PORTABLE PRESSURE GAGE

MODEL 62XX

USER'S MANUAL

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CE DECLARATION OF CONFORMITY

Equipment: **Portable Digital Pressure Gage**

Model #: **62XX (where XX indicates measure features)**

Date of Issue: **09/30/95**

Manufacturer: **Ruska Instrument Corporation**
10311 Westpark Drive
Houston, Texas 77042

This equipment complies with the following standards:

EN 55011: Limits and Methods of Measurement of Radio Disturbances Characteristics of Industrial, Scientific and Medical (ISM) Radio-Frequency Equipment

IEC 801-2; IEC 1000-4-2; Cenelec 60801-2:
Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment:
Part 2: Electrostatic Discharge Requirements

IEC 801-3; IEC 1000-4-3; Cenelec 50140:
Electromagnetic Compatibility for Electrical and Electronic Equipment:
Part 3: Immunity to Radiated, Radio Frequency, Electromagnetic Fields

IEC 801-4; IEC 1000-4-4:
Electromagnetic Compatibility for Industrial-Process Measurement and Control Equipment
Part 4: Electrical Fast Transient/Burst Requirements

IEC 801-6; IEC 1000-4-6:
Electromagnetic Compatibility for Electrical and Electronic Equipment
Part 6: Immunity to Conducted Disturbances Induced by Radio Frequency Fields

This certifies that the aforementioned equipment conforms with the protection requirements of Council Directive 89/336/EEC on the approximation of the laws of the Member States relating Electromagnetic Compatibility.

Signature of Manufacturer:

Michael D. Collins, Business Development Manager
Apex Business Centre
Boscombe Road
Dunstable, Bedfordshire
England LU5 4SB

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REVISION NOTICE

RELEASE NUMBER	REV.	DATE OF RELEASE	DESCRIPTION
62XX-1D01	A	6/16/92	Original Release DR # 7666
62XX-1D01	B	10/23/92	Text changes DR # 7721
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Delete 6240 information; delete Appendix D.
Update zero and cal procedures
Update 6230 and 6250 specifications - ECO 19310

RELEASE 62XX-1D01 Revision F (12/14/94)

Change 6250 Specification Appendix C - Change Tolerance from .25% to .35% - ECO 19102

WARNING

PRESSURIZED VESSELS AND ASSOCIATED EQUIPMENT ARE POTENTIALLY DANGEROUS. THE APPARATUS DESCRIBED IN THIS MANUAL SHOULD BE OPERATED ONLY BY PERSONNEL TRAINED IN PROCEDURES THAT WILL ASSURE SAFETY TO THEMSELVES, TO OTHERS, AND TO THE EQUIPMENT.

BEFORE PERFORMING ANY MAINTENANCE, TURN OFF POWER AND DISCONNECT POWER CORD FROM POWER SOURCE.

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SECTION 1

GENERAL INFORMATION

1.1 INTRODUCTION

This manual contains operation and preventive maintenance instructions for the Series 62XX Portable Pressure Gage (PPG), manufactured by Ruska Instrument Corporation, Houston, Texas.

NOTE: The two 'X' characters in '62XX' are place holders for specific numbers which determine specific model numbers. The number replacing the first X signifies the type and accuracy of the sensor. The second X is '0' if one sensor is installed and '2' if two sensors are installed. Example: 6222 = 0.01% accuracy, two sensors.

1.2 GENERAL INFORMATION

The Ruska Series 62XX Portable Pressure Gage (PPG) is used to measure absolute or gage pressure (depending on the choice of sensor installed), tare pressure, and rate-of-change of pressure. The measured pressure can be displayed in one of fifteen different pressure units. These include units of altitude, which also allow the PPG to be used with altimeters and rate of climb indicators.

The instrument is designed to operate with one or two sensors and is extremely easy to operate and maintain, and its light weight makes it very portable. Its serial interface and optional IEEE-488 interface allow it to communicate with computers and other suitably equipped instruments. These and the unit's other features are discussed below.

1.3 FEATURES

The following features are standard on the PPG.

Ease of calibration: A three point calibration can be performed either remotely or entirely from the front panel, requiring minimal operator interaction.

Ease of setting zero: Once a suitable pressure has been applied to the input port, zero is set simply by pressing a sequence of buttons on the front panel.

Choice of medium: See Appendix C.

Choice of display units: Standard units include inches of mercury (inHg), kiloPascals (kPa), pounds per square inch (psi), millimeters of water (mmH_2O), inches of water (inH_2O), kilograms per square centimeter (kg/cm^2), millimeters of mercury (mmHg), millibars (mbar), pounds per square foot (psf), feet, and meters. In addition, four user-defined units are also available.

Adjustable pressure display: The pressure display can be adjusted to show the desired number of digits after the decimal point.

Adjustable rate display: Rate-of-change of pressure can be displayed in either change per second or change per minute, allowing measurement of leak rate and rate-of-climb. In addition,

the user can also adjust the interval at which the rate display updates as well as the time it takes for the rate display to respond to a step change in the rate.

Tare mode: After a reference pressure has been established at the test port, tare mode instructs the PPG's software to subtract this reference pressure from all subsequent pressures detected at the test port. In this way, the PPG can simulate gage pressure if it has an absolute transducer.

Serial interface: An RS-232 communication syntax allows the PPG to be used in automated measurement systems for easy data acquisition.

Lightweight: Weighing less than 9 lbs, the PPG can easily be carried between measurement sites.

Sturdy Case: The PPG is housed in a sturdy aluminum case. The carrying handle is reinforced with steel to ensure long life and dependability.

Adjustable LED brightness: The user selects the desired level of brightness for the front panel LED's. This feature allows the user to conserve battery life in applications where only battery power is available.

Choice of pressure range: The PPG is currently available in many full-scale ranges from 1 to 30,000 psi. Consult Ruska's Sales Department for a current list of available ranges.

Self-test: Upon power up, the PPG performs a brief self-test to ensure that all hardware and software are operating properly.

Ease of operation: All local operations are accessed through a menu-style interface. Frequently used selections such as the display units are maintained in memory through power off and on.

1.4 OPTIONS

A standard PPG comes with the pressure transducer of the customer's choice, a plug-in power supply and battery charging cord and a user's manual. Although the PPG is fully functional with just these items, the following options are also available.

> **WARNING:** Do not install or remove IEEE-488, parallel output, analog, or other option while power is applied to the PPG. Do not connect RS-232 or IEEE-488 cables to the PPG while power is applied to either the PPG or the device at the other end of the cable. In either case, improper insertion or a defective connector could cause a power disturbance which could damage the PPG or the connected device, or cause the loss of stored calibration constants.

IEEE-488 Interface: All models of the PPG accommodate an IEEE-488 card. This card simply slides through an opening in the back panel of the PPG and attaches to the main board.

Quad Analog Output plus IEEE-488: Adds four channels of 0-10 VDC analog data (12-bit resolution) to the IEEE module.

Battery Operation: All models of the PPG accommodate a sealed lead-acid battery. This battery is easy to install and provides the user with over 7 hours of operation in most circumstances.

Battery Charger: This battery charger is specially designed to charge the sealed lead-acid battery mentioned above.

CAUTION: Chargers not designed to charge sealed lead-acid batteries may lead to battery failure or reduce battery life.

Cigarette Lighter Adapter: An adapter designed to operate off of an automobile cigarette lighter provides the user with an alternative to the standard plug-in power supply and the optional sealed lead-acid battery.

Calibration report: In addition to the standard certificate of compliance, calibration per MIL-STD-45662, traceable to the National Institute of Standards and Technology (NIST), is available.

Carrying Case: This soft-sided case holds the PPG, the power supply, the manual, two batteries, the charger, small tools, and the Ruska Precision Pressure Adjuster or a small pressure pump. This case is padded to protect its contents and fits easily under an airplane seat.

Rack Mount Kit: This rack mount kit is 5.219" high and can be used to mount the PPG in a standard 19" rack. The ANSI/EIA AS-310-C-77 standard refers to this type of rack mount kit as a 3U.

The options available are summarized in Table 1-1. Ruska periodically introduces new features and options, most of which can be retrofitted into existing units. Contact your Ruska sales representative for further information.

TABLE 1-1
PORTABLE PRESSURE GAGE OPTIONS

ITEM	RUSKA PART NO.
Sealed Lead-Acid Battery	4-701
Battery Charger	4-702
Carrying Case	6220-CASE
IEEE-488 Interface	6220-IEEE
Additional Battery Charging Cord (Fig. 3-3)	6220-PWR-W01
Special Battery Charging Cord, 2 ft. length	6220-PWR-W02-2
Special Battery Charging Cord, 6 ft. length	6220-PWR-W02-6
RS-232 Adapter (Table 5-2)	6220-ADP-001
Quad Analog & IEEE Interface	6220-DAC
Additional Manuals	62XX-1D01
Calibration Option	62X0-CAL
Rack Mount Kit	6220-RMK
Cigarette Lighter Adapter	contact Ruska
Additional Plug-In Power Supplies	6220-PWR

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SECTION 2

THEORY OF OPERATION

2.1 INTRODUCTION

The Ruska Series 62XX Portable Pressure Gage (PPG) uses state of the art sensor and electronics technology to provide a highly accurate and flexible pressure instrument. This portion of the manual reduces the PPG to its individual function blocks and explains the relationship of each subsystem to the system as a whole.

