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Rev B, 3/99
Instruction Manual

MKS Type 1651C
Pressure Controller

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WARRANTY

Type 1651C Equipment

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

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

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

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Table of Contents

List of Figures

List of Tables

Safety Information

Symbols Used in This Instruction Manual

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

Warning 

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

Caution 

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

Note 

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

Symbols Found on the Unit

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

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

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

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

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

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

SERVICE BY QUALIFIED PERSONNEL ONLY

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

GROUNDING THE PRODUCT

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

DANGER ARISING FROM LOSS OF GROUND

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

GROUND AND USE PROPER ELECTRICAL FITTINGS

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

USE THE PROPER POWER CORD

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

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

USE THE PROPER POWER SOURCE

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

USE THE PROPER FUSE

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

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

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

HIGH VOLTAGE DANGER

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

Sicherheitshinweise

In dieser Betriebsanleitung vorkommende Symbole

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

Warnung!

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

Vorsicht!

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

Hinweis

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

Am Gerät angebrachte Symbole

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

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

Tabelle 2: Definitionen der am Gerät angebrachten Symbole

Sicherheitsvorschriften und Vorsichtsmaßnahmen

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

Keine Teile austauschen und keine Veränderungen vornehmen!

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

Wartung nur durch qualifizierte Fachleute!

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

Produkt erden!

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

Gefährdung durch Verlust der Schutzerdung!

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

Erdung und Verwendung geeigneter elektrischer Armaturen!

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

Richtiges Netzkabel verwenden!

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

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

Richtige Stromquelle verwenden!

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

Richtige Sicherung benutzen!

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

Gerät nicht in explosiver Atmosphäre benutzen!

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

Hochspannungsgefahr!

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

Informations relatives à la sécurité

Symboles utilisés dans ce manuel d'utilisation

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

Avertissement

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

Attention

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

Remarque

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

Symboles apparaissant sur l'appareil

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

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

Tableau 3: Définition des symboles apparaissant sur l'appareil

Mesures de sécurité et mises en garde

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

NE PAS SUBSTITUER DES PIÈCES OU MODIFIER L'APPAREIL

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

DÉPANNAGE EFFECTUÉ UNIQUEMENT PAR UN PERSONNEL QUALIFIÉ

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

MISE À LA TERRE DE L'APPAREIL

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

DANGER LIÉ À UN DÉFAUT DE TERRE

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

MISE À LA TERRE ET UTILISATION CORRECTE D'ACCESSOIRES ÉLECTRIQUES

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

UTILISATION D'UN CORDON D'ALIMENTATION APPROPRIÉ

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

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

UTILISATION D'UNE ALIMENTATION APPROPRIÉE

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

UTILISATION D'UN FUSIBLE APPROPRIÉ

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

NE PAS UTILISER DANS UNE ATMOSPHÈRE EXPLOSIVE

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

DANGER DE HAUTE TENSION

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

Información sobre seguridad

Símbolos usados en el manual de instrucciones

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

Advertencia

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

Precaución

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

Observación

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

Símbolos que aparecen en la unidad

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

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

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

Procedimientos y precauciones de seguridad

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

NO UTILIZAR PIEZAS NO ORIGINALES NI MODIFICAR EL INSTRUMENTO

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

REPARACIONES EFECTUADAS ÚNICAMENTE POR TÉCNICOS ESPECIALIZADOS

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

PUESTA A TIERRA DEL INSTRUMENTO

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

PELIGRO POR PÉRDIDA DE LA PUESTA A TIERRA

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

PUESTA A TIERRA Y USO DE ACCESORIOS ELÉCTRICOS ADECUADOS

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

USAR EL CABLE ELÉCTRICO ADECUADO

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

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

USAR LA FUENTE DE ALIMENTACIÓN ELÉCTRICA ADECUADA

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

USAR EL FUSIBLE ADECUADO

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

EVITAR SU USO EN ENTORNOS EXPLOSIVOS

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

PELIGRO POR ALTO VOLTAJE

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

Chapter One: General Information

Introduction

The MKS Type 1651C instrument is a self-tuning, displayless pressure controller for throttle valves that requires ±15 Volts input power. The 1651 controller is intended for computer control by means of RS-232 communications, or analog/TTL signals. The Self-Tuning feature of the Type 1651 unit determines the system characteristics necessary for control. This feature takes into account time constants, transfer functions of the valve and plumbing, valve gain, pump speed, and many other important parameters when determining the system characteristics. The 1651 unit also includes an adjustable softstart function (to minimize turbulence in the chamber which can stir up particulates), transducer zeroing capability, and two process limit relays to indicate if the pressure deviates from the desired range.

The 1651 controller is configured to be attached to a computer and to send, by means of RS-232 communications, the pressure reading and the valve position, expressed as a percent of open. Five reprogrammable set points are provided, each one having the option of being setup for pressure or position control. Valve open, close, and stop functions are also provided for system setup and diagnostic purposes.

The 1651 instrument has a high-powered driver to operate most MKS type throttle valves, including valves up to 100 mm (4”) with vacuum shutoff capability, giving the unit a control range from 10^{-4} to 760 Torr with the appropriate pressure transducers. *Unpacking Checklist*, page 21, lists all MKS products that are compatible with the 1651 controller. All MKS unheated and 45° C temperature-controlled linear Baratron® transducers are compatible with the 1651 controller.

The 1651 unit configuration backup by means of a battery-backed memory module that stores configuration and *learned* system information while power is off.

How This Manual is Organized

This manual is designed to provide instructions on how to set up, install, and operate a Type 1651 unit.

Before installing your Type 1651 unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

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

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

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

Chapter Four, *RS-232 Operation,* describes how to use the instrument and explains all the functions and features.

Chapter Five, *Digital Logic Control,* discusses the features available through the I/O connector on the rear panel of the 1651 controller.

Chapter Six, *Battery-Backed Memory Module,* provides instructions on how to replace the battery-backed memory module.

Chapter Seven, *Maintenance,* lists any maintenance required to keep the instrument in good working condition.

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

Appendix B, *Model Code Explanation,* describes the model code used to order the instrument.

Appendix C, *Initial Settings,* lists the initial settings for the controller.

Appendix D, *Command and Request Reference,* provides quick reference tables for RS-232 commands and requests.

Manual Conventions

The following conventions apply throughout this manual:

$\overline{\text{XXXXXX}}$	*For inputs:*	Indicates that the line must be pulled low to activate the function.
$\overline{\text{XXXXXX}}$	*For outputs:*	Indicates that the output is active low.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 1651 instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an ERA Number (Equipment Return Authorization Number) from the MKS Calibration and Service Center before shipping. The ERA Number expedites handling and ensures proper servicing of your instrument.

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

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

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Chapter Two: Installation

How To Unpack the Type 1651 Unit

MKS has carefully packed the Type 1651 unit so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

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

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

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

Unpacking Checklist

Standard Equipment:

- Type 1651 Unit
- Type 1651 Instruction Manual (this book)

Optional Equipment:

- Electrical Connector Accessories Kit, 1651C-K1 (includes mates to the electrical connectors)
- Interface cables (refer to Table 5, page 22)
- MKS downstream control valves: Type 253 (fast or standard) and 653
- Transducer

  The choice of transducers to use with the 1651 controller depends upon the power supplied to the unit. The 1651 controller will handle approximately 3 Amperes of power when connected to an external power supply with ±15 Volts @ 5 Amperes. Consult your transducer manual for its power requirements.

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.

Note

1. An overall metal braided, shielded cable, properly grounded at both ends, is required during use to meet CE specifications.
2. To order an overall metal braided shielded cable, add an "S" after the cable type designation. For example, to order a cable to connect a 1651 unit to a 627 unit, use part number CB259-5-xx, where xx designates the cable length; for a braided, shielded cable use part number CB259S-5-xx.

Interface Cables		
To Connect the 1651 Unit to . . . Transducer	**Use the MKS Cable . . .**	
	Standard	**Shielded**
122, 124, 223, 224, 225, 622, 623	CB112-2-xx	CB112S-2-xx
624, 625	CB147-1-xx	CB147S-1-xx
127, 128, 619, 621, 626, 627, 628	CB259-5-xx	CB259S-5-xx
270/690, 670/690	CB112-6-2	CB112S-2-6
120	CB120-1-xx	CB120S-1-xx
220	CB112-10-xx	CB112S-10-xx
121, 221	CB112-14-xx	CB112S-14-xx
xx indicates the cable length, in feet; standard length is 10 ft		
To Connect the 1651 Unit to . . . Valve	**Use the MKS Cable . . .**	
	Standard	**Shielded**
653B	CB652-1-xx	CB652S-1-xx
253B	CB651-30-xx	CB651S-30-xx
xx indicates the cable length, in feet; standard length is 10 ft		

Table 5: Interface Cables

Cables for RS-232 Communication	
Serial Interface Cable	**Cable Number**
RS-232 Serial Communications	CB651-10-10
1651 Serial Communications to 25-pin serial port (pins 2 and 3 reversed)	CB651-11-10

Table 6: Cable Numbers for RS-232 Serial Communications

Generic Shielded Cable Guidelines

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. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in the instruction manual.
5. In selecting the appropriate type and wire size for cables, consider:
   A. The voltage ratings.
   B. The cumulative I^2R heating of all the conductors (keep them safely cool).
   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device.
   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables).
   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Product Location and Requirements

Operating Environmental Requirements

- Ambient Operating Temperature: 15° to 50° C (59° to 122° F)
- Ventilation requirements include sufficient air circulation

  Position the 1651 controller in a location to provide ample air circulation for the cooling fan mounted on the front of the unit. Refer to *Figure 1: Front Panel Dimensions*, page 25, for the location of the fan.
- Storage humidity range: 0 to 95% relative humidity, non-condensing
- Maintain a solid system ground for proper operation and safety conditions

Caution  **Verify that the fuse type is appropriate for your voltage setting. Using an improper fuse may damage your system.**

Setup

Dimensions

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

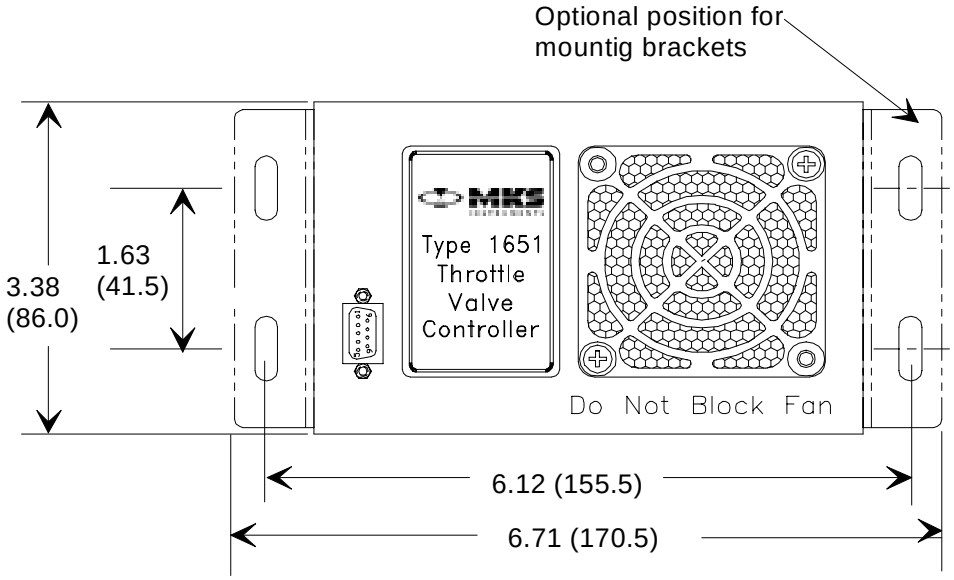

Figure 1: Front Panel Dimensions

Note The height dimension increases to 3.5” (88.9 mm) when the mounting brackets are positioned on the sides of the unit.

