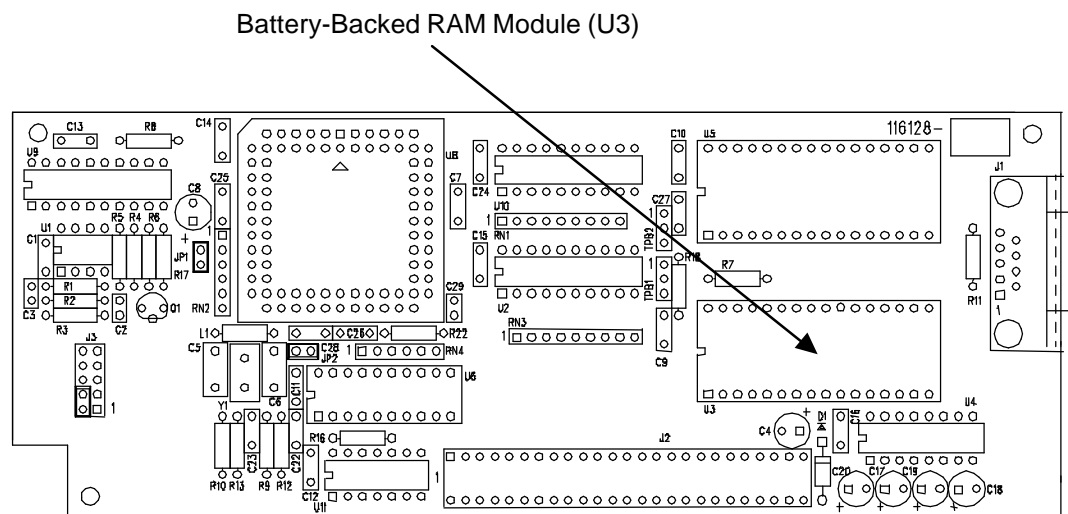


Figure 19: Location of the Battery-Backed RAM Module

2. Remove the RAM module from its socket using either needle-nose pliers, a screwdriver, or an IC puller.
3. Position the new RAM module over the socket, being careful to line up the pins correctly (pin 1 is located directly to the left of the notch).
4. Snap the module firmly into place on the CPU board.

***How To Replace the CPU Board***

1. Position the CPU board over slot 1 in the 651 unit, ensuring that the board's edge is behind the next connector's edge.
2. Push on the bottom tab to snap the board into the slot.
3. Use any instrument to gently seat the clamping spring firmly in place.  
A metal tab prevents the spring from sliding in completely. The space left by the tab enables a small screwdriver to be inserted into the space for easy board removal the next time it is required.
4. Slide the cover (from rear to front) into place at the front panel using the clips on the cover as a guide.
5. Position the cover so that the cover slots engage the top of the connector plates.
6. Tighten the three Phillips head screws on the top of the rear panel and the one on the side.  
From the front (looking at the top of the unit toward the rear), push the cover toward the front while incrementally tightening the screws. This ensures good electrical connections between the top cover and rear connector plates.
7. Reconnect the AC power cord.
8. Turn the power on.

**Note**

---

All user configuration settings may have to be reset

---

## How To Replace the Optional Valve Failsafe Battery

### Warning

**The 651 unit has lethal voltages inside. Only qualified personnel must perform servicing of the unit.**

**To avoid an electrical shock, disconnect the power line *before* opening the unit.**

1. Turn the power off.
2. Disconnect the AC power cord.

### Caution



**To avoid damage to sensitive internal components, personnel should be grounded through a safety impedance while working inside the 651 unit, and the unit itself must be static-free.**

3. Remove the three Phillips screws located at the top of the rear panel and the one on the side.
4. Disengage the cover from the rear chassis by lifting it up from the clips.
5. Remove the top cover by firmly pulling it up and back to clear the top of the connector plates.
6. Locate the area of the unit where the chassis splits (to the rear of the front panel) and remove the two screws on both sides of the front panel as well as the two screws on both sides of the battery backup housing.
7. Slide the front panel out far enough to enable the ribbon cable to lay flat.
8. Slide the battery backup housing out about an inch.
9. Disconnect the battery power bus interface from the battery backup circuit board.
10. Unsnap the ribbon cable connector.
11. Pull both the front panel module and the battery backup housing away from the card cage/power assembly.
12. Remove the screw located on the left side of the housing.
13. Orient the housing on its side, and remove the two visible screws.