2.2 THE PPG: A FUNCTIONAL DIAGRAM

Figure 2-1 on page 2-2 shows a simplified block diagram of the PPG. Each subsystem will be addressed in the following sections.

2.2.1 THE VOLTAGE SOURCE

The PPG is designed to accept many different sources of 12 VDC power. Typical sources include the plug-in AC-to-DC power converter provided with the unit, the optional 12-volt battery, the optional automobile cigarette lighter adapter, or a wall-mounted AC-to-DC power converter provided by the user. For more information on these products, see either Section 1, "General Information" or Section 3.4, "Getting Started."

2.2.1.1 Reverse Polarity Protection

In general, the PPG will be powered by way of either the plug-in AC-to-DC power converter or the optional 12-volt battery. Due to their package design, these devices can only be used in the proper polarity. However, with other power supplies, there exists the possibility that power may be applied in reverse polarity.

In response to this possibility, the PPG is internally protected against reverse polarity. In the event that power is applied in the reverse polarity, the PPG fails to operate but is not damaged.

2.2.2 THE VOLTAGE REGULATOR

The switching voltage regulator located on the PPG's main printed circuit (PC) board generates the various voltages required for system operation. The input to the voltage regulator is the 12 VDC supplied by the voltage source. A switching regulator is used because of its ability to efficiently generate several different voltages while producing very little heat. This minimizes thermal disturbances to the sensor and maximizes battery life if a battery is being used as the voltage source.

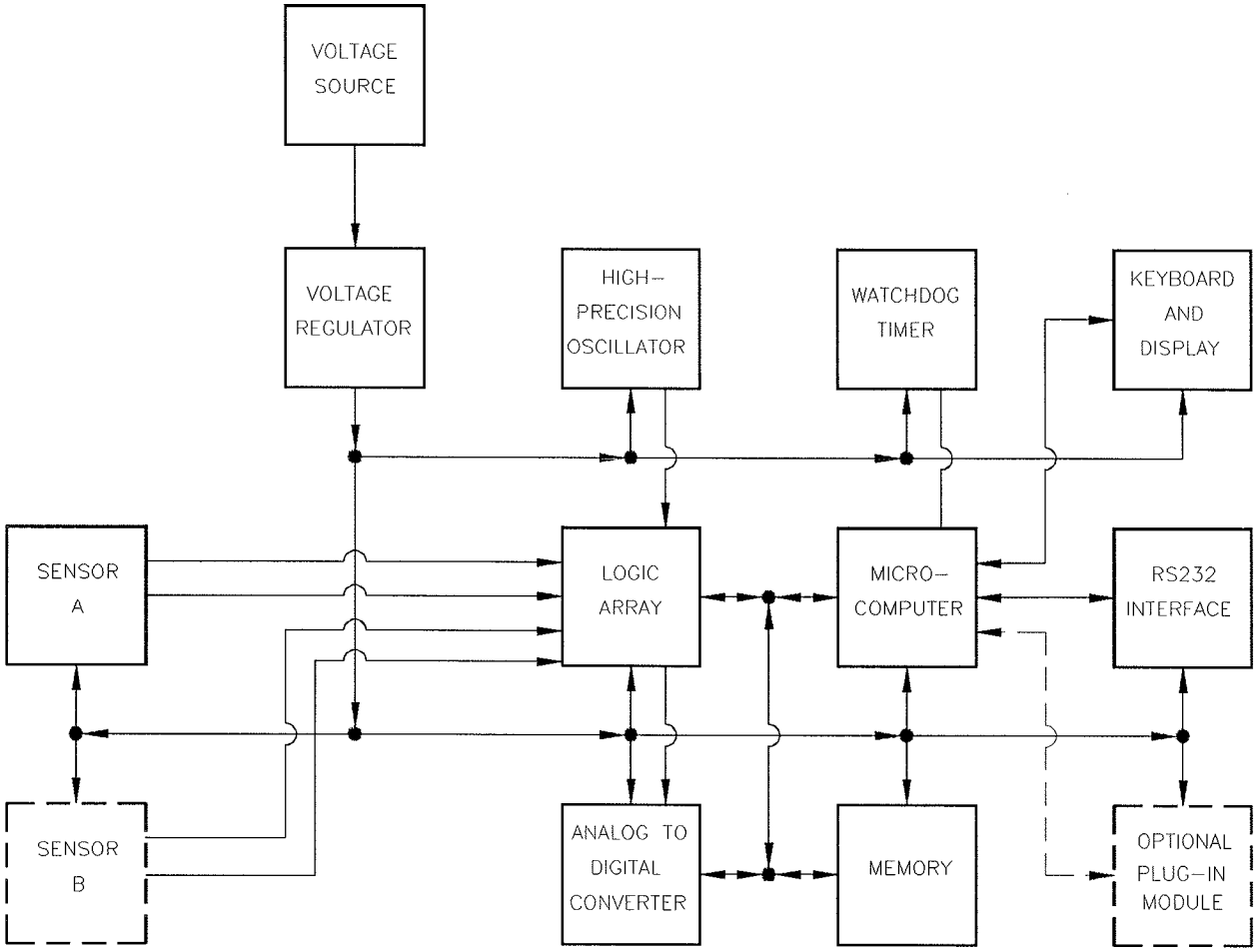

Figure 2-1
Functional Diagram of the PPG

The main output from the switching voltage regulator is the +5 VDC used by the microcomputer, displays, and other logic circuitry. Two secondary outputs of + and - 15 VDC are used by the sensor. A reference voltage of 0.8192 VDC is also produced for the analog-to-digital (A/D) converter on the main board.

2.2.3 THE SENSOR(s)

The sensors have frequency output(s) and/or voltage output for measuring pressure and temperature. The PPG has two 12-bit A/D inputs for voltage measurement and four inputs for frequency measurements and a high-accuracy, temperature-compensated, 20 MHz crystal oscillator as a reference. There are two independent sets of counters to measure the four frequencies, therefore, more than two frequency signals require multiplexing.

The starting edge of the transducer frequency signal starts a 22-bit counter which counts the 20MHz clock, and stops the counter on the first falling edge after a 0.1 second time interval. The counter value will be approximately (20 MHz x 0.1 second) or 2 million which gives an accuracy of 1 count in 2 million. A second counter counts the exact number of cycles of the transducer's output frequency within the same time interval. The frequency is then determined as follows:

frequency = (20 MHz) * (signal counter) / (crystal counter)

Pressure values are calculated every 0.1 second from the frequencies (and voltage) according to the equation and coefficients supplied by the manufacturer of the transducer. Two pressure values are calculated every 0.1 second for dual sensor PPGs with one frequency output per sensor. Dual sensors with two frequency signals per sensor updates one pressure value in 0.1 second then the other. This is due to the multiplexing required for four inputs. See Appendix C for signal outputs of sensors.

The coefficients are empirically determined by the transducer's manufacturer, and their values differ slightly from one transducer to the next. Ruska stores these coefficients in the main microcomputer's memory after the sensor is installed in the instrument. The main microcomputer uses the polynomial equation with the stored coefficients and values of period and temperature to calculate the transducer's pressure.

2.2.3.1 Conversion Factors

Once the pressure has been calculated, the factors shown in Table 2-1 are used to convert the pressure in kPa to the units requested by the user.

2.2.4 THE LOGIC ARRAY

One function of the logic array is to perform all of the conventional address decoding and "glue logic" functions normally required for support of a microcomputer. As discussed above, two presetable counters are also implemented in the logic array. Under control of the microprocessor, these counters are used to determine the frequency of the sensor's square wave output. Using a single-chip logic array greatly reduces the number of parts on the main circuit board, and this in turn increases reliability.

2.2.5 THE ANALOG-TO-DIGITAL CONVERTER

The single-chip analog-to-digital (A/D) converter also includes an 8-input analog multiplexer. One input is used to measure the amplitude of the input voltage source. When this source is a battery, the microcomputer is able to determine when the battery is nearing the end of its discharge cycle.

The entire operation of the A/D converter is controlled by the microcomputer, and the microcomputer is the user of the A/D converter's output information.