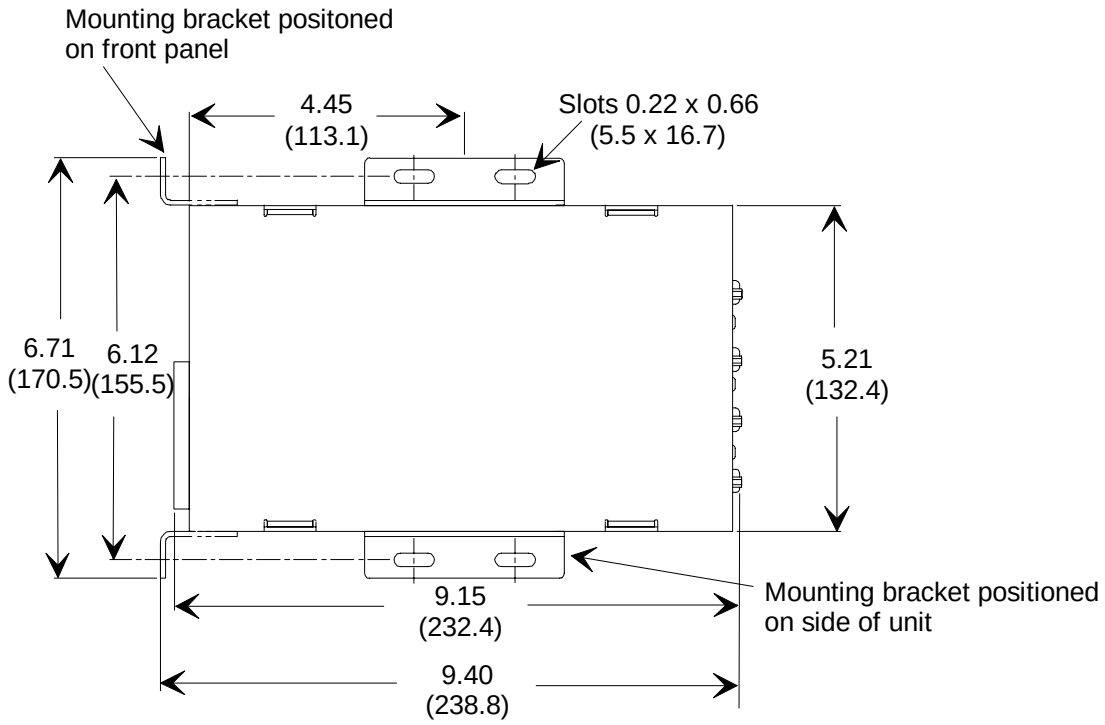

Figure 2: Top View Dimensions

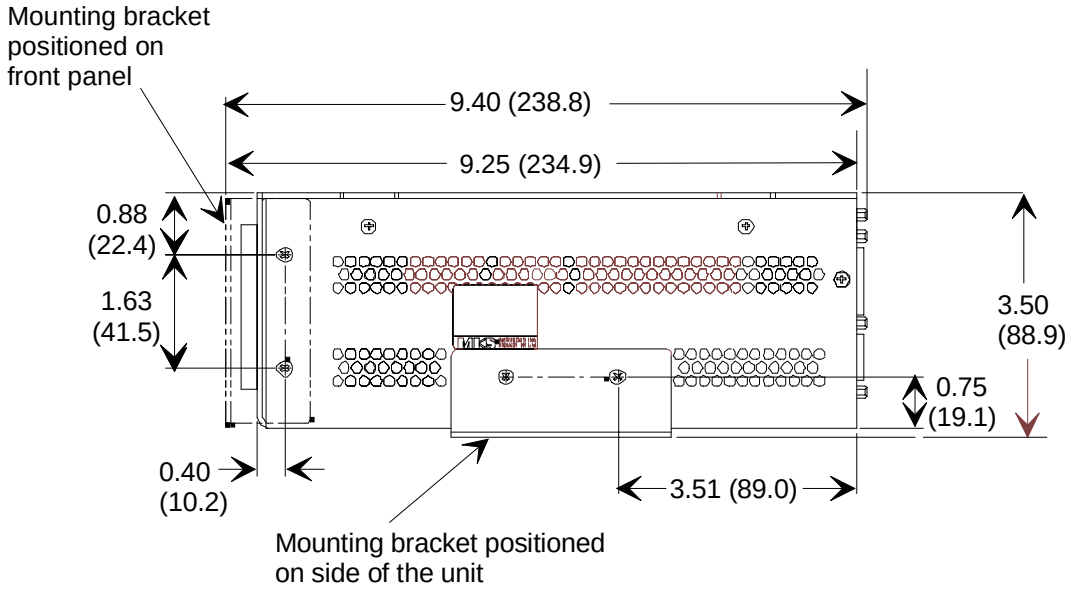

Figure 3: Side View Dimensions

Mounting

The 1651 unit is shipped with two detachable mounting brackets affixed to the sides of the unit. These brackets enable you to mount the unit inside another piece of equipment, or inside a cabinet. The brackets can also be located on either side of the front panel. The brackets do not have to be mounted symmetrically — you can locate one bracket on the front and one on the side of the unit. To move a bracket, simply remove the two screws to release the bracket, then position the bracket in the new location and tighten the two screws.

Caution **If you reposition both mounting brackets on the sides of the front panel, you must allow sufficient room for air circulation to feed the fan. Without sufficient air circulation, the unit may overheat.**

The proper positions for the mounting brackets are shown in *Figure 2: Top View Dimensions* and *Figure 3: Side View Dimensions*. Figure 4 shows the mounting brackets positioned on the front panel of the unit.

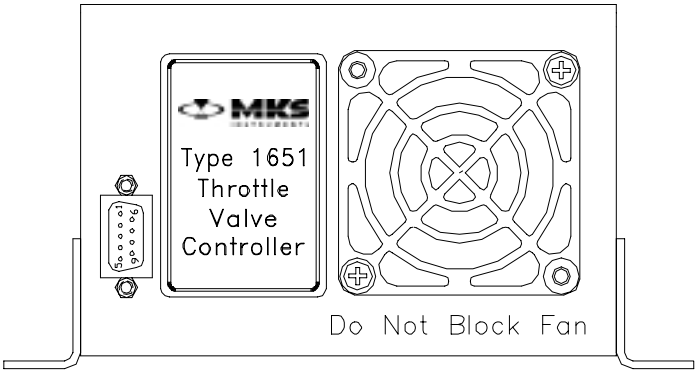

Figure 4: Mounting Brackets Attached to the Front of the Type 1651 Unit

System Configuration

The 1651 pressure controller is configured entirely through RS-232 commands, received through either the front or rear Serial Interface connector. Refer to *Chapter Four: RS-232 Operation*, page 45, for a description of how to use RS-232 communications with the 1651 pressure controller.

Internal Switches

A dipswitch bank inside the 1651 unit allows you to customize RS-232 communications parameters. The dipswitch bank is located on the I/O board.

Opening/Closing the 1651 Controller

1. Turn the power off.

2. Remove the phillips screws and washers on the rear panel.

Caution  **Be sure you are properly grounded while working on internal components of the 1651 unit. This precaution will avoid damage to sensitive internal components of the unit.**

3. Remove the top cover by firmly pulling it up and towards the back of the unit.

   The dipswitch bank is now accessible.

   After changing the dipswitch settings, replace the cover on the unit and replace the screws and washers you removed in step 2, above. After verifying that the unit is properly reassembled, power up the 1651 controller. The new dipswitch settings will be recognized.

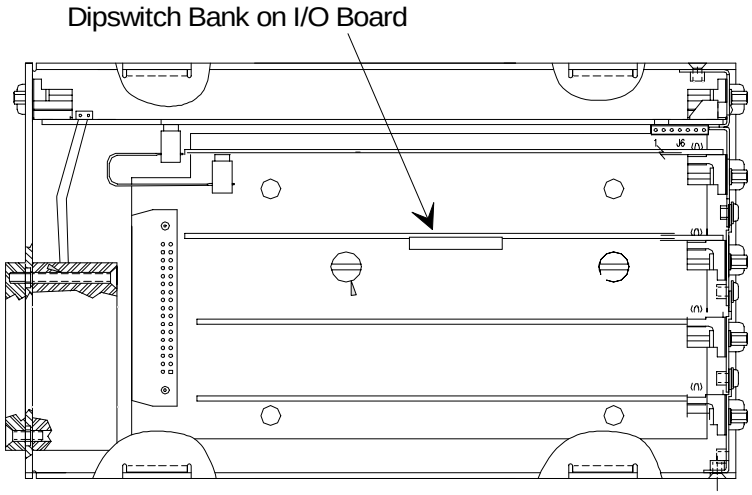

Figure 5: Dipswitch Bank Location (Top View)

The dipswitch bank is located on the I/O board, shown in *Figure 5: Dipswitch Bank Location (Top View)*. You can also identify the I/O board by locating the I/O connector on the rear panel, shown in *Figure 8: Rear Panel of the Type 1651 Instrument*, page 42.

Figure 6: Example of Dipswitch Bank is an enlarged view of a dipswitch bank. The switches in the dipswitch bank are numbered from 1 to 8. The dipswitch bank has the word **OPEN** written on it. To set a dipswitch to open, push it toward the OPEN label. To set a dipswitch to closed, push it away from the OPEN label. For example, in *Figure 6: Example of Dipswitch Bank*, all the switches are closed.

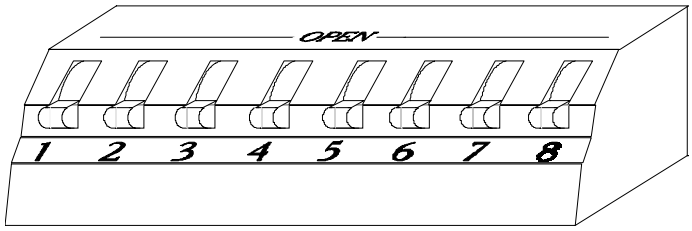

Figure 6: Example of Dipswitch Bank

Dipswitch Bank Settings

The dipswitch settings control the RS-232 communications parameters. When you receive your 1651 controller, the unit is set up with the following initial dipswitch settings:

Default Dipswitch Settings		
Dipswitch	**Setting**	**Function**
Switch 1, 2, 3 Switch 4	Closed Open	9600 Baud Rate
Switch 5	Closed	Parity - None, 8 data bits
Switch 6	Closed	Reserved for future use*
Switch 7	Closed	Reserved for future use*
Switch 8	Closed	End-of-Line Delimiter CRLF
** Reserved for future use means that the pin may be assigned a function in the future.*		

Table 7: Default Dipswitch Settings

Note

Parity and data bit setting are dependent. You may select either no parity with 8 data bits or even parity with 7 data bits.

There is no stop bit setting. RS-232 communications uses 1 stop bit under all circumstances. This setting *cannot* be changed.