14. Pull the front panel module completely forward and remove the battery circuit board assembly.
15. Disconnect the two insulated clips from the battery terminals.

**Caution**

---

***Do not allow anything to short across the battery terminals, such as a screwdriver.***

---

16. Push the battery straight up (from underneath) and out.
17. Be sure that the new battery is positioned such that the terminals are at the rear and (+) is on the right-hand side.
18. Reconnect the two insulated clips.  
Be sure that (+) is connected to (+) and (-) is connected to (-).
19. Feed the ribbon cable through the slot.  
Be sure to keep the cable away from the heatsink.
20. Replace the two screws that attach the circuit assembly to its chassis and the screw removed from the left side of the housing.
21. Position the front panel module and battery backup housing so that the ribbon cable connector can be plugged into the card cage.
22. Plug the bus connector into the circuit board located in the battery backup housing.
23. Slide the battery backup housing into position and snap it into place.
24. Replace the two screws on each side of the battery backup housing.
25. Push the front panel module slightly back and fold the ribbon cable.
26. Slide the front panel module into the battery backup housing and snap into place.
27. Replace the two screws on both sides of the front panel module.
28. Replace the top cover and its four screws.

## **Troubleshooting**

### **How To Identify an Out-of-Range Pressure Condition**

An out-of-range condition occurs at  $\pm 105\%$  of FS ( $\pm 10.5$  Volts at sensor input) and is displayed as a positive or negative polarity.

An example of a positive out-of-range pressure condition is shown below.

PRES	+++++++
POS	0.0%

An example of a negative out-of-range condition is shown below.

PRES	- - - - - Torr
POS	100.0%

## How To Respond to a Checksum Error

A checksum error message indicates the controller has detected a calibration problem. The controller sends a checksum error message in the following circumstances:

- at system power up
- in response to the **R52** checksum command (1 = error).

If the controller detects a checksum error, perform a full calibration to correct the problem.

To perform a full calibration:

1. Calibrate the span of the A/D converter.

Refer to *How To Calibrate the Span of the A/D Converter*, page 128.

2. Zero the analog set point.

Refer to *How To Zero the Analog Set Point*, page 102.

3. Calibrate the full scale of the analog set point.

Refer to *How To Calibrate the Full Scale of the Analog Set Point*, page 103.

If the checksum error persists after you perform a full calibration, the error indicates a hardware failure of the EEPROM. Contact any MKS Service Center, listed on the inside back cover of this manual, for assistance.

## How To Calibrate the Span of the A/D Converter


The controller's A/D (analog-to-digital) converter converts the analog input to a digital value that the controller uses. The span of the A/D converter is calibrated at the factory. However, you may need to recalibrate the span if your unit issues a checksum error when you power up the controller, or if the transducer's readings are incorrect.

### *How To Calibrate the Span of the A/D Converter using Local Control*

To calibrate the span of the A/D converter:

1. Apply a *known* voltage of between +6.6 Volts and +7.4 Volts to the pressure input pins 2 and 12 on the Transducer connector. (connect pin 12 to pin 5)

Refer to Table 9, page 22, for the Transducer connector pinout.

2. Press the  and [STOP] keys simultaneously for about three seconds.

The screen displays:

**CAUTION**

**CALIBRATION MODE**

3. Press the [SET POINT C] [SET POINT A] and [SET POINT E] keys, *in this order*.

The screen displays:

**CAL VOLTS:**

**REF COUNTS:**

Enter the known voltage value from step 1 as the Cal Volts.

4. Press the [STOP] key to exit the calibration procedure.

The controller takes the Cal Volts value and assigns it to the converter reading of the pressure, as an analog input. Calibrating the span of the A/D converter may take up to 5 seconds.

***How To Calibrate the Span of the A/D Converter using Remote RS-232 Operation***

To calibrate the span of the A/D converter:

1. Apply a *known* voltage of between +6.6 Volts and +7.4 Volts to the pressure input pins 2 and 12 on the Transducer connector. (connect pin 12 to pin 5)

Refer to Table 9, page 22, for the Transducer connector pinout.