TABLE 2-1
CONVERSION FACTORS

InHg	inches of Mercury (0°C)	= kPa x 0.2952998
kPa	kiloPascals	= kPa x 1.0
mbar	millibars	= kPa x 10.00000
psi	pounds per inch^2	= kPa x 0.1450377
psf	pounds per foot^2	= kPa x 20.88543
"H_2O	inches of water (4°C)	= kPa x 4.014742
kgcm	kilograms per cm^2	= kPa x 0.0101972
mmHg	millimeters of Hg (0°C)	= kPa x 7.500605
mH_2O	millimeters of H_2O (4°C)	= kPa x 101.9744
feet	feet of altitude	per MIL-STD-859A
mtrs	meters of altitude	per MIL-STD-859A
usr1		= kPa x User defined
usr2		= kPa x User defined
usr3		= kPa x User defined
usr4		= kPa x User defined

2.2.6 THE MICROCOMPUTER

The microcomputer located on the main PC board controls all of the system's operations. It controls the presetable counters which are used to determine the sensor's output frequency. It also controls the A/D converter. The microcomputer calculates the sensor pressure P given by the polynomial mentioned in Section 2.2.3. The results of this calculation are then sent to the microcomputer on the display board, where they are presented to the user.

The main microcomputer also handles all communications with other systems connected to the PPG, via the RS-232 or optional IEEE-488 interface. Using these communications links, the microcomputer can receive commands, reconfigure the system, and supply information in response to requests received.

The main microcomputer also performs diagnostic tests within the system. It always performs a self-diagnostic routine when power is first applied, and it can be commanded to execute other built-in tests at the user's request.

2.2.7 MEMORY

The main board has EPROM for program storage, RAM for work area, and EEPROM for transducer coefficient and system configuration storage.

Coefficients are stored in the EEPROM at the Ruska factory, when the sensor is first installed in the system. If it should ever become necessary to replace the sensor, the coefficients must also be replaced in order for the sensor calibration to be accurate.

When the user of the PPG changes the system's configuration, relevant information is stored in the EEPROM. Such information includes the active units of measure, the user-defined units of measure and the RS-232 configuration. When power is subsequently removed and later reapplied, the microcomputer reads this system configuration information from the EEPROM and restores the system to its previous configuration.

2.2.8 THE WATCHDOG TIMER

A watchdog timer is utilized to reset the microprocessor if it should suffer certain temporary operational problems. The microcomputer's program instructs it to periodically reset the watchdog timer. Should the processor cease operation of its main program, it would cease resetting the watchdog timer. The watchdog timer would then time out, and reset the processor. In this event, the processor would begin operating its program from the start, beginning with the self-diagnostics tests. Detectable errors would be reported to the user.

2.2.9 THE KEYBOARD AND DISPLAY

The keyboard and display are implemented on the keyboard/display circuit board, and they have their own dedicated microcomputer. The microcomputer communicates with the microcomputer on the main electronics board via a serial channel. The display microcomputer controls each individual segment of each display device.

The display has three types of indicators. Seven-segment LED displays show numeric values; dot-matrix LED displays show units of measure and other alphanumeric information; and large-area LED lamps back-light the indicators located underneath the seven-segment LED's. All LED indicators in the PPG are high-efficiency devices which minimize power consumption. Each segment of each display, as well as each decimal point indicator, is individually controlled by the display's microcomputer. The upper display is updated every 200 milliseconds.

The instrument's LED displays consume most of the power drawn from the power source. To optimize the efficient use of power, each segment of each display is driven by short pulses of current, rather than being driven by a steady current limited by voltage-dropping resistors. This technique reduces the amount of heat generated within the enclosure.

Operation of the PPG is locally controlled through the use of six membrane switches, plus two recessed switches for the zero and calibration operations. The consequences of a switch closure are context-sensitive. In other words, the result of pressing a switch depends on the state of the system when the switch is pressed. For example, by pressing the switches in a particular sequence, the user can change the system's state from normal display to normal display plus rate display, tare display, etc. The two dot-matrix displays indicate the state of the system to the user. In addition to the normal mode of operation (displaying pressure), other states include the selection of units of measure, modifying the system's configuration, monitoring internal operations, and performing self-tests. Moving from one state or mode of operation to another is most easily understood by referring to Table 4-1 or Table 4-2.

All of the operations available at the front panel can also be commanded through the RS-232 or optional IEEE-488 interface. Some operations, such as defining new units of measure, are achievable using the PPG's keyboard and display, but are more easily accomplished via the serial interfaces. For more information on these interfaces, see Section 5, "Remote Operation."

2.2.10 THE RS-232 INTERFACE

A standard feature of Ruska's Series 6230 Portable Pressure Gage is an RS-232 serial data communication link. This can be used for such operations as accepting commands from external systems, configuring the system, or sending data to remote computers. Detailed operational information and a discussion of commands and data formats for the RS-232 link are discussed Section 5.4.

2.2.11 THE PLUG-IN INTERFACES

The IEEE-488 interface is optional on the PPG. It can be installed in the factory or by the user. Like the RS-232 interface, it can be used for such operations as receiving commands, configuring the system, and sending data to external systems. Detailed operational information and a discussion of commands and data formats for IEEE-488 interface are discussed in Section 5.5.

Other optional interfaces (BCD, Analog) can be installed in the PPG, in place of the IEEE-488 interface. Instructions for use are given in Appendix D.

> **WARNING:** Do not install or remove IEEE-488, parallel output, analog, or other option while power is applied to the PPG. Do not connect RS-232 or IEEE-488 cables to the PPG while power is applied to either the PPG or the device at the other end of the cable. In either case, improper insertion or a defective connector could cause a power disturbance which could damage the PPG or the connected device, or cause the loss of stored calibration constants.

SECTION 3

PREPARATION FOR USE

3.1 INTRODUCTION

This portion of the manual covers initial installation. Front and rear diagrams are presented in Sections 3.2 and 3.3. Alternate power sources are discussed in Section 3.4, and battery operation is covered Section 3.5. Section 3.6 explains connecting a test pressure to the PPG, and Section 3.7 tells the user what to expect during the power-up procedure.

3.2 THE FRONT PANEL

All indicators and function keys are provided on the front panel of the instrument, as shown in Figure 3-1.

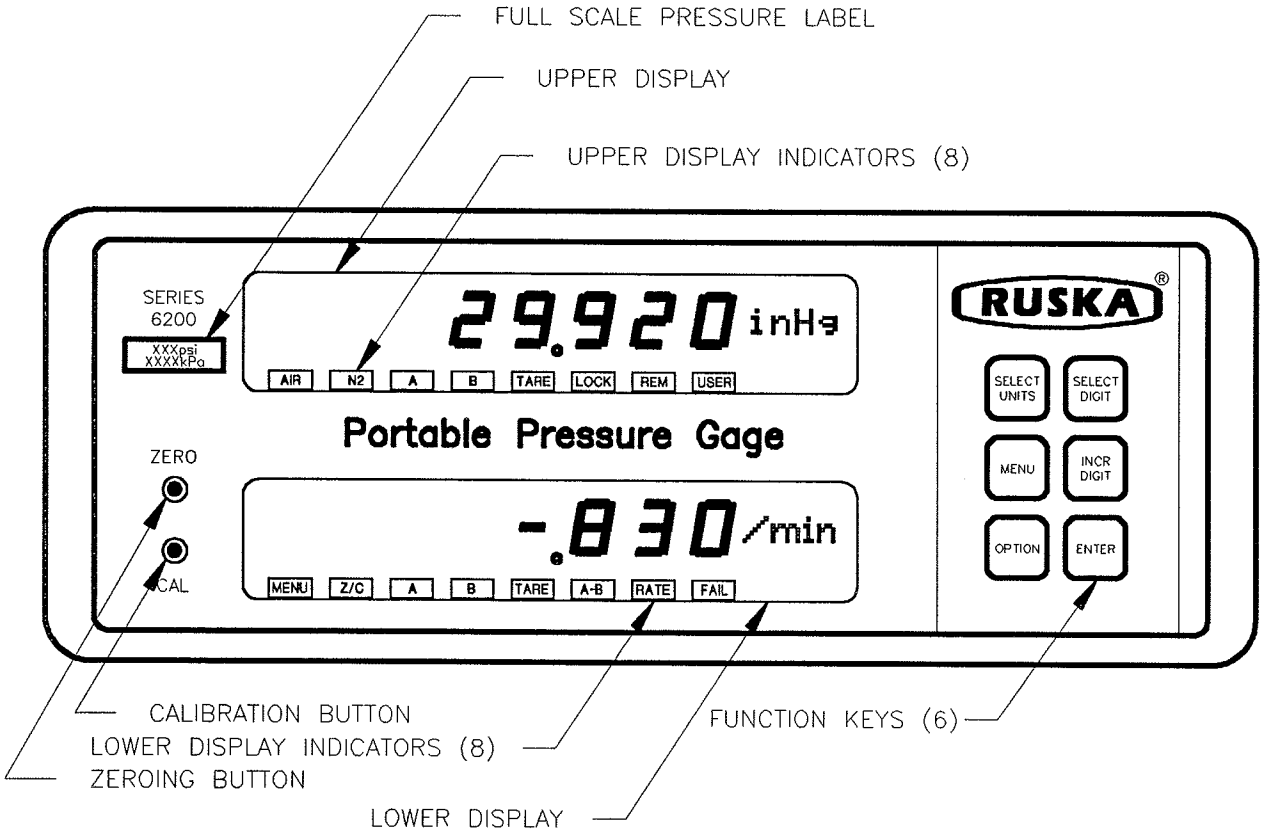

Figure 3-1
The Front Panel

3.3 THE REAR PANEL

All connections and interface options are accessible through the rear panel of the instrument (see Figure 3-2).