If the initial settings, shown in *Table 7: Default Dipswitch Settings*, page 30, are not appropriate for your application, refer to Refer to *Table 8: I/O Board Dipswitch Bank and RS-232 Communications Settings*, page 31, for switch settings you can use to change baud rate, parity and data bits, and end-of-line delimiter.

Note 

Before opening a 1651 unit to change dipswitch settings, you must power off the unit as a safety precaution. Refer to *Opening/Closing the 1651 Controller*, page 28. Any new dipswitch settings take effect when the unit is powered up.

I/O Board Dipswitch Bank and RS-232 Communications Settings									
Function	**Choices**	**Switches**							
RS-232 Baud Rate		**1**	**2**	**3**	**4**				
The five choices for baud rate are:	300	O	C	O	O				
	1200	O	O	C	O				
	2400	O	O	O	C				
	4800	O	C	C	O				
	9600	C	C	C	O				
RS-232 Parity and Data Bits						**5**			
The two choices for parity checking are:	Even 7 data bits					O			
	None 8 data bits					C			
Reserved Switches							6	**7**	
Reserved for future use.							C	C	
RS-232 End-of-Line Delimiter									**8**
The two choices for end-of-line delimiter are:	CR								O
	CRLF								C
Note: O = Open C = Closed									

Table 8: I/O Board Dipswitch Bank and RS-232 Communications Settings

Electrical Information

There are electrical connectors on both the front and rear panels of the 1651 controller.

Note 

The "No Connection" pin assignment refers to a pin with no internal connection. The "Reserved" pin assignment refers to a pin with an internal connection, that may be assigned a function in the future.

Serial Interface (RS-232) Connector

The two Serial Interface (RS-232) connectors are 9-pin male Type "D" connectors used to connect the 1651 controller to a computer.

The pinouts for both the front and rear Serial Interface ports are the same. Refer to *Table 9: Serial Interface (RS-232) Connector Pinout*, page 32 for the pin assignments. *Table 6: Cable Numbers for RS-232 Serial Communications*, page 23, lists the compatible MKS cable part numbers.

Caution 

You *must* use an MKS RS-232 Serial Communications cable (CB651-10-10) for the 9-pin Type "D" Serial Interface connector. Unlisted pins on this connector are *not compatible* with the current 9-pin Type "D" industry-standard cable.

Serial Interface (RS-232) Connector	
Pin Number	**Assignment**
1	No Connection
2	Transmit Data
3	Receive Data
4	No Connection
5	Digital Ground
6	Reserved
7	Reserved
8	No Connection
9	No Connection

Table 9: Serial Interface (RS-232) Connector Pinout

Connecting to One Computer

Use either the front or rear panel to connect the controller to your computer, whichever is most convenient. Whether you are using the front or rear port makes no difference, the controller respond to all commands and requests received through the RS-232 connection.

Connecting to Two Computers

Connect the controller to two computers using both the front and rear ports of the controller. The front panel connection is the RS-232 communications link; that is, the controller will respond to all commands and requests received from the computer connected to the front panel. The computer connected to the rear panel is using a "receive-only" RS-232 link; that is, when the controller receives a request for information from the front panel computer, it sends the response to both computers. The controller ignores commands and requests sent from the computer connected to rear panel. To read about the difference between commands and requests, refer to *Command Reference*, page 93, and *Request and Response Reference*, page 99.

I/O Connector

The I/O connector is a 37-pin female Type "D" connector, that provides access to the set points, the relays, and valve control functions. *Table 10: I/O Connector Pinout* lists the pin assignments.

I/O Connector Pinout	
Pin Number	**Assignment**
1	PLO Relay 1 - NC Contact
2	PLO Relay 1 - NO Contact
3	PLO Relay 2 - NC Contact
4	Digital Ground
5	$\overline{\text{Learn System}}$
6	$\overline{\text{Select Position Set Point}}$ Hold *both* pins 6 and 11 low to select analog set point with position control.
7	$\overline{\text{Softstart}}$
8	$\overline{\text{Close Valve}}$
9	Reserved
10	Analog set point ÷ 10
11	$\overline{\text{Select Analog Set Point}}$ Hold *only* pin 11 low to select analog set point with pressure control. Hold *both* pin 6 and pin 11 low to select analog set point with position control.
12	$\overline{\text{Select Set Point E}}$
13	$\overline{\text{Select Set Point D}}$
14	$\overline{\text{Select Set Point C}}$
15	$\overline{\text{Select Set Point B}}$
16	$\overline{\text{Select Set Point A}}$
17	Reserved
18	Reserved
19	Valve open status (hi = open)

Table 10: I/O Connector Pinout
(Continued on next page)

I/O Connector Pinout *(Continued)*	
Pin Number	**Assignment**
20	PLO Relay 1 - Common Contact
21	PLO Relay 2 - Common Contact
22	PLO Relay 2 - NO Contact
23	Valve closed status (hi = closed)
24	Reserved
25	$\overline{\text{Remote Zero}}$
26	$\overline{\text{Stop Valve}}$
27	$\overline{\text{Open Valve}}$
28	PLO 2 status (low = out of limit)
29	PLO 1 status (low = out of limit)
30	+15V Output
31	-15V Output
32	Power Ground
33	+ Set Point Input
34	- Set Point Input
35	Analog Ground
36	Pressure Output Voltage
37	Position Output Voltage

Table 10: I/O Connector Pinout

Transducer Connector

The Transducer connector is a 15-pin female Type “D” connector, that allows the 1651 controller to communicate with a pressure transducer. Refer to *Table 11: Transducer Connector Pinout* for the pin assignments. *Interface Cables*, page 22, lists the compatible MKS transducer cables.

Transducer Connector Pinout	
Pin Number	**Assignment**
1	+15v 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 11: Transducer Connector Pinout

Valve Connector

The Valve connector is a 9-pin female Type “D” connector. Use this connector to attach a valve to the 1651 controller. Refer to *Table 12: Valve Connector Pinout* for the pin assignments. *Interface Cables*, page 22, lists the MKS valves, and the appropriate cables, supported by the 1651 controller. MKS does not recommend that you fabricate your own cables.

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 12: Valve Connector Pinout

Power Connector

The Power connector is a 9-pin male Type ‘‘D’’ connector. Use this connector to attach a power supply to the 1651 controller. Refer to *Table 13: Power Connector Pinout* for the pin assignments.

Power Connector Pinout	
Pin Number	**Assignment**
1	+15 Volts
2	Reserved
3	Reserved
4	-15 Volts
5	Power Ground
6	+15 Volts
7	Chassis Ground
8	-15 Volts
9	Power Ground

Table 13: Power Connector Pinout

Chapter Three: Overview

Front Panel

Figure 7: Front View of the Type 1651 Instrument shows the 1651 front panel. You can use either the front panel serial port or the rear panel serial port, to connect the controller to your computer.

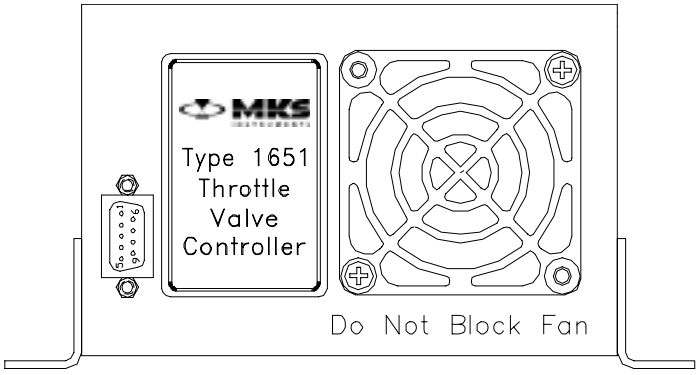

Figure 7: Front View of the Type 1651 Instrument

For more information, refer to:

Figure 8: Rear Panel of the Type 1651 Instrument, page 42.

Serial Interface (RS-232) Connector, page 32.

Control Mode: Self-Tuning or PID Control

The 1651 instrument can control a vacuum system in one of two ways. When used in the *Self-Tuning control mode*, the 1651 instrument determines control parameters based upon the system's characteristics using a unique control algorithm, and does not require the input of lead or gain values.

When used in the *PID control mode*, the 1651 unit employs a **P**roportional, **I**ntegral, and **D**erivative (PID) algorithm for control. PID control requires the input of user-defined lead and gain values. Each set point uses its own lead and gain values to optimize response from set point to set point. Although there are default values for lead and gain, you should select the values for optimum control.

The control mode selection applies to the five internal set points (A through E) and the analog set point.

For more information, refer to:

How To Determine and Change the Control Mode, page 50.

How To Set the Lead and Gain Parameters, page 66.

Set Points

The 1651 controller supports five user-definable set points (set point A through set point E) and one external analog set point, received through the I/O connector. The 1651 unit controls the system based on the value of the "active" set point. Only one set point can be designated as the active set point.

Each set point can be configured as a *pressure* set point or a valve *position* set point. Pressure set points are reported in user-defined units of Torr, mTorr, mbar, µbar, Pascal, or kPa.

Position set points are reported in % open for direct direction operation and % closed for reverse direction operation. If you are controlling the valve in a direct direction, 0 = a closed valve, and 100 = an open valve. If you are controlling the valve in a reverse direction, 0 = an open valve, and 100 = a closed valve.

For more information, refer to:

How To Select the Active Set Point, page 58.

How To Select Pressure or Position Control, page 59.

How To Change the Set Point Value, page 60.

How To Change the Valve Control Direction, page 71.

Softstart Control

The softstart feature is used to reduce the rate at which a control valve moves toward set point. The rate is given as a percent of full speed and can be used on either a pressure or position set point. Once the set point is achieved under softstart control, the valve is free to move at full speed. Softstart control can be applied to set points A through E, the analog set point, valve open, and valve close.

For more information, refer to *How To Set The Softstart Control Rate*, page 68.

Configuration Backup

There is a lithium battery included inside each 1651 unit to power memory for storage of configuration and learned system information while power is off.

For more information, refer to *Chapter Six: Battery-Backed Memory Module*, page 81.

Rear Panel

Rear Panel Components

Figure 8: Rear Panel of the Type 1651 Instrument shows all the components located on the rear panel of the 1651 instrument. The power connector, the I/O connector, the transducer connector, the valve connector, and the serial communications port are located on the back of the 1651 unit.