2. Send the command:

**Y 1 value**

where **value:** known voltage from step 1, expressed as a percent  
(applied voltage / FS)

For example, if the applied voltage is +7.0 Volts, and the full scale range is 10 Volts, then *value* = +70, and the command is:

**Y 1 + 70.00**

The controller takes the entered value from the command and assigns it to the converter reading of the pressure as an analog input. In this example, the 7 V input = 70.00.

Calibrating the span of the A/D converter may take up to 5 seconds.

3. Check that the calibration is finished by sending the checksum error request:

**R 52**

The controller responds to the request immediately after the span calibration is complete.

The controller responds with the message:

CS value

where *value:* 0 = OK  
1 = Error Condition

An example response, if the span calibration was successful, is:

CS 0

An example response, if the span calibration was not successful, is:

CS 1

If the response to the **R52** checksum request is “1”, the controller is reporting that the checksum error still exists. In that case, repeat the A/D converter calibration.

If the error persists, it indicates a hardware failure of the EEPROM. Contact any MKS Service Center, listed on the inside back cover of this manual, for assistance.

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## Appendix A: Product Specifications

Ambient Operating Temperature Range	15° to 40° C (59° to 104° F) 15° to 35° C (59° to 95° F) with the optional valve failsafe battery backup
Analog Output Signal Position Pressure	0 to 5 Volts or 0 to 10 Volts, selectable 110% FS pressure, same range as sensor
CE Mark Compliance Electromagnetic Compatibility <sup>2</sup> Low-Voltage Requirements Installation Category Pollution Degree Product Safety Requirements	<i>Pending</i> EMC Directive 89/336/EEC Low-Voltage Directive 73/23/EEC II, according to EN 61010-1 2, according to IEC 664 Product Safety Directive 92/59/EEC
Connectors <sup>3</sup> RS-232 Serial Communications Interface Transducers Valve	9-pin Type "D" male 37-pin Type "D" female 15-pin Type "D" female (Stand. & Hi-Dens.) 9-pin Type "D" female
Controller Repeatability	±0.1% of FS
Digital Interface	Inputs (16): HCMOS pulled high with a 4.7k resistor to be TTL compatible. Driver must sink 1 mA and hold low for > 50 msec to select function.  Outputs (6):HCMOS with 240 ohm series protection resistor. Will sink & source 1 TTL load. Time constant < 500 nanoseconds.
Dimensions  With optional valve failsafe battery back-up	3½" H x 9½" W x 9" D (8.9 cm x 24.1 cm x 22.9 cm) 12"D (30.5 cm)
Display	2 line LCD with 4½ place readout

<sup>2</sup> An overall metal braided shielded cable, properly grounded at both ends, is required during use.

<sup>3</sup> Interconnecting cables between the 651 controller and the valve, sensor, and serial communications are available at an additional charge. Please consult factory for ordering information.

External Set Point Signal	5 Volts or 10 Volts*, selectable
Fuses Low power unit: 90 to 132 VAC 180 to 264 VAC High power unit: 90 to 132 VAC 180 to 264 VAC	0.63A (T), 250V, 5 x 20 mm 0.315A (T), 250V, 5 x 20 mm 1.25A (T), 250V, 5 x 20 mm 0.63A (T), 250V, 5 x 20 mm
Maximum relative humidity	80% for temperatures up to 31° C, decreasing linearly to 50% at 40° C
Input Power Low power unit High power unit	90 to 132 or 180 to 264 VAC @50/60 Hz 75 VA (max) 90 to 132 or 180 to 264 VAC @48/62 Hz 150 VA (max)
Output Power Low power unit High power unit	±15 VDC @ 0.5 Amps (max) <sup>4</sup> ±15 VDC @ 1.5 Amps (max)
Overrange Pressure	±10.5 Volts
Pressure Input Signal	0 to +10 Volts DC
Pressure Units	Torr, mTorr, mBar, µBar, Pascal, kPa, cmH <sub>2</sub> O, inH <sub>2</sub> O
Set Points Internal External	5, each one pressure or position selectable 1, pressure or position selectable
Weight Low power unit High power unit Optional valve failsafe battery backup	7 lbs. 3 oz. (3.26 kg) 6 lbs. (2.04 kg) 3 lbs. 8 oz. (1.25 kg)

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

<sup>4</sup>Derated to 0.4 Amps with 90 to 99 or 180 to 198 VAC input.