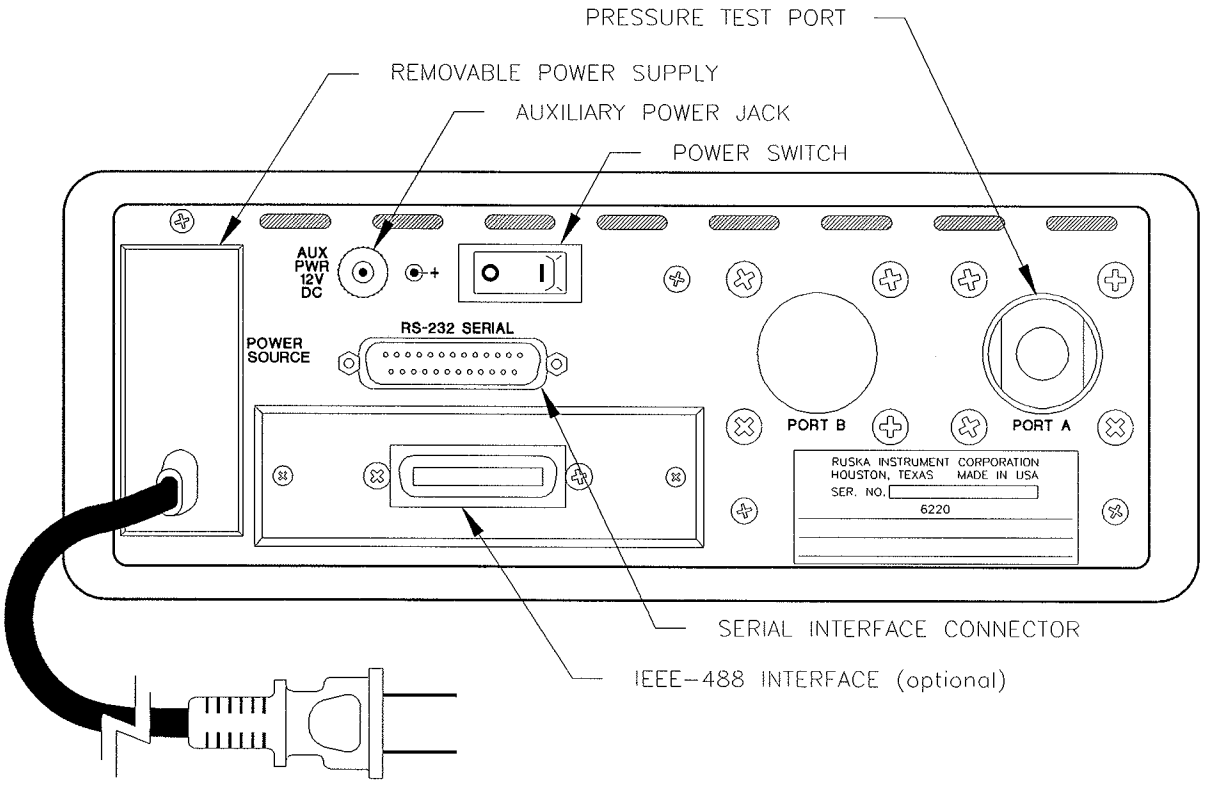

Figure 3-2
The Rear Panel

3.4 GETTING STARTED

Unpack the PPG and retain the packaging if possible. A standard PPG comes with the pressure transducer of the customer's choice, a plug-in power supply and battery charging cord and a user's manual. After the PPG has been unpacked, the following checklist should be completed.

1. Inspect the PPG for any visible signs of damage.
2. Locate the full-scale pressure label on the front panel of the PPG (Figure 3-1). Verify that the unit is rated for the range of pressure desired.
3. Locate the power source enclosure on the rear panel of the PPG (Figure 3-2). Install the power supply as follows. Position the power supply so that its positive lead is closest to the power switch. Slide the power supply into the power source enclosure. The power supply will snap into place. Notice that the power supply will not snap into place if it is upside down. Plug the power supply cord into an outlet rated for 110, 120, 220, or 240 VAC at 50 or 60 Hz.
4. If battery operation is desired, see Section 3.5.

5. If auxiliary power is desired, remove the power supply or battery from the power source enclosure, and use the auxiliary 12VDC power jack on back of the PPG (Figure 3-2). The internal lead of the adapter used must be positive, as is indicated by the figure on the back panel of the PPG. Furthermore, the adapter used must be able to supply at least 0.5 amps of current.

> **Warning:** Do not use the 12VDC auxiliary power jack with the power supply in the power source enclosure. Doing so can damage this device.

6. If power from an automobile cigarette lighter is desired, install the cigarette lighter adapter as you would the power supply (step 4).

3.5 BATTERY OPERATION (OPTIONAL)

All models of the PPG are fully operational when used with the optional sealed lead-acid battery. This battery will not leak and therefore can be used in any position. It is approved for air travel by the Department of Transportation (DOT) and the International Air Transport Association (IATA). This battery is easy to install and typically provides the user with over 7 hours of operation.

3.5.1 INSTALLING THE BATTERY

To install the battery, first locate the power source enclosure on the rear panel of the PPG (Figure 3-2). If necessary, remove the power supply from the power source enclosure. Position the battery so that its positive lead is closest to the power switch. Slide the battery into the power source enclosure. The battery will snap into place. Notice that the battery will not snap into place if it is upside down.

3.5.2 LOW BATTERY INDICATION

When the battery voltage drops below 11.75 VDC, all lower indicators will start blinking. If this occurs, remove the battery from the power source enclosure and charge it as explained in the following section.

3.5.3 CHARGING THE BATTERY

There are 2 ways to charge the battery:

1. When the battery is not in the PPG, use the optional battery charger of the Power Supply and charging connector (as indicated in Figure 3-3).
2. Use the power supply and special charging cable (6220-PWR-W02-2 or 6220-PWR-W02-6) while the battery is installed in the PPG.

These options are discussed below.

3.5.3.1 Battery Charger

For charging the sealed lead-acid battery, when the battery is not in the PPG, Ruska recommends the optional battery charger. This charger accepts 115 VAC at 60 Hz and has two indicators on the front. The upper indicator lights up when the charger is correctly plugged into a 115 VAC outlet. The lower indicator lights up when the battery is charging and turns off when the "fast charge" is complete.

After the "fast charge" is complete, the battery should remain on the charger an additional 3 to 4 hours. Failure to do this can shorten the life of the battery.

> **Warning:** Do not charge the battery upside down. Doing so can damage the battery.

3.5.3.2 Plug-in Power Supply

For charging the battery from voltages other than 115 VAC at 60 Hz, two options are available. A power converter rated for the voltage available can be used. Adapters of this type can usually be found in the travel department of department stores, or if necessary, contact Ruska.

The second option uses the plug-in power supply provided with the unit. This allows the battery to be charged from 110, 120, 220, or 240 VAC at 50 or 60 Hz. However, unless another power source is available, the PPG itself will not have power until the battery has finished charging.

To charge the battery from the plug-in power supply, use the battery charging cord provided with the power supply to connect the power supply to the battery (See Figure 3-3). As mentioned in the warning above, do not turn the battery upside down. In approximately 8 hours, the battery will be ready for use.

Some models of the plug-in power supply have a charging indicator lamp which turns on while the battery is charging and turns off when the "fast charge" is complete, usually after 3 or 4 hours.