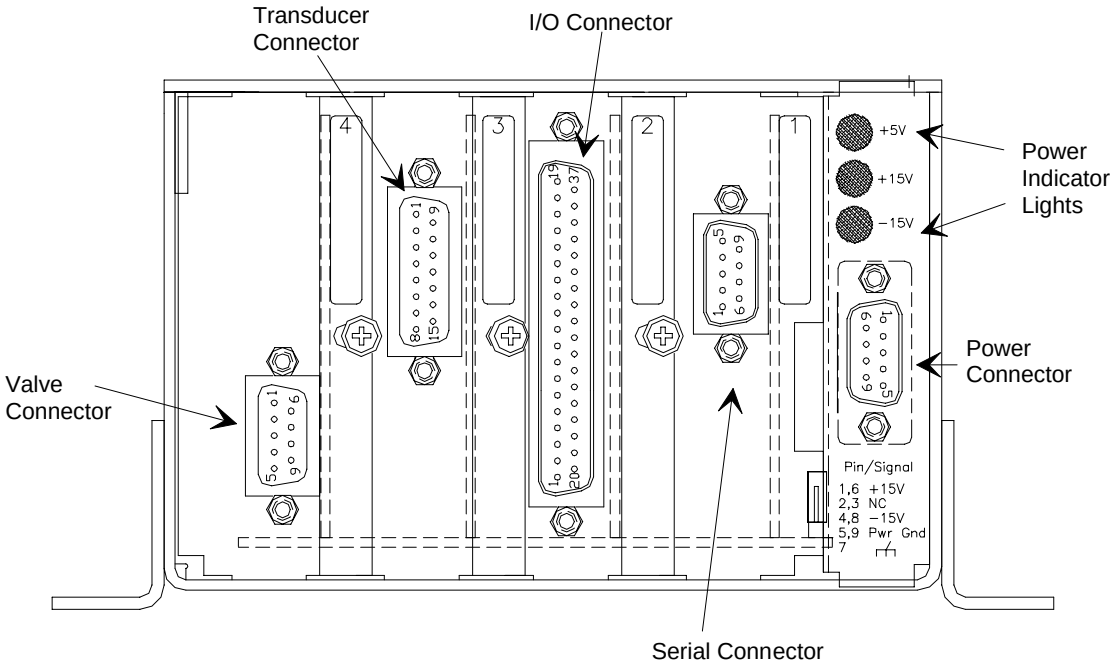

Figure 8: Rear Panel of the Type 1651 Instrument

The connectors are numbered on the rear panel, as listed in Table 14.

Rear Panel Slot Labels	
Slot	**Label**
Serial Interface connector	1
I/O connector	2
Transducer connector	3
Valve connector	4
Note: The Power connector is not labeled.	

Table 14: Rear Panel Slot Labels

Refer to *Electrical Information*, page 32, for information on the connectors.

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 9: Serial Number Label

The model code is identified as "1651C2S." Refer to *Appendix B: Model Code Explanation*, page 89, for more information.

Attention Label

If the battery backup is installed, an **ATTENTION** label is affixed to the side of the 1651 unit stating that it contains a lead-acid battery.

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Chapter Four: RS-232 Operation

RS-232 Commands and Requests

The 1651 unit is operated by RS-232 communication between the controller and a computer. Messages sent to the 1651 controller are either *commands* that instruct the controller to change an operating parameter, or *requests* that prompt the controller to report the value of an operating parameter or other status information.

Responses sent by the 1651 controller either acknowledge a command issued by means of your computer's RS-232 communication software, or reply to a request sent the same way.

All messages must use a carriage return-line feed (CRLF) as the end-of-line delimiter. Use your computer's communications software to assign the CRLF action to the ENTER key.

Message Syntax

The information presented in this section applies to all RS-232 messages. The RS-232 message syntax uses the following typographical conventions:

bold	Commands and requests that you must enter exactly as shown in the manual.
italics	Placeholder that represents text or numeric values you must supply.
`response`	Format of messages sent from the 1651 controller.
ENTER	Represents carriage return-line feed combination (CRLF) that you have configured, through your communications software, as the end-of-line delimiter.

Commands Sent from the Computer to the 1651 Controller

Commands instruct the controller to change an operating parameter. *Table 21: RS-232 Commands*, page 94, lists the syntax for RS-232 commands. Commands are not case sensitive. If a command requires user-supplied parameters, it is not necessary to type a space between the command and the parameters. In examples, the command may be separated from parameters with an optional space for clarity. For example, the **S1** command to assign set point A a *value* of 20 is:

S1 value

The actual keys pressed would be:

S120 ENTER

If you choose to use an optional space for clarity, the actual keys pressed would be:

S1 20 ENTER

Note

When sending *any* message (command or request) to the 1651 controller, you must finish the message by pressing the ENTER key. This appends a carriage return-line feed to the end of the message. Use your communications software to configure the end-of-line delimiter as a carriage return-line feed.

Requests Sent from the Computer to the 1651 Controller

Requests prompt the controller to report the value of an operating parameter or other status information. *Table 22: RS-232 Requests and Responses*, page 99, lists RS-232 request and response messages. Requests are not case sensitive. You do not supply additional parameters with requests. For example, the **R1** request is:

R1 and the actual keys pressed would be:

R1 ENTER

The 1651 will respond to the request by sending the *value* of set point A to your computer.

Responses Sent from the 1651 Controller to the Computer

Responses sent from the 1651 controller to your computer are shown in the last column of *Table 22: RS-232 Requests and Responses*, page 99. The format of responses sent by the 1651 controller to the computer will appear in the table as:

response *value*

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

Note

Controller responses do not contain spaces. Any spaces shown in the response syntax are simply used to improve readability.

The 1651 controller appends a carriage return-line feed to the end of every response.

For example, the controller's response to the **R1** request for the value of set point A is shown in Appendix D as:

`S1` *`value`* where *value* is a % of F.S

To report a set point of 3 Torr on a 10 Torr sensor, the controller sends:

S130

Priority 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. In fact, an RS-232 command will override a *high priority* digital logic command. (Refer to *Digital Input Priorities*, page 77, for more information.) 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.

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

- **T** (set point type) and **F** (pressure unit) commands can take up to 100 milliseconds to execute
- **J** (valve calibration) and **L** (learn function) commands can take several seconds to execute

How To Change Communication Parameters

You only need to change dipswitch settings if your computer's communication software cannot communicate using the initial settings shown in *Table 15: RS-232 Communication Parameters*.

As described in *Internal Switches*, page 28, you can change the baud rate, parity and data bits, and end-of-line delimiter parameters by means of dipswitch settings. The stop bit setting (one stop bit) cannot be changed. Refer to *Table 15: RS-232 Communication Parameters* and *Table 8: I/O Board Dipswitch Bank and RS-232 Communications Settings*, page 31, to see exactly how to set the dipswitches to change the configuration.

RS-232 Communication Parameters		
Parameter	**Setting**	**Change via**
Baud Rate	9600	Dipswitches 1, 2, 3, 4
Parity and Data Bits	No parity, 8 data bits	Dipswitch 5
Stop Bit	1	*cannot change*
End-of-Line Delimiter	CRLF	Dipswitch 8

Table 15: RS-232 Communication Parameters

How To Change Valve Selection and Calibration

The 1651 controller is initially configured to control a Type 653 valve. You must reconfigure the 1651 controller to work with a Type 253 valve. Follow the steps below to select another valve.

Caution 

This procedure 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 1651 controller and the valve in the system.

1. Be sure that the valve is connected to the 1651 unit.

2. Issue the following command to calibrate the controller and valve:

   J *value* ENTER

   where *value* = 1 for standard 253 valve
   2 for a fast 253 valve
   3 for a 653 valve

   The valve will move (from fully open to fully closed) and then stop at the completion of the calibration procedure.

Note 

Be sure to select the correct valve, otherwise the 1651 pressure controller will not function properly.

3. Learn the new valve by following the procedures described in *How To Activate the Learn Function*, page 55.

How To Determine and Change the Control Mode

The 1651 controller is initially configured for PID control. Follow the steps below to change the control mode setting.

1. To determine which control mode is currently selected, issue the request:

   R51 ENTER

   The 1651 controller will return the following response:

   V *value*

   where *value* is:

   0 = Self-Tuning control
   1 = PID control

2. To change the control mode, issue one of the following two commands.

   For Self-Tuning control:

   V0 ENTER

   For PID control:

   V1 ENTER

3. If you choose Self-Tuning control, issue the following command to learn the system:

   L ENTER

   The 1651 unit will "learn" the characteristics of your system.

Caution  **During the learn process, the 1651 controller moves the valve from the opened to the closed position. Be sure your system is set up to allow the valve to move from full open to full closed.**

How To Configure the Sensor Parameters

The 1651 controller is initially configured to use 0 to 10 Volts for the sensor input signal and 100 Torr as the sensor full scale range. Follow the steps below to change these parameters.

Note  Be sure that the sensor is connected to the 1651 controller before changing the sensor parameters.

How To Change the Sensor Type

The 1651 controller can work with either Absolute or Differential pressure sensors. Issue the following command to select the sensor type:

U *value* ENTER

where *value* is 0 for Absolute; 1 for Differential.

How To Change the Sensor Full Scale Voltage

The 1651 controller is initially configured for a 10 Volt full scale sensor. To change the full scale voltage, issue the command:

G *value* ENTER

where *value* is a valid sensor full scale voltage. Valid full scale voltages are:

value		**Full Scale Voltage**
0	=	1 Volt
1	=	5 Volts
2	=	10 Volts*

** initial value*

How To Change the Sensor Range

The 1651 controller is initially configured to work with a 100 Torr pressure sensor. If your sensor covers a different range, issue the command:

E *value* ENTER

where *value* is a valid sensor range. Refer to *Table 16: Sensor Range Values* for the complete list of valid sensor ranges.

Sensor Range Values					
value		**Torr**	**value**		**millibar**
0	=	0.1	13	=	1.33
1	=	0.2	14	=	2.66
2	=	0.5	15	=	13.33
3	=	1	16	=	133.3
4	=	2	17	=	1333
5	=	5	18	=	6666
6	=	10	19	=	13332
7	=	50			
8	=	100*			
9	=	500			
10	=	1000			
11	=	5000			
12	=	10000			
** initial value*					

Table 16: Sensor Range Values

Note

Pressure readings are reported as % of full scale (F.S.), where full scale is the sensor range value shown in *Table 16: Sensor Range Values*. For example, if the actual pressure is 10 Torr for a 10 Torr F.S. unit, then the 1651 controller reports a pressure reading *value* = 100 (for 100%).

If the pressure is 10 Torr for a 100 Torr F.S. unit, then the 1651 controller reports a pressure reading *value* = 10 (for 10%).

How To Request the Pressure Reading

To request the system pressure, issue the request:

R5 ENTER

The 1651 controller responds with the message:

P *value*

where *value* is % of Full Scale.

For example, if the pressure is 10 Torr for a 10 Torr F.S. unit, then *value* = 100.

If the pressure is 10 Torr for a 100 Torr F.S. unit, then *value* = 10.

Converting Pressure Readings to Absolute Pressure Values

To convert pressure readings to absolute pressure values:

1. Request the pressure reading by issuing the request:

   R5 ENTER

   The 1651 controller responds with the message:

   P *value*

   where *value* is % of Full Scale.

2. Calculate the absolute pressure using the formula:

   Absolute pressure = (P *value*/100) X (Full Scale)

For example, if the pressure reading for a 1000 Torr F.S. unit was reported as 65 (65%), the absolute pressure is:

Absolute pressure = (65/100) X (1000) = 650 Torr

How To Zero a Sensor

Zeroing a sensor allows you to correct any zero offsets.

1. Turn the gas flow off.
2. Fully open the control valve.
3. Wait until the system is pumped down to base pressure.

   In order to achieve a proper zero, the pressure of the system must be *lower* than the resolution of the Baratron® used to measure system pressure. If the pressure reading (at base pressure) is greater than 4% of full range, the sensor will not be zeroed.
4. Issue the following command to zero the sensor:

   Z1 ENTER

   The system responds by zeroing the sensor. The system pressure reading will be zero.

How To Use the Special Zero

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

- To command the special zero function, set your system at base pressure and send the command:

  Z2 *value* ENTER

  The *value* is expressed as % of full scale pressure.