## Appendix B: Model Code Explanation

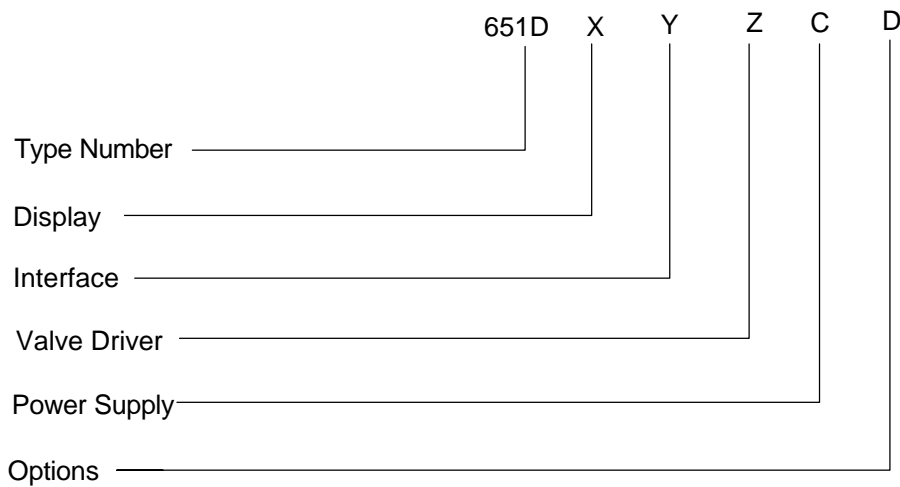
### Model Code

The desired options for the 651 controller are identified in the model code when you order the unit.

The model code is identified as follows:

**651D X Y Z C D**

where:



### **Type Number (651D)**

This designates the model number of the controller.

### **Display (X)**

The display on your 651 unit is designated by a single letter code.

	Ordering Code
No Display	N
Display	D

### Interface (Y)

The type of interface is indicated by a single digit code.

RS-232

#### Ordering Code

2

### Valve Driver (Z)

The valve driver is designated by a single letter code.

Stepper motor

#### Ordering Code

S

### Power Supply (C)

Two power supplies are available, designated by a single number code.

0.5 Amp

1.5 Amp

#### Ordering Code

1

2

### Options (D)

The battery back-up for valve control is designated by a single letter code.

None

Battery Back-Up

#### Ordering Code

N

B

### Channels (E)

The number of pressure sensor channels

Dual

#### Ordering Code

2

## Appendix C: Initial Settings

Your 651 controller is shipped with the initial configuration settings listed alphabetically in Table 20. Since the 651 unit stores most of the settings in non-volatile RAM, the values are not default settings. Values stored in non-volatile RAM are saved when the power is turned off. When the power is restored, the 651 unit “remembers” the latest configuration, not the initial configuration.

Initial Settings			
Parameter	Initial Setting	Other	
Analog Set Point	None	None	
Analog Set Point Full Scale Range	5 V	10 V	
Baud Rate	9600	300 1200 2400 4800	19200 38400 57600 115200
End-of-Line Delimiter	CRLF	CR	
Gain Values			
Gain	None	0 to 100%	
Phase	None	0 to 100%	
Parity / Data Bits	None / 8	Even / 7	
Pressure Control Mode	PID	None	
Pressure Units	Torr	mTorr mBar μBar kPa	Pa cmH <sub>2</sub> O inH <sub>2</sub> O
Sensor Ranges (units)	10 and 1,000	Torr	mBar
		10000	5
		5000	2
		1000	1
		500	0.5
		50	0.2
		10	0.1
			1.33 2.66 13.33 133.3 1333 6666 13332

Table 20: Initial Settings (*Continued on next page*)