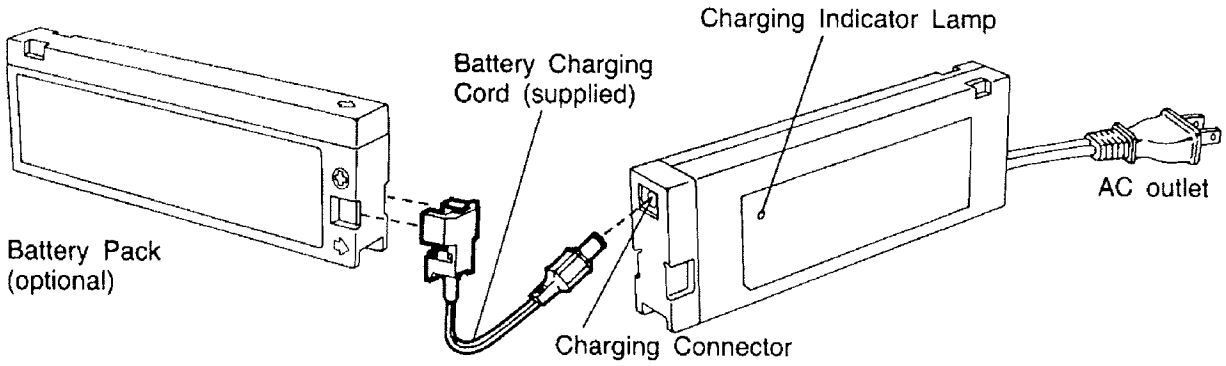

Figure 3-3
Using the Power Supply to Charge the Battery

After the "fast charge" is complete, the battery should remain connected to the power supply for an additional 3 to 4 hours. Failure to do this can shorten the life of the battery.

3.5.3.3 Power Connector

To charge the battery while it is installed in the PPG, the AC power supply supplied with the PPG must be used with the optional power connector (6220-PWR-W02-2 or 6220-PWR-W02-6). The AC power supply is capable of simultaneously operating the PPG and properly charging its battery. Note that this connection can be used to provide an uninterruptible power supply for the PPG. While AC power is available, the PPG will draw power from the AC power supply. If AC power fails, the battery will automatically take over until AC power is restored. Typical battery life is 6 to 8 hours.

3.5.4 STORING THE BATTERY

To prolong the life of the battery, it should be thoroughly charged before it is stored. Once it has been fully charged, it should hold its charge for six to nine months. Temperatures at or below 50° F (10° C) are ideal for battery storage.

3.6 CONNECTING A TEST PRESSURE

A test pressure may be connected to the pressure test port prior to turning the unit on. To connect a test pressure to the PPG, first locate the pressure test port on the rear of the unit (Figure 3-2). Use appropriate fittings to connect the test pressure to the PPG, and tighten to the specifications provided by the manufacturer of the fittings.

> **Warning:** In order to avoid damage to the unit, test pressures applied to the test port must be well within 120% of full-scale.

3.7 POWER-UP

Turn on the PPG by flipping the rocker switch on the rear panel.

Once the PPG passes its self-test, the upper display will show the pressure measured at the test port in one of the display units listed in Section 1.3. If an error code should appear, refer to Section 4.16, "Error Codes."

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SECTION 4

LOCAL OPERATION

4.1 INTRODUCTION

At this point, it is assumed that the unit has been prepared for use as explained in Section 3. This portion of the manual contains local operating instructions and the error codes that may be encountered during power-up and local operation. For instructions concerning the RS-232 and the IEEE-488 interface, see Section 5, "Remote Operation."

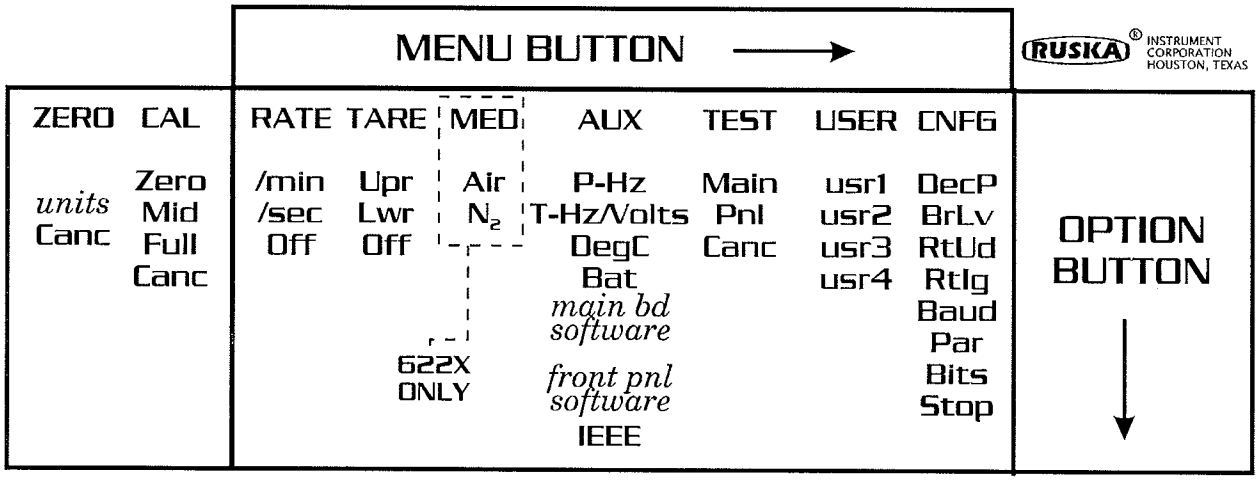
4.2 THE FUNCTION KEYS

The six function keys on the front panel of the PPG are used to perform all local operations.

The **MENU** and **OPTION** keys simulate the menu-style interface common in computer software. The menu reference cards provided in this manual displays the relationship between these two keys. Table 4-1 shows the menu for single sensor operation and Table 4-2 shows the menu for dual sensors.

NOTE: The title and options available on the menu may vary dependent on the specific model.

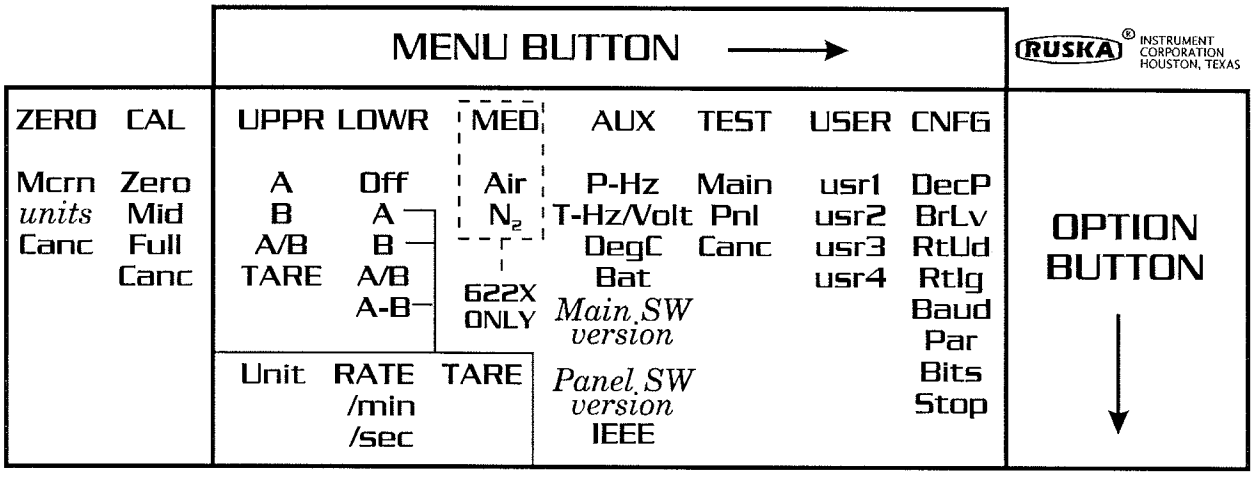
Table 4-1
Menu Titles and Options — Single Sensor Operation



Repeatedly pressing **MENU** moves the user from left to right through the different menu titles (**RATE, TARE,** ...) shown in Tables 4-1 and 4-2. Pressing **OPTION** moves the user down the list of options under a given title.

Table 4-2

Menu Titles and Options — Dual Sensor Operation



The **ZERO** and **CAL** menus can only be invoked by pressing the **ZERO** or **CAL** buttons on the front panel. These menus should only be used during preventive maintenance, as discussed in Section 6.

After all menu titles have been displayed, the PPG exits menu mode and returns the lower display to its previous state.

The **SELECT DIGIT** and **INCR DIGIT** keys primarily assist the user in zeroing the unit, calibration, programming the user-defined units, and configuring the unit for the RS-232 interface.

Finally, the **ENTER** key is most often used to select an option under a given menu title. It is also used along with the **SELECT DIGIT** and **INCR DIGIT** keys to complete the functions associated with those keys.

4.3 SINGLE SENSOR OPERATION ONLY

4.3.1 RATE DISPLAY

To display rate or to turn rate off:

1. Press **MENU** until the word **RATE** appears in the lower display.
2. Press **OPTION** to view selections ("**/min**", "**/sec**", and "**Off**").
3. Press **ENTER** to make selection.
4. To exit without making a selection, press **MENU** then **ENTER**.

4.3.2 SELECTING TARE MODE

Tare mode is used to simulate gage pressures for PPG's with absolute transducers. After a reference pressure has been established at the test port, tare mode instructs the PPG's software to subtract this reference pressure from all subsequent pressures measured at the test port. Tare pressure can be shown in the upper display (**Upr**), the lower display (**Lwr**), or turned off (**Off**) when it is not needed.