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

How To Remove the Zero

The remove zero function removes the zero correction factors (**Z1** and **Z2** corrections) stored in memory, and is used to determine the uncorrected signal from the pressure transducer. Each time a sensor is zeroed, the offset changes. In some applications it may be important to keep the zero offset within a specific range.

- To remove the zero correction, send the command:

  Z3 ENTER

How To Activate the Learn Function

The learn function enables the 1651 unit to identify important system characteristics for Self-Tuning control. Use the learn function whenever you install a new vacuum system or change any processing conditions (such as a new or refurbished pump, or piping changes). The learning process may take several minutes to complete.

Note  The system pressure will vary during the learn cycle to as low and high as is possible for the current flow rate.

1. Initiate proper gas flow into the system.

   Gas flow rate should be close to that used for the actual process (use the maximum flow rate if several flow rates are used in the process). ***Do not*** vary the gas flow rate during the learn function.

2. Issue the following command to initiate the learn function:

   L ENTER

   The system responds by initiating the learn system process. This process may take several minutes to complete.

3. Issue a system status request message to determine the status of the learn process:

   R37 ENTER

   The 1651 controller responds with the following message:

   M*XYZ*

   where *X* =0 for remote control
   - *Y* indicates the system status
     - 0 when not performing the learn process
     - 1 when performing the learn process
     - 2 when learning the valve
   - *Z*
     - 0 for valve open
     - 1 for valve close
     - 2 valve 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

How To Stop the Learn Function

It is recommended that the learn function go through to completion. However, if your process is slow to reach its highest pressures *and* your process will not be operating at those pressures, it is possible to stop the learn function early.

Caution  **Do not stop the learn function until it is well above the highest pressure at which the process will be operating.**

- To stop the learn function, issue the command:

  Q ENTER

The system responds by stopping the learn function and returning to its prior operation. For example, if the valve was closed before the learn function was initiated, the valve will now close.

How To Determine the Active Set Point

To determine the set point currently selected as active:

- Issue the following request to determine the active set point:

  R7 ENTER

  The 1651 controller responds with the following message:

  M*XYZ*

  where *X* = indicates the active set point:
  0 for the analog set point
  1 for set point A
  2 for set point B
  3 for set point C
  4 for set point D
  5 for set point E

  Y = indicates the valve status:
  0 for controlling
  2 for valve open (direct direction)
  4 for valve close (direct direction)
  2 for valve close (reverse direction)
  4 for valve open (reverse direction)

  Z = indicates the pressure:
  0 when the pressure < 10% F.S.
  1 when the pressure ≥ 10% F.S.

How To Select the Active Set Point

The 1651 instrument provides five user-definable set points (set point A through set point E) and one external analog set point, received through the I/O connector. The 1651 controller uses the "active" set point to control the system. Only one set point can be designated as the active set point.

- Issue the following command to select the active set point:

  D*x* ENTER

  where *x* = 1 for set point A
  2 for set point B
  3 for set point C
  4 for set point D
  5 for set point E
  6 for the analog set point.

How To Select Pressure or Position Control

The 1651 controller is initially configured to use *pressure* control for the internal set points, A through E, and the analog set point.

1. To select pressure or position control, issue the command:

   T*x value* ENTER

   where *x* = 1 for set point A type
   2 for set point B type
   3 for set point C type
   4 for set point D type
   5 for set point E type
   6 for the analog set point type

   value = 0 for position
   1 = pressure

Note 

This RS-232 command overrides the digital logic control for the analog set point. Refer to *Chapter Five: Digital Logic Operation*, page 75, for information about the digital logic control of the analog set point.

2. To check the type of control selected for a set point, issue the request:

   R*xx* ENTER

   where *xx* = 25 for the analog set point type
   26 for set point A type
   27 for set point B type
   28 for set point C type
   29 for set point D type
   30 for set point E type

   The 1651 controller responds with the following message:

   `Tx value`

   where *x* = 0 for the analog set point
   1 for set point A
   2 for set point B
   3 for set point C
   4 for set point D
   5 for set point E

   value = 0 for position
   1 = pressure

How To Change the Set Point Value

Follow these instructions to change the value of one of the internal set points, A through E. Refer to *How To Adjust the Analog Set Point Value*, page 61, to change the analog set point value.

1. Issue the following command to set the value of the set point:

   S*x value* ENTER

   where *x* = 1 for set point A
   2 for set point B
   3 for set point C
   4 for set point D
   5 for set point E

   value = % of full scale pressure, if the unit is in pressure control
   % of open, if the unit is in position control (direct direction)
   % of close, if the unit is in position control (reverse direction)

   The system responds by immediately storing the set point value. The system pressure does not change however, unless the selected set point is the *active* set point.

2. To check the set point value for any set point, issue the request:

   R*x* ENTER

   where *x* = 1 for set point A value
   2 for set point B value
   3 for set point C value
   4 for set point D value
   10 for set point E value.

   The 1651 controller responds with the following message:

   `Sx value`

   where *x* = 1 for set point A value
   2 for set point B value
   3 for set point C value
   4 for set point D value
   5 for set point E value

   value = % of full scale pressure, if the unit is in pressure control
   % of open, if the unit is in position control (direct direction)
   % of close, if the unit is in position control (reverse direction)

How To Adjust the Analog Set Point Value

The 1651 controller is capable of accepting one *analog set point* through the I/O connector on the rear panel. The analog set point value is expressed as a % of full scale, using the following formula:

analog set point = (analog set point voltage / full scale voltage)

For example, if the 1651 unit is configured for 5 Volt full scale input, and the actual input applied is 3 Volts, the analog set point value will be 60%. Similarly, if the 1651 unit is configured for 10 Volt full scale input, and the actual input applied is 5 Volts, the analog set point value will be 50%.

The system responds to an analog set point voltage by immediately storing the analog set point value. The system pressure does not change however, unless the analog set point is the active set point. Refer to *How To Determine the Active Set Point*, page 57, for more information.

How To Set the Analog Set Point Full Scale Range

The analog set point can be configured for 5 Volt or 10 Volt full scale input.

1. To change the analog set point full scale range, issue the command:

   A *value* ENTER

   where *value* is 0 for 5 Volt range; 1 for 10 Volt range.

2. To check the analog set point full scale range, issue the request:

   R24 ENTER

   The 1651 controller will send the following response:

   A *value*

   where *value* is 0 for 5 Volt range; 1 for 10 Volt range.

How To Zero the Analog Set Point

Zeroing the analog set point allows you to correct any zero offsets.

The **Z4** command instructs the controller to take the current value of the external analog set point for its zero value. If the current value of the analog set point is ±15% of full scale, the controller will not change the current zero value.

To zero the analog set point:

1. Supply zero input voltage on I/O connector pins 33 and 34.

2. Issue the following command to learn the zero of the analog set point:

   Z4 ENTER

   The 1651 controller learns the input voltage that corresponds to an analog set point zero value.

How To Learn Analog Set Point Full Scale

The controller is calibrated at the factory for 10 Volt full scale input; if the actual input applied is 10 Volts, the controller's analog set point reading is 100 (100%). To recalibrate the controller to operate at a full scale input of, for example, 9.5 Volts, you can learn the analog set point full scale via the **Y2** command. This command allows you to correct any full scale offsets.

The **Y2** command instructs the controller to take the current value of the external analog set point for its full scale value.

To learn the analog set point full scale:

1. Supply full scale input voltage on I/O connector pins 33 and 34.

2. Send the command:

   Y2 ENTER

   If the current value of the analog set point is beyond ±15% of full scale, the controller will not change the current full scale value.

How To Set the Full Scale Level of the Analog Set Point

1. Issue the following command to set the value of the analog set point:

   S6 *value* ENTER

   where *value* = 0 for 100% of the controlling transducer's range
   1 for 10% of the controlling transducer's range

2. To check the full scale level of the analog set point value, issue the request:

   R0 ENTER

   The 1651 controller responds with the following message:

   `S0 value`

   where `value` is % of the controlling transducer's range.

How To Calibrate 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 before you receive your controller. You should perform this calibration if you receive a checksum error when you power up the controller, or if the transducer's readings are incorrect.

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 on the transducer connector. Connect a differential voltage to pins 2 and 12 with pin 12 tied to pin 5.

   Refer to *Table 11: Transducer Connector Pinout*, page 36, for the transducer connector pinouts. You must know the exact voltage applied, in order to complete step 2.

2. Send the command:

   Y1 *value* ENTER

   where *value* is the (applied voltage/F.S.) expressed as a percent. For example, if the applied voltage is 7.0 Volts with 10 Volts = F.S., *value* = +70

   For this example, *value* = 70 and the command is:

   Y1+70.00 ENTER

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

Calibrating the span of the A/D converter may take up to 5 seconds. To check that the calibration is finished, issue a request like **R52** (checksum error request) that the controller responds to ''immediately.'' The controller will respond to the request immediately after it finishes the span calibration.

Note If the response to the **R52** checksum command is ''1'', the controller is reporting that the checksum error still exists. In that case, perform the procedure to calibrate the span of the A/D converter again. 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.

How To Respond To a Checksum Error

A checksum error message indicates that the controller has detected a calibration problem. The controller reports a checksum error at the following times:

- 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. Zero the analog set point.

   Perform the steps on page 62, *How To Zero the Analog Set Point*.

2. Learn the analog set point full scale.

   Perform the steps on page 62, *How To Learn Analog Set Point Full Scale*.

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

   Perform the steps on page 64, *How To Calibrate Span of the A/D Converter*.

If the checksum error persists after you perform a full calibration, it 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 Set the Lead and Gain Parameters

When the 1651 unit is configured for PID control, separate lead and gain parameters are maintained for each pressure set point. Set point A is associated with Lead A and Gain A. Set point B is associated with Lead B and Gain B, and so forth.

When an analog set point is used with PID control, the lead and gain parameters associated with any of the pressure set points (set points A through E) may be used. To specify which set point's lead and gain parameters to use, apply a TTL low level signal to the I/O connector pin assigned to the desired set point. Refer to *Table 18: Digital Input Functions*, page 78, for a description of the pin assignments for the digital inputs. The TTL low level signal (0 to 0.8 Volts) is "level sensitive" meaning that once the signal is held low, the 1651 unit may take up to 50 milliseconds to recognize the command. The line must be held low *continuously* for the 1651 unit to use the selected parameters. Once the signal goes high, the instrument will default back to set point A parameters within 50 milliseconds. The 1651 unit will use the lead and gain values associated with set point A by default.

For example, to apply the lead and 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.

If a set point is configured as a valve position, then *no* lead or gain parameters are associated with it.

1. To determine which control mode is currently selected, issue the request:

   R51 [ENTER]

   The 1651 controller will return the following response:

   V *value*

   where *value* is a 0 for Self-Tuning control; a 1 for PID control.