<b>Initial Settings (<i>Continued</i>)</b>		
<b>Parameter</b>	<b>Initial Setting</b>	<b>Other</b>
Sensor Signal Input Range	10 V	5 V 1 V
Sensor Type	Absolute	None
Set Point Control	Pressure	Position
Soft Start Rate	100%	User selectable; 0.1 to 100%
Valve Failsafe Battery Back-Up Option	None	Close, Open, Disable
Valve Signal Output Range (analog output)	Pressure: 10 V Position: 10 V	Pressure: No option Position: 5 V
Valve Type	253 Standard	253 Fast 653

Table 20: Initial Setting

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## Appendix E: RS-232 Message Summary

The RS-232 messages required for operation of the 651 controller are listed alphabetically—by command—in Table 20. For complete information on any RS-232 message, refer to *Chapter Five: Remote RS-232 Operation*, page 67.

RS-232 Message Summary			
Command	Description	Request	Response
<b>A value</b> <i>value:</i> 0 = 5 V* 1 = 10 V	Analog Set Point Range	<b>R 24</b>	A <i>value</i> <i>value:</i> 0 = 5 V 1 = 10 V
<b>B value</b> <i>value:</i> 0 = 5 V 1 = 10 V*	Valve Position Signal Output Range	<b>R 31</b>	B <i>value</i> <i>value:</i> 0 = 5 V 1 = 10 V
<b>BE value</b> <i>value:</i> 0 = Disable 1 = Enable	BackFill	<b>RBE</b>	BE <i>value</i> <i>value:</i> 0 = Disable 1 = Enable
<b>BL value</b>	BackFill Limit	<b>RBL</b>	BL <i>value</i>
<b>C</b>	Valve Close • drives valve fully closed	None	None
<b>Checksum Status</b>	Reports the status of the A/D converter calibration	<b>R 52</b>	CS <i>value</i> <i>value:</i> 0 = OK 1 = Error
<b>D x</b> <i>x:</i> 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 0 = Analog Set Pt	Activate Set Point	<b>R 7</b>  Reports: • active set point • valve status • pressure	M <i>x y z w</i>  X: Active Set Pt 0 = Analog Set Pt 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E  Y: Valve Status 0 = Controlling 2 = Valve open 4 = Valve close  Z: Pressure 0 = ≤ 10% FS 1 = > 10% FS

			<i>W</i> : Active Sensor/Channel Select/Zero Adjust  0 = L/A/D 1 = H/A/D 3 = H/H/D 4 = L/A/E 5 = H/A/E 7 = H/H/E 8 = L/L/D := L/L/E
RS-232 Message Summary ( <i>Continued</i> )			
Command	Description	Request	Response
<b>Ex value</b> <i>x</i> = <i>H</i> or <i>L</i> <b>value:</b> 00 = 0.1 Torr 01 = 0.2 02 = 0.5 03 = 1 04 = 2 05 = 5 06 = 10 21 = 20 07 = 50 08 = 100* 22 = 200 09 = 500 10 = 1000 11 = 5000 12 = 10000 13 = 1.33 mBar 14 = 2.66 15 = 13.33 16 = 133.3 17 = 1333 18 = 6666 19 = 13332	Sensor Range  High or Low	<b>R 33</b>  <b>(High)</b>  <b>R55</b>  <b>(Low)</b>	<b>Ex value</b> <i>x</i> : <i>H</i> or <i>L</i> <b>value :</b> 00 = 0.1 Torr 01 = 0.2 02 = 0.5 03 = 1 04 = 2 05 = 5 06 = 10 21 = 20 07 = 50 08 = 100 22 = 200 09 = 500 10 = 1000 11 = 5000 12 = 10000 13 =1.33mBar 14 = 2.66 15 = 13.33 16 = 133.3 17 = 1333 18 = 6666 19 = 13332
<b>F value</b> <b>value:</b> 00 = Torr* 01 = mTorr 02 = mBar 03 = $\mu$ Bar 04 = kPa	Pressure Units	<b>R 34</b>	<b>F value</b> <b>value :</b> 00 = Torr 01 = mTorr 02 = mBar 03 = $\mu$ Bar 04 = kPa