1. Press **MENU** until the word **TARE** appears in the lower display. During this time, the **MENU** indicator on the lower display will be lit.
2. Press **OPTION** until **Upr**, **Lwr**, or **Off** appears in the lower display.
3. To select the option shown in the display, press **ENTER**. The **MENU** indicator will turn off, and the upper or lower **TARE** indicator will turn on or off, depending on the selection.
4. To exit without making changes, press **MENU** then **ENTER**. The **MENU** indicator will turn off, and no changes will have been made.

> **WARNING:** In order to avoid damage to the unit, test pressures applied to the test port must be well within 120% of full-scale.

4.4 DUAL SENSORS OPERATION ONLY

4.4.1 UPPER DISPLAY

The upper display may be set to display pressure/altitude of sensor A or sensor B, the ratio of A to B, or the TARE mode of A or B.

1. Press **MENU** until **Upr** appears in the lower display.
2. Press **OPTION** to view selections (**A**, **B**, **A/B**, and **TARE**)
3. Press **ENTER** to make selection.
4. To exit without making a selection, press **MENU** then **ENTER**.

4.4.2 LOWER DISPLAY

The lower display may display one of the following options:

- Pressure A
- A minus B
- TARE of A
- Pressure B
- Rate of A
- TARE of B
- Ratio (A/B)
- Rate of B
- TARE of A-B

1. Press **MENU** until **Lwr** appears in the lower display.
2. Press **OPTION** to view selections (**Off, A, B, A/B**, and **A-B**).
3. Press **ENTER** to make selection.
4. If "**A**", "**B**", or "**A-B**" is selected, the current unit will appear in the display. Press **ENTER** to make the selection or press **OPTION** to view "**RATE**", "**TARE**", and current unit for next selections. Press **ENTER** to make next selection.
5. If RATE is selected, press **OPTION** to view selections under the rate option. Press **ENTER** to select "**/min**" or "**/sec**".
6. To exit without making a selection press **MENU** then **ENTER**.

When the lower display is displaying pressure or altitude of A or B, changing the units of the upper display will not change the units of the lower display.

4.5 ADJUSTING THE DISPLAY BRIGHTNESS

To adjust the brightness level of the front panel LED's, press **MENU** until **CNFG** appears in the lower display, then press **OPTION** until **BrLv** appears. Press **INCR DIGIT** until the front panel LED's reach the desired level of brightness.

To retain your selection in memory through power off and on, press **OPTION**, **MENU**, or **ENTER**.

4.6 SELECTING THE PRESSURE UNITS

The PPG can display pressure in inHg, psi, mbar, kPa, mmHg, inH_2O (iH2O), mmH_2O (mH2O), kg/cm^2 (kgcm), or psf. Units of altitude include feet and meters (mtrs). In addition, the user can define four additional units.

To select the units, press **SELECT UNITS** until the desired units appear in the upper display. The user-defined units will not appear among the selections until they have been programmed (see Section 4.12).

Once selected, these units will be held in memory through power off and on.

4.7 SELECTING DECIMAL POINT

To adjust the number of digits after the decimal point in the pressure reading, press **MENU** until **CNFG** appears in the lower display, then press **OPTION** to select **DecP**. Press **INCR DIGIT** until the pressure reading reaches the desired format.

The first time the **INCR DIGIT** key is pressed, the pressure reading may appear either to ignore the command or to change by more than one digit at a time. This happens because the first keystroke sets the display format of the current units to its default value. However, continuing to press the **INCR DIGIT** key will cause the pressure display to change by one digit at a time.

To retain your selection in memory through power off and on, press **OPTION**, **MENU**, or **ENTER**.

Finally it should be noted that this feature applies to all standard and user-defined units, except for units of altitude.

4.8 ADJUSTING THE RATE UPDATE INTERVAL

The PPG's rate display can be adjusted to update as quickly as 5 times a second or as slowly as every 2 seconds.

To adjust how often the rate display is updated, press **MENU** until **CNFG** appears in the lower display, then press **OPTION** until the lower display reads **RtUd**. Press **INCR DIGIT** until the desired rate update interval appears in the lower display. Selections run from 0.2 seconds to 2 seconds, in steps of 0.2 seconds.

To retain your selection in memory through power off and on, press **OPTION**, **MENU**, or **ENTER**.

4.9 ADJUSTING THE RATE INTEGRATION VALUE

In addition to selecting the interval at which the rate display updates (Section 4.8), the user can also adjust the time it takes for the rate display to respond to a step change in the rate. This feature can be used to "smooth" the rate reading and is called Rate Integration (**RtIg**). By adjusting the rate integration value, the rate display can be made to respond to a step change in rate in as quickly as 1 second or as slowly as 20 seconds. The Rate Integration feature is depicted graphically in Figure 4-1 for **RtIg** values of 3 and 10.

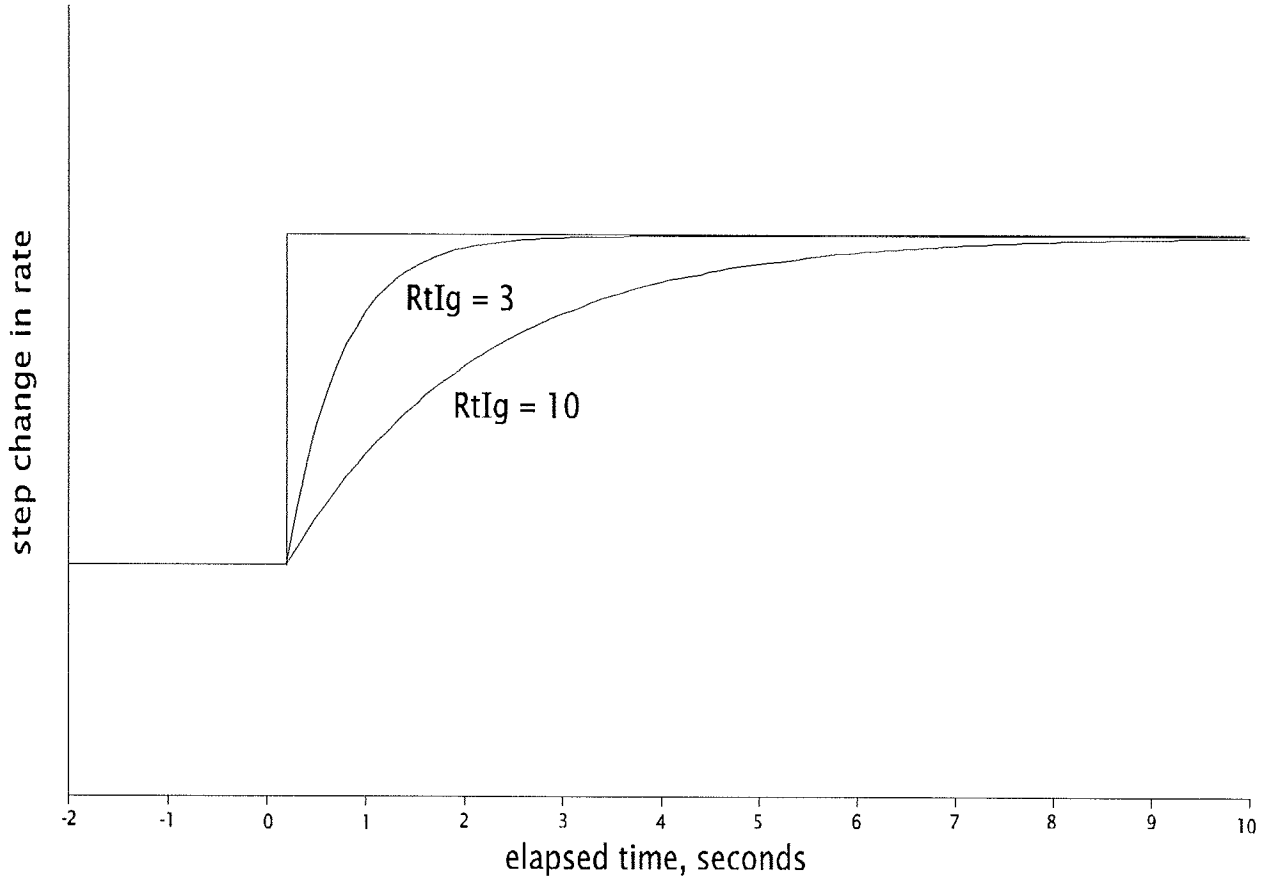


Figure 4-1
Comparison of Rate Integration Values
for RtIg equal to 3 and 10

When **RtIg** is set to 3, the rate display takes about 3 seconds to match the change in rate, whereas when **RtIg** is set to 10, the rate display takes about 10 seconds to match the same step change in rate. Thus, when a step change occurs in the rate, a lower **RtIg** value might cause the rate reading to instantly "jump," whereas with a higher **RtIg** value, the response is smoother.