2. If necessary, issue the following command to select PID control:

   V1 [ENTER]

3. Issue the following command to enter a new lead parameter:

   X*xvalue* [ENTER]

   where *x* = 1 is the lead parameter for set point A
   2 is the lead parameter for set point B
   3 is the lead parameter for set point C
   4 is the lead parameter for set point D
   5 is the lead parameter for set point E

   value = lead value (in seconds)

4. Issue the following command to enter a new gain parameter:

M*x value* ENTER

where *x* =	1 is the gain parameter for set point A
	2 is the gain parameter for set point B
	3 is the gain parameter for set point C
	4 is the gain parameter for set point D
	5 is the gain parameter for set point E
value =	gain value (in percent)

5. To check the value of a lead or gain entry, issue the request:

R*xx* ENTER

where *xx* =	41 requests the lead parameter for set point A
	42 requests the lead parameter for set point B
	43 requests the lead parameter for set point C
	44 requests the lead parameter for set point D
	45 requests the lead parameter for set point E
	46 requests the gain parameter for set point A
	47 requests the gain parameter for set point B
	48 requests the gain parameter for set point C
	49 requests the gain parameter for set point D
	50 requests the gain parameter for set point E

If the request is for a *lead* parameter, the 1651 controller sends the response:

`Xx value`

where *x* =	1 is the lead parameter for set point A
	2 is the lead parameter for set point B
	3 is the lead parameter for set point C
	4 is the lead parameter for set point D
	5 is the lead parameter for set point E
value =	lead parameter (in seconds)

If the request is for a *gain* parameter, the 1651 controller sends the response:

`Mx value`

where *x* =	1 is the gain parameter for set point A
	2 is the gain parameter for set point B
	3 is the gain parameter for set point C
	4 is the gain parameter for set point D
	5 is the gain parameter for set point E
value =	gain parameter (in percent)

How To Set The Softstart Control Rate

Each set point, A through E, can be assigned a different softstart rate. In addition, you can assign a softstart rate for the valve open and valve close commands. If it is not necessary to utilize softstart control in your process, leave the softstart rate at 100% (of F.S.).

The softstart control rate is always expressed as a percent of the valve's full speed. The softstart rate can range from 0.1 to 100%.

How To Set Softstart Rate

Issue the RS-232 command:

I*x value* ENTER

where *x* =	1 for set point A 2 for set point B 3 for set point C 4 for set point D 5 for set point E 6 for the analog set point 7 for valve open 8 for valve close
value =	softstart rate, expressed as a percent of full speed (between 0.1 and 100%)

How To Use the Softstart Rate

The use of the softstart rate for the active set point is controlled by digital logic input (pin 7 on the I/O connector). This applies whether the set point is selected through the RS-232 command described above, or through the digital input logic. Refer to *Table 18: Digital Input Functions*, page 78, for the digital input pinout.

The RS-232 command allows you to select the softstart rate, whereas the state of pin 7 determines whether the softstart rate is used.

To activate softstart control:

- Hold the softstart line low (pin 7 on the I/O connector)

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.

How To Check the Softstart Rate

Issue the RS-232 request:

R*xx* ENTER

where *xx* =
- 15 for set point A
- 16 for set point B
- 17 for set point C
- 18 for set point D
- 19 for set point E
- 20 for the analog set point
- 21 for valve open
- 22 for valve close

The 1651 controller responds with the message:

`Ix value`

where *x* =
- 1 for set point A
- 2 for set point B
- 3 for set point C
- 4 for set point D
- 5 for set point E
- 6 for the analog set point
- 7 for valve open
- 8 for valve close

value = softstart rate, expressed as a percent of full speed (between 0.1 and 100%)

How To Configure the Valve Parameters

In order for the 1651 controller to work properly with your valve, you need to check several valve parameters. All of the parameters are set to an initial value, so it may be unnecessary for you to change any entries.

How To Check the Valve Selected

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

   R23 ENTER

   The 1651 controller responds with the message:

   `Jtype`

   where `type` = 1 for a standard 253
   2 for a fast 253
   3 for a 653

How To Change and Calibrate the Valve

Caution 

During the calibration process, the 1651 controller learns the valve by moving it from the opened to the closed position. Be sure your system is set up to allow the valve to move from full open to full closed.

1. To change and calibrate the valve, issue the command:

   J *value* ENTER

   where *value* = 1 for a standard 253
   2 for a fast 253
   3 for a 653

How To Change the Valve Position Output

The valve position output can be configured for 5 Volts or 10 Volts full scale. The 1651 controller is initially configured for 10 Volts. To change the valve position output, follow the steps below.

1. To change the valve position output range, issue the command:

   B *value* ENTER

   where *value* is 0 for the 5 Volt range; 1 for the 10 Volt range.

2. To check the current valve position output, issue the request:

   R31 ENTER

   The 1651 controller responds with the message:

   `B value`

   where `value` is 0 for the 5 Volt range; 1 for the 10 Volt range.

How To Change the Valve Control Direction

A valve can be controlled to open and close in a *direct* or *reverse* direction. *Direct* valve control direction is defined as valve open at 100% of the valve position's full scale and valve close at 0%. *Reverse* valve control direction is defined as valve open at 0% of the valve position's full scale and valve close at 100%.

The 1651 controller is initially configured to use direct action to control the valve.

1. To change the direction, issue the command:

   N *value* ENTER

   where *value* is a 0 for direct direction; 1 for reverse direction.

2. To check the current valve control selection, issue the request:

   R32 ENTER

   The 1651 controller responds with the message:

   `N value`

   where *value* is a 0 for direct action; 1 for reverse action.

How To Control the Valve

You can use RS-232 commands to drive the throttle valve to full open or full close, or hold the valve at its current position.

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

How To Open the Valve

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

O ENTER

The system responds by driving the throttle valve to full open.

How To Close the Valve

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

C ENTER

The system responds by driving the throttle valve to full close.

How To Halt the Valve

To halt the valve in its current position, issue the command:

H ENTER

The system responds by holding the throttle valve in its current position.

How To Set a Process Limit Relay

There are two process limit relays (also known as trip point relays) in the 1651 controller. Each relay has two trip limits: a high trip limit, and a low trip limit. Refer to *Table 10: I/O Connector Pinout*, page 34, for pinouts of the I/O connector 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 the specified limits, the relay is actuated (a normally-open contact closes, and a normally-closed contact opens). Whenever the pressure crosses *above* the *high* process limit, or *below* the *low* process limit, the corresponding relay becomes de-actuated (a normally-open contact opens, and a normally-closed contact closes).

How To View and Adjust a Process Limit Relay

1. To check a process limit threshold, issue the command:

   R*xx* ENTER

   where *xx* = 10 for the low threshold for process limit 1
   11 for the high threshold for process limit 1
   13 for the low threshold for process limit 2
   14 for the high threshold for process limit 2

   The 1651 controller responds with the message:

   P*x value*

   where *x* = 1 for the low threshold for process limit 1
   2 for the high threshold for process limit 1
   3 for the low threshold for process limit 2
   4 for the low threshold for process limit 2
   value = pressure limit

2. To change a process limit threshold, issue the command:

   P*x value* ENTER

   where *x* = 1 for the low threshold for process limit 1
   2 for the high threshold for process limit 1
   3 for the low threshold for process limit 2
   4 for the high threshold for process limit 2
   value = pressure limit

How To Disable a Process Limit Relay

To disable a high limit process limit, set the step 2 *value* to full scale.

To disable a low limit process limit, set the step 2 *value* to negative full scale.

How To Check the System Status

You can issue a "system status" request to determine the state of the 1651 controller. The request is:

R37 ENTER

The 1651 controller sends the response:

M*XYZ*

where *X* = 1 for remote control

Y = describes the state of the learn function:
0 when not performing the learn function
1 when learning the system
2 when learning the valve

Z = 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

How To Check the Firmware Version

To determine the firmware version, issue the request:

R38 ENTER

The 1651 controller sends the response:

H *version*

Chapter Five: Digital Logic Operation

Digital and analog control of the 1651 unit is accomplished via the I/O connector located on the rear panel. Refer to *Table 10: I/O Connector Pinout*, page 34, for a pinout of this connector.

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.

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. A brief description of the digital circuitry of the I/O board is provided in the following section.

I/O Board Digital Circuitry

The I/O board contains 16 type 74HC *inputs.* To select an input function, pull the appropriate input pin low (0 to 0.8 Volts). The TTL low signal is "level sensitive" meaning that once the signal is held low, the 1651 unit may take up to 50 milliseconds to recognize the command. The line must be held low *continuously* for the 1651 unit to use the selected parameters. Once the signal goes high, the instrument 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 10: I/O Board Digital Input Circuitry*.

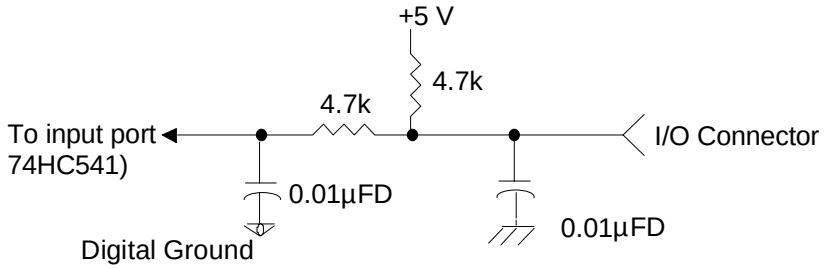

Figure 10: I/O Board Digital Input Circuitry

The I/O board contains 6 type 74HC digital *outputs*, each having the capacity to drive one standard TTL load. The approximate time constant of the outputs are 250 nanoseconds. Each output includes a 240 ohms series resistor to protect it against line surges and spikes. Additionally, there is a 0.001 µFD capacitor connected to the chassis.

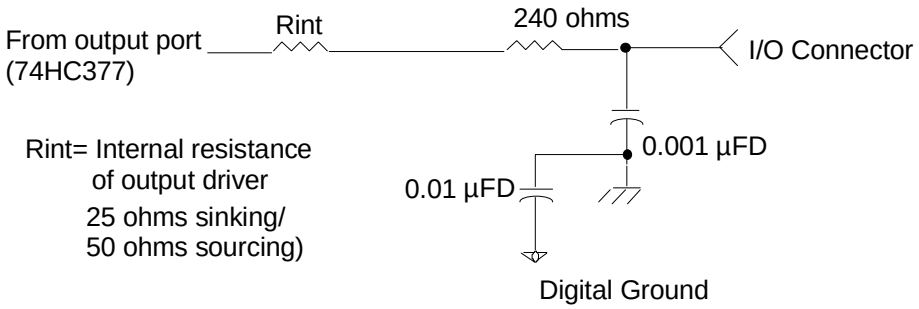

Figure 11: I/O Board Digital Output Circuitry

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 17: Priority of Selection of Digital Inputs*.

Priority of Selection 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
Note: 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	Learn system
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

Table 17: Priority of Selection 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. Refer to *How To Set the Lead and Gain Parameters*, page 66, for more information.

Note 

Activating both the *open* and *close* commands simultaneously, causes the valve to *stop*.

Digital Functions

Most digital input functions are activated by pulling the input 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. When the input is brought high (+2.4 to +5 Volts), any lower priority functions that have been selected will now be activated. If no lower priority functions have been selected, the function most recently requested remains in effect. *Table 18: Digital Input Functions* lists the specific function of each digital input, and *Table 19: Digital Output Functions*, page 80, lists the specific function of each digital output. The first column in each table, lists the I/O port number assignment. This number is useful primarily for software engineers.