05 = Pa 06 = cm H <sub>2</sub> O 07 = in H <sub>2</sub> O			05 = Pa 06 = cm H <sub>2</sub> O 07 = in H <sub>2</sub> O
<b>Firmware Version</b> • NO COMMAND	Reports the installed version of firmware	<b>R 38</b>	H <i>model / version number</i>
<b>G value</b> <i>value:</i> 0 = 1 V 1 = 5 V 2 = 10 V*	Sensor Signal Input Range	<b>R 35</b>	G <i>value</i> <i>value:</i> 0 = 1 V 1 = 5 V 2 = 10 V

Table 20: RS-232 Message Summary (*Continued on next page*)

<b>RS-232 Message Summary (<i>Continued</i>)</b>			
<b>Command</b>	<b>Description</b>	<b>Request</b>	<b>Response</b>
<b>GC value</b>	Gain Compensation	RGC	GC value
<b>H</b>	Valve Stop (Hold) • stops valve in current position	None	None
<b>I x value</b> <i>x:</i> 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Analog Set Pt 7 = Valve open 8 = Valve close  <i>value:</i> 0.1 to 100% full speed	Softstart Rates	<b>R xx</b>  <i>xx:</i> 15 = Set Point A 16 = Set Point B 17 = Set Point C 18 = Set Point D 19 = Set Point E 20 = Analog Set Pt 21 = Valve open 22 = Valve close	I <i>x value</i>  <i>x:</i> 1 = Set Point A 2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Analog Set Pt 7 = Valve open 8 = Valve close  <i>value:</i> 0.1 to 100% full speed
<b>I</b>	Re-Initializes	<b>None</b>	None
<b>J type</b> <i>type:</i> 1 = Std 253* 2 = Fast 253 3 = 653	Select and Calibrate the Valve	<b>R 23</b>	J <i>type</i> <i>type:</i> 1 = Std 253 2 = Fast 253 3 = 653
<b>K value</b> <i>value:</i> 0 = Disable option* 1 = Open valve at power failure	Valve Battery Back-Up Control	<b>R 40</b> • reports the status of the valve failsafe battery back-up	K <i>value</i> <i>value:</i> 0 = Option disabled 1 = Valve opens at power failure

2 = Close valve at power failure			2 = Valve closes at power failure
<b>LH</b> <b>LL</b> <b>LA</b>	Select High channel Select Low channel Select Auto	<b>R7(w)</b>	
<b>M x value</b> <i>x</i> : 1 = Gain SP A 2 = Gain SP B 3 = Gain SP C 4 = Gain SP D 5 = Gain SP E <i>value</i> : 0 to 100%	Gain	<b>R xx</b> <i>xx</i> : 46 = Gain SP A 47 = Gain SP B 48 = Gain SP C 49 = Gain SP D 50 = Gain SP E	<i>M x value</i> <i>x</i> : 1 = Gain SP A 2 = Gain SP B 3 = Gain SP C 4 = Gain SP D 5 = Gain SP E <i>value</i> : 0 to 100%

Table 20: RS-232 Message Summary  
(Continued on next page)

RS-232 Message Summary (Continued)			
Command	Description	Request	Response
<b>MD value</b>	Minimum Difference	<b>RMD</b>	MD value
<b>O</b>	Valve Open • drives valve fully open	None	None
<b>P x value</b> <i>x</i> : 1 = Low - PL1 2 = High - PL1 3 = Low - PL2 4 = High - PL2 <i>value</i> : Pressure limit	Process Limit Relays	<b>R xx</b> <i>xx</i> : 10 = Low - PL1 11 = High - PL1 13 = Low - PL2 14 = High - PL2	<i>P x value</i> <i>x</i> : 1 = Low - PL1 2 = High - PL1 3 = Low - PL2 4 = High - PL2 <i>value</i> : Pressure limit
<b>PC value</b>	Phase Compensation	<b>RPC</b>	PC value
<b>Pressure Reading</b> • NO COMMAND	Reports pressure reading as a % of FS	<b>R 5</b>	<i>P value</i> <i>value</i> : % FS
<b>Valve Position Value</b> NO COMMAND	Reports valve position as % of Open	<b>R6</b>	<i>V value</i> <i>value</i> : % Open
<b>S x value</b> <i>x</i> : 1 = Set Point A 2 = Set Point B	Set Point Values	<b>R x</b> <i>x</i> : 0 = Analog Set Pt 1 = Set Point A	<i>S x value</i> <i>x</i> : 0 = Analog Set Pt 1 = Set Point A