To adjust the rate integration value, press **MENU** until **CNFG** appears in the lower display, then press **OPTION** until the lower display reads **RtIg**. Press **INCR DIGIT** until the desired rate integration value appears in the lower display. Selections run from 1 second to 20 seconds, in steps of 1 second.

To retain your selection in memory through power off and on, press **OPTION**, **MENU**, or **ENTER**.

NOTE: The Rate Update and Rate Integration features do not affect the pressure display. Response time on the pressure is almost immediate (see Section 4.3), with filtering occurring for very small changes in pressure.

4.10 OBSERVING THE STATUS OF THE PPG

Using the auxiliary (**AUX**) menu, certain operating conditions can be displayed on the PPG's front panel. Although this feature primarily serves to assist Ruska personnel in diagnostics, the curious user may wish to observe the following parameters.

The frequency of the pressure transducer is shown under the **P-Hz** option. See Appendix C for nominal frequency values.

The **T-Hz/Volt** option displays the frequency or voltage which is related to the transducer's temperature.The **DegC** option shows the temperature within ±2 degrees centigrade. Temperature information is not displayed for sensors with no temperature signal.

The **Bat** option displays the voltage feeding the main board and provides a quick means of checking the battery voltage. The voltage indicated by the **Bat** option should be around 12-14 V, regardless of the device used to supply power. For information on low battery voltage, see Section 3.5.2, "Low Battery Indication."

The main board and front panel software revision levels are also observable through the **AUX** menu. Typically the main board software will have a number like 6220-1.XX Rev __, and the front panel software will have a number like 6220-2.XX Rev __.

Finally, the **IEEE** option displays the address set on the DIP switch on the optional IEEE card. If the unit does not detect an IEEE card,"- -" will appear under the **IEEE** option.

To observe the operating conditions mentioned above, follow the steps below.

1. Press **MENU** until the word **AUX** appears in the lower display. During this time, the **MENU** indicator on the lower display will be lit.
2. Press **OPTION** until **P-Hz, T-Hz /Volt, DegC, Bat**, the main board software number , the front panel software number, or **IEEE** appears in the lower display.
3. To exit this procedure, press **MENU** then **ENTER**. The lower display will return to its previous state.

4.11 USER-DEFINED UNITS

In addition to the eleven built-in units of pressure and altitude, four user-defined units (**usr1** through **usr4**) are available. By definition, a user-defined unit is an arbitrary multiple of kiloPascals. If a multiple of another unit is desired, refer to Section 2.2.3.1 for the appropriate conversion factor, and include it in your multiple.

4.11.1 PROGRAMMING THE USER-DEFINED UNITS

Programming a user-defined unit is a simple process of using the function keys as described below.

1. Determine the multiple and the name desired for your application, referring if necessary to Section 2.2.3.1 for conversion factors. For example, a user-defined unit named Atm (Atmospheres) would have a multiple of 0.009869 Atm/kPa. The **SELECT DIGIT** and **INCR DIGIT** keys will be used to set the value and name of this multiple, as listed in the steps below. (Note that the multiple must represent User Units/kPa.)
2. Press **MENU** until **USER** appears in the lower display. During this time, the **MENU** indicator on the lower display will be lit.
3. Press **OPTION** until **usr1, usr2, usr3**, or **usr4** appears in the lower display. If all four user-defined units have already been programmed, press **OPTION** until the units you wish to edit appears in the lower display. Unless the unit has already been defined, a series of zeroes and a single decimal point will appear in the lower display. The first zero will be blinking.
4. To change the blinking digit, press **INCR DIGIT** until the desired number (0 through 9) replaces the digit. The digit will still be blinking. (For now, ignore the decimal point — it will be set later.)
5. To select another digit, press **SELECT DIGIT**. The number selected will stop blinking, and the next digit will start blinking.
6. Repeat steps 4 and 5 until all eight digits have been set. *A value of zero will remove the user-defined unit from the selections available when the* **SELECT UNITS** *key is used.*
7. To position the decimal point, first press **SELECT DIGIT** until the decimal point is blinking. Then press **INCR DIGIT** until the decimal point moves to the desired position. Press **SELECT DIGIT** again. The decimal point will be set in place, and an alphanumeric character will start to blink.
8. To edit an alphanumeric character, first press **SELECT DIGIT** until the desired character is blinking. Then press **INCR DIGIT** until the character desired appears. The range of available characters runs from a blank space to lower case z and includes punctuation characters and numerals.
9. Repeat step 8 until all four characters have been set. Note that **usr1** through **usr4** are valid names which may be used if the user does not wish to edit the alphanumeric characters.
10. To select the multiple and name defined in steps 3 through 9, press **ENTER**. The multiple and name selected will be held in memory through power off and on, and the name selected will appear as an available unit when the **SELECT UNITS** key is used.
11. To exit this option without programming a new unit, press **MENU** then **ENTER**. The **MENU** indicator will turn off, and no changes will have been made.

4.11.2 SPECIAL USER UNIT (KNOTS)

The USER unit "**knts**" is a special user unit. If "**knts**" is entered as one of the user defined units with a non zero value for a dual-sensor PPG, the PPG will take the pressure difference A-B to calculate and display knots based on the calibrated air speed equations which conform to MIL-STD-1524.

4.12 CONFIGURING THE UNIT FOR THE RS-232 INTERFACE

To configure the PPG for the RS-232 interface, the function keys on the front panel are used to select the baud rate (**Baud**), the parity (**Par**), the number of bits per word (**Bits**), and the number of stop bits (**Stop**). Four baud rates are available: 1200, 2400, 9600, and 19.2k. The parity can be set to even (2), odd (1), or none (0). Seven (7) or 8-bit words can be selected using the **Bits** option, and 1 or 2 stop bits are available from the **Stop** option. Once selected, these parameters remain in memory through power off and on.

1. Press **MENU** until **CNFG** appears in the lower display. During this time, the **MENU** indicator on the lower display will be lit.
2. Press **OPTION** until **Baud, Par, Bits,** or **Stop** appears in the lower display. The present configuration will be shown.
3. To change the configuration, press **INCR DIGIT** until the desired selection appears in the lower display.
4. Repeat steps 2 and 3 until all four parameters have been set. Note that when a value is changed, it is not programmed in memory until either **MENU** or **ENTER** is pressed.
5. To exit this procedure, press **MENU** or **ENTER**.

4.13 TESTING THE PPG

The user may request that the PPG perform a diagnostic test on either the front panel or the main printed circuit board. For more information on this topic, see Section 6.

4.14 ZEROING THE UNIT

Once a suitable pressure has been applied to the pressure test port, the function keys are used to define zero within the PPG's software. This topic is covered in Section 6.

4.15 CALIBRATION

A three point calibration can be performed either remotely or entirely from the front panel. This topic is discussed in Section 6.

4.16 ERROR CODES

Under unusual circumstances, the error codes listed in Table 4-3 may be encountered during power-up or local operation. Other error codes may be encountered during remote operation or preventive maintenance and are listed in Section 5 or 6, depending on the application.

Table 4-3
Error Codes (Local)

Code	Meaning and Corrective Action
EE-002	The pressure at the test port is greater that 120%FS. Reduce the total pressure to below 120%FS.
EE-003	An error has been detected in the main board EPROM*. Use the AUX menu (see Section 4.10) to find out the release number of the main board software .
EE-004	Checksum error on sensor A coefficients.
EE-005	An error has been detected in the main board RAM*.
EE-006	Pressure signal from sensor A is out or range or not detected.
EE-007	Temperature signal from sensor A is out of range or not detected.
EE-008	Either the battery voltage is out of range, or an error has been detected in the A/D converter* on the main board. Check the battery voltage using the AUX menu (see Section 4.10). If the battery voltage is below 11.75 V, recharge the battery as described in Section 3.5.3. If the battery voltage is at or near 12 VDC, report an error in the A/D converter.
EE-014	Checksum error on sensor B coefficients.
EE-016	Pressure signal from sensor B was not detected.
EE-017	Temperature signal from sensor B is out of range or not detected.
EE-020	An error has been detected in the display board EPROM*. Use the AUX menu (see Section 4.10) to find out the release number of the display board software.
EE-021	An error has been detected in the display board RAM*.
EE-034	Entry to the Zero or Calibration mode was attempted while the current units were altitude. Press **SELECT UNITS** until units other than feet or meters appear in the upper display, and reenter zero or cal mode.
EE-035	The pressure detected at the test port corresponds to an altitude greater than 200,000 feet (61 km). Reduce the altitude by increasing the pressure at the test port, or press **SELECT UNITS** until units other than feet or meters appear in the upper display.
EE-036	The transducer* is not being detected.
EE-055	Temporary power failure or software failed to reset watchdog.

* This component cannot be serviced in the field. Prepare the PPG for shipment as discussed in Section 8.