Digital Input Functions			
I/O Port No.	**I/O Pin No.**	**State**	**Digital Input Function**
1	27	Low	Open the valve
		High	No function
2	8	Low	Close the valve
		High	No function
3	26	Low	Stop the valve
		High	No function
4	7	Low	Softstart is *active* for selected command function
		High	Softstart is *inactive* for selected command function (used in conjunction with another valve control function)
5	25	Low	Performs the *remote zero* function
		High	No function
6	6	Low	Analog set point to *position*
		High	Analog set point to *pressure*
7	24	Low	No function
		High	No function
8	5	Low	Performs the *learn* system function
		High	No function

Table 18: Digital Input Functions
(Continued on next page)

Digital Input Functions *(Continued)*			
Digital Input No.	**I/O Pin No.**	**State**	**Digital Input Function**
9	16	Low	Selects set point A
		High	No function
10	15	Low	Selects set point B
		High	No function
11	14	Low	Selects set point C
		High	No function
12	13	Low	Selects set point D
		High	No function
13	12	Low	Selects set point E
		High	No function
14	11	Low	Selects analog set point
		High	No function
15	10	Low	F.S. analog set point yields 10% of the F.S. pressure of the controlling transducer or 10% position
		High	F.S. analog set point yields F.S. pressure of the controlling transducer or 100% position (Pressure/position function controlled by input 6)
16	9	Low	No function
		High	No function

Table 18: Digital Input Functions

Digital Output Functions			
Digital Output No.	**I/O Pin No.**	**State**	**Digital Output Function**
1	29	Low	Pressure outside of PLO#1 band (relay is *not* energized)
		High	Pressure inside of PLO#1 band (relay *is* energized)
2	28	Low	Pressure outside of PLO#2 band (relay is *not* energized)
		High	Pressure inside of PLO#2 band (relay *is* energized)
3	23	Low	Valve is not closed
		High	Valve is closed
4	19	Low	Valve is not open
		High	Valve is open
5	18	Low	No function
		High	No function
6	17	Low	No function
		High	No function

Table 19: Digital Output Functions

Analog Set Point Inputs

The analog set point inputs, +set point (I/O pin 33) and -set point (I/O pin 34) on the I/O 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.

To achieve softstart control of analog (or digital logic) set points, the *softstart line (I/O pin 7) must be held low*. If the line is *not* held low, the valve will move at 100% full speed.

If an analog set point is established via RS-232 input, the softstart rate for the analog set point is selected through use of an RS-232 command (**I6** *value).*

Chapter Six: Battery-Backed Memory Module

Replacing the Battery-Backed Memory Module

The 1651 pressure controller has a battery-backed memory module which stores configuration and *learned* system information while power is off. The battery-backed memory module (MKS part no. 037-9227) is specified to provide at least seven years of memory storage under all operating conditions. No maintenance should normally be required during this period.

Note 

The module is also available from the following sources:

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

Eventually, the memory module will need to be replaced. If the 1651 unit continually requires relearning at each power cycle (power off then on again), it may be time to replace it. The memory module is located on the CPU board inside the electronics unit and may be replaced by MKS or other qualified personnel.

Opening the Unit

Warning 

The 1651 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 power cable.

Caution 

To avoid damage to sensitive internal components, personnel should be grounded through a safety impedance while working inside the 1651 unit, and the unit itself must be static-free.

3. Unscrew the phillips screws located on each side of the unit (total of four screws) and remove the cover by lifting up.

Removing the CPU Board and Memory Module

1. Locate the CPU board.

   It is labeled on the rear panel as the Serial Interface connector (1).

2. Remove the phillips screw to the left of the Serial Interface connector.

   The screw is located under the label for the I/O board.

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

4. *Figure 12: Location of the Battery-backed RAM Module* provides the location of the battery-backed memory module on the CPU board.

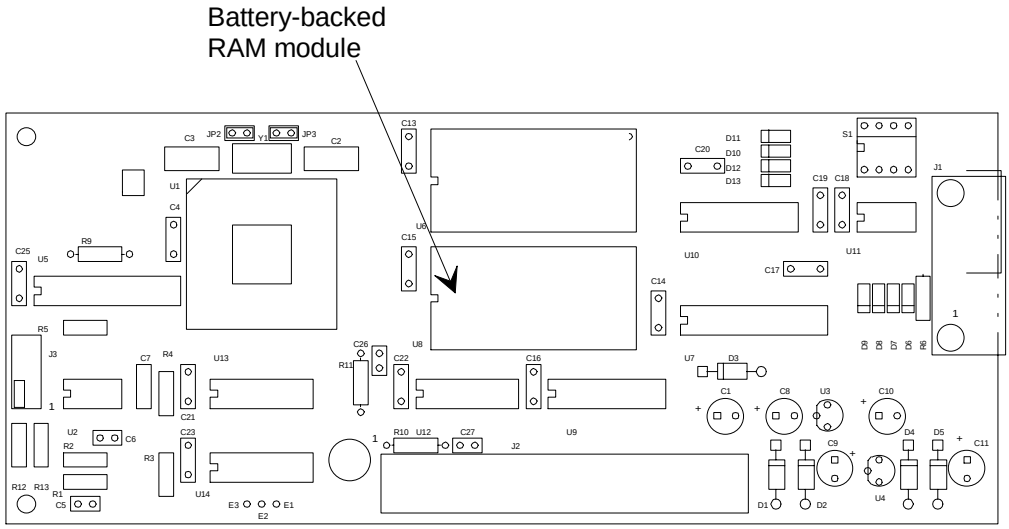

Figure 12: Location of the Battery-backed RAM Module

5. Use needle-nose pliers, a screwdriver, or an IC puller to remove the memory module from its socket.

Installing a New Memory Module and Replacing the CPU Board

1. Position the new memory module over the socket, being careful to line up the pins correctly (pin 1 is located directly to the left of the notch). Snap the module firmly into place.

2. Position the CPU board over its slot in the unit, ensuring that the board's edge is behind the next connector's edge. Push on the bottom tab to snap the board into the slot.

Replacing the Cover

1. Position the cover over the unit so that the end with the five slots is over the rear panel of the unit.

2. Replace the four phillips screws, two per side.

3. Reconnect the power cord.

4. Turn the power on.

Note 

All user configuration settings may have to be reset and the control system may have to be relearned after replacement of the memory module.

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Chapter Seven: Maintenance

General Information

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

How To Clean the Unit

Periodically wipe down the unit with a damp cloth.

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Appendix A: Product Specifications

Type 1651 Product Specifications

Ambient Operating Temperature	15 to 50° C (59 to 122° F)
Analog Output Signal	
Position	0 to 5 Volts or 0 to 10 Volts, selectable
Pressure	110% F.S. pressure, same range as sensor
CE Compliance	
Electromagnetic Compatibility[1]	EMC Directive 89/336/EEC
Connectors[2]	
Power Connector	9-pin Type "D" male
Valve	9-pin Type "D" female
I/O	37-pin Type "D" female
Transducer	15-pin Type "D" female
RS-232 Serial Communications	9-pin Type "D" male
Controller Repeatability	±0.1% of F.S.
Cooling	Fan cooled
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.
External Set Point Signal Range	0 to 5 Volts or 0 to 10 Volts, selectable
Fuses	7 Amp printed circuit type, mounted on the Power Interface board.

(Continued on next page)

[1] An overall metal braided shielded cable, properly grounded at both ends, is required during use.

[2] Interconnecting cables between the Type 1651 and the valve, sensor, and serial communications are available at an additional charge. Please consult factory for ordering information.

Input Power Requirements	*The Input Power Must Meet Or Exceed The Following:*
Input Voltage	±15 Volts
Tolerance	±5%
Input Current Minimum	1A (Type 653 valve) ½ A (Type 253 valve)
Input Current Maximum	Do not exceed 7 Amp
Regulation	<1% of 15 Volts
Peak-To-Peak Noise	<0.3% of 15 Volts
Over-Range Pressure Signal	±11 Volts
Power Available To External Transducers	±15 Volts (maximum) @ 3 Amp (90 Watts) when powered from an external power supply with a capacity of ±15 Volts @ 5 Amp (150 Watts)
Pressure Input Signal	-10 to 10 Volts
Set Points	
Internal	5, each one pressure or position selectable
External	1, pressure or position selectable
Size	6.71”W x 9.15”L (9.40” with brackets on the front panel) x 3½”H (3.38” without brackets on the sides) 170.5 mm W x 232.4 (238.8) mm L x 88.9 (85.8) mm H
Trip Point Relays (2)	Form C contacts
Relay Contact Rating	24 Volt AC/DC @ 1 Ampere, resistive
Weight	3 lbs. (1.36 kg)

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

Appendix B: Model Code Explanation

Model Code

The model code for the Type 1651 controller is identified as follows:

1651C2S

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Appendix C: Initial Settings

Initial Configuration

Your 1651 controller is shipped with the following initial configuration. This configuration is not a default configuration, however, since the 1651 unit stores most of the configuration settings in non-volatile RAM. Settings stored in non-volatile RAM are not lost when the power is turned off. When the power is restored, the 1651 unit "remembers" the latest configuration, not the initial configuration. Refer to *Table 20: Initial Settings* for a complete list of the initial configuration settings. The last column lists the page number for information on each entry, should you wish to change the setting.

Initial Settings			
Parameter	**Default**	**Options**	**Page**
Control Valve	653	253 Fast, 253 Standard	49
Control Mode	PID	Self-Tuning	50
Internal Set Points	A Pressure B Pressure C Pressure D Pressure E Pressure	Position Position Position Position Position	59
Gain and Lead Values	A Gain = 100 Lead = 10 B Gain = 100 Lead = 10 C Gain = 100 Lead = 10 D Gain = 100 Lead = 10 E Gain = 100 Lead = 10	User selectable	66

Table 20: Initial Settings
(Continued on next page)

Initial Settings (*Continued*)			
Parameter	**Default**	**Options**	**Page**
Sensor Full Scale	100 Torr	Torr: 10000, 5000, 1000, 500, 50, 10, 5, 2, 1, 0.5, 0.2, 0.1 millibar: 1.33, 2.66, 13.33, 133.3, 1333, 6666, 13332	52
Response Units	Torr	mTorr, mbar, µbar, Pa, kPa, cmH_2O, inH_2O	95
Analog Set Point Input	0 - 5 V	0 - 10 V	61
Pressure Sensor Input	0 - 10 V	0 - 5 V, 0 - 1 V	51
Analog Output	Position: 0 - 10 V Pressure: 0 - 10 V	0 - 5 V No option	71
Control Mode	Direct Acting	Reverse	71
RS-232			48
Baud Rate	9600	300, 1200, 2400, 4800	
Parity and Data Bits	None, 8 data bits	Even, 7 data bits	
Delimiter	CRLF	CR	

Table 20: Initial Settings

Appendix D: Command and Request Reference

Command Reference

A *command* sent to the 1651 unit instructs it to perform a task or change a setting. Commands are grouped into two categories: *control commands* and *parameter commands*.

Control commands directly control the actions of the valve. Valve open, valve close, and valve halt, as well as selection of the controlling set point, are examples of control commands.

Parameter commands determine the settings used by the 1651 controller. Set point levels, softstart rates, and sensor full scale are examples of parameter commands.

Note

To conserve space, the ENTER key is not included in the request messages listed the following tables. You must press the ENTER key to send the request message to the 1651 controller.

Enter commands without spaces. Spaces are used in the manual to improve readability.

RS-232 command syntax is shown in *Table 21: RS-232 Commands*, page 94.