3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Analog Set Pt <i>value:</i> Set points A to E = % FS pressure or % open Analog set point = 0 = 100% of controlling transducer's range 1 = 10% of controlling transducer's range		2 = Set Point B 3 = Set Point C 4 = Set Point D 10 = Set Point E	2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E <i>value:</i> Set points A to E: % FS pressure % open Analog set point: % of the analog set point FS voltage range
---	--	---	---

Table 20: RS-232 Message Summary  
(Continued on next page)

RS-232 Message Summary (Continued)			
Command	Description	Request	Response
<b>System Status</b> • NO COMMAND	Reports: • type of learning • state of learning • valve control	<b>R 37</b>	M x y z X: Type of Operation 0 = Local 1 = Remote Y: State of the Learn Function 0 = Not learning 4 = Learning valve Z: Valve Control 0 = Open 1 = Close 2 = Stop 3 = Set point A 4 = Set point B 5 = Set point C 6 = Set point D 7 = Set point E 8 = Analog set point
<b>T x value</b> x: 1 = Set Point A 2 = Set Point B	Set Point Control	<b>R xx</b> xx: 25 = Analog Set Pt 26 = Set Point A	T x value x: 0 = Analog Set Pt 1 = Set Point A

3 = Set Point C 4 = Set Point D 5 = Set Point E 6 = Analog Set Pt <b>value:</b> 0 = Position 1 = Pressure*		27 = Set Point B 28 = Set Point C 29 = Set Point D 30 = Set Point E	2 = Set Point B 3 = Set Point C 4 = Set Point D 5 = Set Point E <b>value:</b> 0 = Position 1 = Pressure
<b>U value</b> <b>value:</b> 0 = Absolute	Sensor Type	<b>R 36</b>	<b>U value</b> <b>value:</b> 0 = Absolute

Table 20: RS-232 Message Summary  
(Continued on next page)

<b>RS-232 Message Summary (Continued)</b>			
<b>Command</b>	<b>Description</b>	<b>Request</b>	<b>Response</b>
<b>V value</b> <b>value:</b> 1 = PID	Pressure Control Mode	<b>R 51</b>	<b>V value</b> <b>value:</b> 1 = PID
<b>Valve Battery Back-Up Status</b> • NO COMMAND	Reports the voltage status of the optional valve failsafe battery back-up	<b>R 39</b>	BT x x: 0 = Battery voltage is out of range 1 = Battery voltage is within acceptable range 2 = Battery back-up option is not installed
<b>X x value</b> x: 1 = Phase SP A 2 = Phase SP B 3 = Phase SP C 4 = Phase SP D 5 = Phase SP E <b>value:</b> 0 to 100%	Phase	<b>R xx</b> xx: 41 = Phase SP A 42 = Phase SP B 43 = Phase SP C 44 = Phase SP D 45 = Phase SP E	<b>X x value</b> x: 1 = Phase SP A 2 = Phase SP B 3 = Phase SP C 4 = Phase SP D 5 = Phase SP E <b>value:</b> 0 to 100%
<b>Y1 value</b>	Calibrate A/D Converter	<b>R 52</b> Reports status of A/D converter calibration	<b>CS value</b> <b>value:</b> 0 = OK 1 = Error

Table 20: RS-232 Message Summary  
(Continued on next page)

RS-232 Message Summary ( <i>Continued</i> )			
Command	Description	Request	Response
<b>Y2</b>	Calibrate Analog Set Point Full Scale	<b>R 0</b>	S 0 <i>value</i> <i>value:</i> % of the analog set point FS voltage range
<b>Z 1</b>	Sensor Zero • corrects sensor zero offsets	None	None
<b>Z 2 value</b> <i>value:</i> % FS pressure	Special Zero • zeros base pressure	None	None
<b>Z 3</b>	Remove Zero • removes [ <b>Z1</b> ] and [ <b>Z2 value</b> ]	None	None
<b>Z 4</b>	Zero Analog Set Point	None	None
* <i>Initial setting</i>			

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