RS-232 Commands	
Command	**Function**
S1 *value*	Set level of set point A; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S2 *value*	Set level of set point B; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S3 *value*	Set level of set point C; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S4 *value*	Set level of set point D; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S5 *value*	Set level of set point E; where *value* is the % of F.S. pressure for pressure set points; position for position set points % of open for direct direction control % of closed for reverse direction control
S6 *value*	Set F.S. level of analog set point 0 = 100% of controlling transducer's range 1 = 10% of controlling transducer's range
D1	Select set point A
D2	Select set point B
D3	Select set point C
D4	Select set point D
D5	Select set point E
D6	Select analog set point

Table 21: RS-232 Commands
(Continued on next page)

RS-232 Commands *(Continued)*	
Command	**Function**
E *value*	Sensor range, *value* is 0 = 0.1 10 = 1000 1 = 0.2 11 = 5000 2 = 0.5 12 = 10000 3 = 1 13 = 1.33 4 = 2 14 = 2.66 5 = 5 15 = 13.33 6 = 10 16 = 133.3 7 = 50 17 = 1333 8 = 100 18 = 6666 9 = 500 19 = 13332
F *value*	Pressure units, *value* is 0 = Torr 1 = mTorr 2 = mbar 3 = µbar 4 = kPa 5 = Pa 6 = cmH_2O 7 = inH_2O *Note:* The **F** command merely assigns a label to the pressure units. It does not convert pressure readings. Pressure readings are % of F. S.
G *value*	Sensor voltage range, *value* is 0 = 1 Volt 1 = 5 Volts 2 = 10 Volts
O	Open valve
C	Close valve
H	Hold valve
I1 *value*	Set softstart rate of set point A, *value* is % of full speed
I2 *value*	Set softstart rate of set point B, *value* is % of full speed
I3 *value*	Set softstart rate of set point C, *value* is % of full speed
I4 *value*	Set softstart rate of set point D, *value* is % of full speed
I5 *value*	Set softstart rate of set point E, *value* is % of full speed

Table 21: RS-232 Commands
(Continued on next page)

RS-232 Commands *(Continued)*	
Command	**Function**
I6 *value*	Set softstart rate of analog set point, *value* is % of full speed
I7 *value*	Set softstart rate of open valve, *value* is % of full speed
I8 *value*	Set softstart rate of close valve, *value* is % of full speed
P1 *value*	Set low threshold for process limit 1, *value* is % of F.S.
P2 *value*	Set high threshold for process limit 1, *value* is % of F.S.
P3 *value*	Set low threshold for process limit 2, *value* is % of F.S.
P4 *value*	Set high threshold for process limit 2, *value* is % of F.S.
Z1	Zero the sensor
Z2 *value*	Special zero, *value* is % F.S. of the base pressure reading
Z3	Remove the zero correction factors
Z4	Learn the zero of the analog set point. Assigns current value of external analog set point to zero value. If the current value of the analog set point is beyond ±15% of full scale, the controller ignores the command and does not change the current zero value.
Y1 *value*	Calibrate span of A/D converter; calibrate position output and zeroed pressure output. The controller will assign *value* to the converter reading of the pressure channel.
Y2	Learn the full scale of the analog set point. Assigns currrent value of external analog set point to the full scale value. If the current value of the analog set point exceeds ±15% of full scale, the controller ignores the command and does not change the current full scale value.
L	Learn the system (Self-Tuning control)
Q	Stop the learn function (while in process)
J *value*	Calibrate the valve, where *value* is: 1 = Std 253 2 = Fast 253 3 = 653

Table 21: RS-232 Commands

(Continued on next page)

RS-232 Commands *(Continued)*	
Command	**Function**
A *value*	Analog set point range, where *value* is: 0 = 5 Volts 1 = 10 Volts
T1 *value*	Set point A type, where *value* is: 0 = position 1 = pressure
T2 *value*	Set point B type, where *value* is: 0 = position 1 = pressure
T3 *value*	Set point C type, where *value* is: 0 = position 1 = pressure
T4 *value*	Set point D type, where *value* is: 0 = position 1 = pressure
T5 *value*	Set point E type where *value* is: 0 = position 1 = pressure
T6 *value*	Set point analog type where *value* is: 0 = position 1 = pressure
B *value*	Valve position output range where *value* is: 0 = 5 Volts 1 = 10 Volts
N *value*	Direct/reverse control where *value* is: 0 = direct 1 = reverse
U *value*	Sensor type where *value* is: 0 = Absolute 1 = Differential
X1 *value*	Set lead of set point A, where *value* = seconds
X2 *value*	Set lead of set point B, where *value* = seconds
X3 *value*	Set lead of set point C, where *value* = seconds

Table 21: RS-232 Commands
(Continued on next page)

RS-232 Commands *(Continued)*	
Command	**Function**
X4 *value*	Set lead of set point D, where *value* = seconds
X5 *value*	Set lead of set point E, where *value* = seconds
M1 *value*	Set gain of set point A, where *value* = % gain
M2 *value*	Set gain of set point B, where *value* = % gain
M3 *value*	Set gain of set point C, where *value* = % gain
M4 *value*	Set gain of set point D, where *value* = % gain
M5 *value*	Set gain of set point E, where *value* = % gain
V0	Select Self-Tuning control
V1	Select PID control

Table 21: RS-232 Commands

Request and Response Reference

A *request* to the 1651 controller causes it to send back information. Refer to *Table 22: RS-232 Requests and Responses*, for a complete list of request messages.

Note

To conserve space, the ENTER key is not included in the request messages listed the following tables. You must press the ENTER key to send the request message to the 1651 controller.

Response message do not contain spaces. Spaces are used in the response messages to improve readability.

RS-232 Requests and Responss		
Request Message	**Information Requested**	**Response Message**
R0	Analog set point value	`S0 value` where `value` is % of F.S.
R1	Set point A value	`S1 value`. where `value` is % of F.S
R2	Set point B value	`S2 value` where `value` is % of F.S
R3	Set point C value	`S3 value`. where `value` is % of F.S
R4	Set point D value	`S4 value` where `value` is % of F.S.
R5	System pressure value	`P value` where `value` is % of F.S.
R6	Valve position value	`V value` where `value` is % of open

Table 22: RS-232 Requests and Responses
(Continued on next page)

Note

Unless specified otherwise, the *value* in a response is a percent value. For example, a response of `S1+30.00` means the set point value is 30% of F.S. For a 10 Torr F. S. unit, the set point would be 3 Torr.

RS-232 Requests and Responses *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R7	Alternate system status (for compatibility)	M*XYZ* For the *value* of *X:* 0 = analog set point 1 = set point A 2 = set point B 3 = set point C 4 = set point D 5 = set point E For the *value* of *Y:* 0 = controlling 2 = valve open 4 = valve close For the *value* of *Z:* 0 = pressure ≤ 10% F.S. 1 = pressure > 10% F.S.
R10	Set point E value	S5 *value* where *value* is % of F.S.
R11	Low threshold process limit #1	P1 *value* where *value* is % of F.S.
R12	High threshold process limit #1	P2 *value* where *value* is % of F.S.
R13	Low threshold process limit #2	P3 *value* where *value* is % of F.S.
R14	High threshold process limit #2	P4 *value* where *value* is % of F.S.
R15	Softstart rate for set point A	I1 *value* where *value* is % of full speed
R16	Softstart rate for set point B	I2 *value* where *value* is % of full speed
R17	Softstart rate for set point C	I3 *value* where *value* is % of full speed

Table 22: RS-232 Requests and Responses
(Continued on next page)

RS-232 Requests and Responses *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R18	Softstart rate for set point D	`I4 value` where *value* is % of full speed
R19	Softstart rate for set point E	`I5 value` where *value* is % of full speed
R20	Softstart rate for analog set point	`I6 value` where *value* is % of full speed
R21	Softstart rate for valve open	`I7 value` where *value* is % of full speed
R22	Softstart rate for valve close	`I8 value` where *value* is % of full speed
R23	Valve type	`J type`, where *type* equals: 1 = Std 253 2 = Fast 253 3 = 653
R24	Analog set point range	`A range`, where *range* equals: 0 = 5 Volts 1 = 10 Volts
R25	Analog set point type(either pressure or position)	`T0 type`, where *type* equals: 0 = position 1 = pressure
R26	Set point A type (either pressure or position)	`T1 type`, where *type* equals: 0 = position 1 = pressure
R27	Set point B type (either pressure or position)	`T2 type`, where *type* equals: 0 = position 1 = pressure
R28	Set point C type (either pressure or position)	`T3 type`, where *type* equals: 0 = position 1 = pressure

Table 22: RS-232 Requests and Responses
(Continued on next page)

RS-232 Requests and Responses *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R29	Set point D type (either pressure or position)	T4 *type*, where *type* equals: 0 = position 1 = pressure
R30	Set point E type (either pressure or position)	T5 *type*, where *type* equals: 0 = position 1 = pressure
R31	Position indicator range output	B *value*, where *value* equals: 0 = 5 Volts 1 = 10 Volts
R32	Direct/reverse control	N *value*, where *value* equals: 0 = direct 1 = reverse
R33	Sensor range	E *value*, where *value* equals: 00 = 0.1 01 = 0.2 02 = 0.5 03 = 1 04 = 2 05 = 5 06 = 10 07 = 50 08 = 100 09 = 500 10 = 1000 11 = 5000 12 = 10000 13 = 1.33 14 = 2.66 15 = 13.33 16 = 133.3 17 = 1333 18 = 6666 19 = 13332
R34	Pressure units	F *value*, where *value* equals: 00 = Torr 01 = mTorr 02 = mbar 03 = µbar 04 = kPa 05 = Pa 06 = cmH_2O 07 = inH_2O

Table 22: RS-232 Requests and Responses
(Continued on next page)

RS-232 Requests and Responses *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R35	Sensor voltage range	G *value*, where *value* equals: 0 = 1 Volt 1 = 5 Volts 2 = 10 Volts
R36	Sensor type	U *value*, where *value* equals: 0 = Absolute 1 = Differential
R37	System status	M*XYZ* For the *value* of *X:* 0 = Local 1 = Remote For the *value* of *Y:* 0 = not learning 1 = learning system 2 = learning valve For the *value* of *Z:* 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
R38	Software version	H *version number*
R39	Status of battery used in optional valve failsafe backup	BT2 = Option is not installed *This request is retained for software compatibility with the Type 651 controller.*

Table 22: RS-232 Requests and Responses
(Continued on next page)

RS-232 Requests and Responses *(Continued)*		
Request Message	**Information Requested**	**Response Message**
R40	Valve response to power fail (when using the optional valve failsafe backup)	`K0` = Option is disabled (or not installed) *This request is retained for software compatibility with the Type 651 controller.*
R41	Lead A value	`X1` *value* where *value* is seconds
R42	Lead B value	`X2` *value* where *value* is seconds
R43	Lead C value	`X3` *value* where *value* is seconds
R44	Lead D value	`X4` *value* where *value* is seconds
R45	Lead E value	`X5` *value* where *value* is seconds
R46	Gain A value	`M1` *value* where *value* is % gain
R47	Gain B value	`M2` *value* where *value* is % gain
R48	Gain C value	`M3` *value* where *value* is % gain
R49	Gain D value	`M4` *value* where *value* is % gain
R50	Gain E value	`M5` *value* where *value* is % gain
R51	Type of control	`V` *value* 0 = Self-Tuning 1 = PID
R52	Checksum error	`CS` *value* 0 = OK 1 = Error condition *If a checksum error condition is reported perform a full calibration, as described on page 65.*

Table 22: RS-232 Requests and Responses

Index