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SECTION 5

REMOTE OPERATION

5.1 INTRODUCTION

The PPG may be operated remotely by connecting a computer, or *host*, to either the RS-232 serial interface or the optional IEEE-488 interface on the rear of the PPG (see Figure 3-2). This portion of the manual contains remote operating instructions for the PPG. Section 5.2 lists the remote interface capabilities, and Section 5.3 provides an overview of the message syntax, including errors. Section 5.4 covers the specifics of the RS-232 serial interface, and Section 5.5 covers the specifics of the IEEE-488 interface.

Finally, it should be noted that these two interfaces should never be used simultaneously.

5.2 INTERFACE CAPABILITIES

Remote operation allows the host computer to interact with the PPG to perform the following functions.

- Set and read the display units.
- Read the current pressure measured at the test port in the current units.
- Read the current pressure measured at the test port in the current units with elapsed time.
- Read the current tare pressure in the current units.
- Read the current displayed pressure in the current units.
- Set or read the elapsed time. (See Section 5.3.4)
- Enable or disable the continuous transmission of pressure information.
- Set or read the continuous pressure transmission interval.
- Read the current rate in the current units for the selected rate period.
- Enable or disable the continuous transmission of the rate.
- Set the continuous rate transmission interval.
- Set the rate period.
- Enable or disable tare mode.
- Enable or disable the rate display.
- Set or read the user defined units.
- Read error/status information.
- Read the battery voltage.
- Perform the zero adjust procedure.
- Perform the calibration procedure.
- Change the number of digits displayed after the decimal point.
- Blank the pressure display.

5.3 MESSAGE SYNTAX: AN OVERVIEW

During remote operation, the host computer communicates with the PPG by sending and receiving messages. This section describes the messages that are common to both the RS-232 and the IEEE interface. For messages specific to each interface, see Sections 5.4 and 5.5.

A message is the smallest quantity of data that the PPG can send or receive. A message consists of one or more words which are separated by commas and followed by a termination character that is either a carriage return (0D hex) or a line feed (0A hex).

A message consisting only of a termination character is ignored by the PPG. For example, if the host sends a message to the PPG that is terminated with both a carriage return and a line feed, the PPG will process the carriage return and preceding text as a message. The line feed, however, is interpreted as having no preceding text and is ignored.

The PPG's message syntax is case *in*sensitive. That is, messages sent to the PPG may be in either upper case or lower case.

All messages transmitted from the PPG are in response to messages received from the host and will always be terminated with a line feed (0A hex). Numeric values will be transmitted in the same format and precision as they are displayed on the front panel.

The message syntax for both the RS-232 and the IEEE interface are listed in Sections 5.3.1 through 5.3.5. The column labeled 'Message' contains a list of the possible messages, or commands, that may be sent by the host computer to the PPG. The column labeled 'Response' describes the PPG's response to those messages. The messages are divided into 6 categories which include pressure, rate, units, miscellaneous, calibration, and dual sensor commands. *For dual-sensor PPG's, use the XR command to select sensor A or B (see section 5.3.6).*

If an undefined message is sent to the PPG, its response will depend on the interface. See either Section 5.3 or 5.4 for more information on undefined messages.

5.3.1 PRESSURE MESSAGES

Message	Response
PA	Returns 'PA,x' where x is the current pressure in current units in the same format and precision as displayed on the front panel (including decimal point). This value will not be affected by tare mode.
PB	Returns 'PB,x,y' where x is the current pressure as with the syntax 'PA' and y is the elapsed time in tenths of seconds (see ET, under misc. message, for a description of elapsed time).
PF	Returns 'PF, x, y, Fp, Ft,' where x and y are as defined for PB, Fp is the transducer pressure frequency and Ft is the transducer temperature frequency.
PT	Returns 'PT,x' where x is the current pressure less the tare pressure in current units. If the PPG has not been placed in tare mode since the last time it was powered up (i.e. no tare value), then 'PS,x' will be returned.
PS	Returns 'PS,x' where x is the current pressure independent of tare in current units in the same format and precision as displayed on the front panel or as specified by the last 'DP' command.
PC,x	Turns on (x=1) or off (x=0) continuous transmission of pressure. When on the PPG will return 'PB,x,y' at the interval set by the PI message (see PB and PI syntax). If the interval is shorter than the acquisition interval, then the PPG will return every pressure value at the interval it is acquired.

Message	Response
PC	Returns 'PC,1' if the continuous pressure transmission is enabled or 'PC,0' if disabled.
PI,x	Sets the continuous pressure transmission interval to x tenths of seconds. x can be any number from 1 to 999 giving an interval from 0.1 to 99.9 seconds. The default interval will be 1 second.
PI	Returns 'PI,x' where x is the current value of PI.
DP,x	Sets the number of digits after the decimal point in the pressure reading to x.
CLD,x	Turns the pressure display on (x = 1) or off (x = 0).

5.3.2 RATE MESSAGES

Message	Response
RS	Returns 'RS,x' or 'RM,x' where x is the latest rate value in the current units for the selected rate period (/min or /sec). Will return 'RS,x' if rate period is units/second and will return 'RM,x' if rate period is units/minute. Will not affect display mode. The rate period will be the last selected rate period if not displaying rate.
RC,x	Turns on (x=1) or off (x=0) continuous transmission of rate. When on the PPG will return 'RS,x' or 'RM,x' (see RS above) at the interval set by the RI message. If the interval is shorter than the acquisition interval, then the PPG will return every rate value at the interval the pressure is acquired.
RC	Returns 'RC,1' if the continuous rate transmission is enabled or 'RC,0' if disabled.
RI,x	Sets the continuous rate transmission interval to x tenths of seconds. x can be any number from 1 to 999 giving an interval from 0.1 to 99.9 seconds. The default interval will be 1 second.
RI	Returns 'RI,x' where x is the current value of RI.
RP,x	Sets the rate period as seconds (x=0) or minutes (x=1).
RP	Returns 'RP,x' where x is the current value of RP.
RO,x	Turns rate display on (x=1) or off (x=0). If the lower display is in tare mode, 'RO,1' will turn tare mode off and rate display on, but 'RO,0' will only turn the lower display off if it was in rate mode.
RO	Returns 'RO,x' where x is the current value of RO.

5.3.3 UNITS MESSAGES

Message	Response

UN,x — Sets the current units to x according to the table below. Units cannot be changed in the calibration mode.

x	Units
0	inHg
1	psi
2	mbar
3	kPa
4	mmHg
5	inH_2O
6	mmH_2O
7	kg/cm^2
8	feet
9	meters
10	psf (pounds per square foot)
11	usr1 (user defined unit 1)
12	usr2 (user defined unit 2)
13	usr3 (user defined unit 3)
14	usr4 (user defined unit 4)

UN — Returns 'UN,x' where x is the value of UN.

UD,x,y,z — Sets the user defined units where x is 1 to 4 for the 4 user defined units, y is the conversion constant that is to be multiplied by kPa, and z is the 4 character units code abbreviation for the front panel display. z can be less than 4 characters and will be truncated if more than 4 characters.

UD,x — Returns UD,x,y,z where x, y and z are as defined above.

5.3.4 MISCELLANEOUS MESSAGES

Message	Response
ET,x	Sets the elapsed time to x. The elapsed time is an internal timer that is incremented every one tenth of a second. It is set to 0 when power is first turned on. After 24 hours (ET = 864000) the timer is reset back to 0.
ET	Returns 'ET,x' where x is the elapsed time in tenths of seconds since the elapsed time clock was started.
TM,x	Sets tare mode as follows. x=0 Turns tare display off (lower or upper display). x=1 Puts upper display in tare mode. Turns lower display off if it was in tare mode. Sets tare pressure equal to current pressure. x=2 Puts lower display in tare mode. Puts upper display in normal mode if it was in tare mode. Sets tare pressure equal to current pressure.

NOTE: In the dual sensor version, the tare function can be executed on a sensor (selected through the 'XR' command) even when its output is not being displayed. This will have no effect on the displayed sensor's output. If that sensor is then selected to be displayed, it will return to the normal mode.

TM	Returns 'TM,x' where x is as defined above.
ER	Returns 'ER,x' where x is the error code from the error code buffer. See Section 5.3.7 for list of error codes.
ST	Puts the upper display in test mode and performs a self test. Clears error buffer and inserts test result(s). Returns 'ST,x' where x is the first test result as defined for error codes (Section 5.3.6). User must use ER message to read additional results if any.
XB	Returns 'XB,x' where x is the battery voltage.
V1	Returns 'V1,x' where x is the version of main board software.
V2	Returns 'V2,x' where x is the version of front panel software. Returns 'V2,0.00' if there is no front panel.
ECHO,x	Turns echo mode on (x=1) or off (x=0). Will be off by default.
ECHO	Returns 'ECHO,x' where x is 1 if echo mode is on and 0 if echo mode is off.

5.3.5 CALIBRATION MESSAGES

The commands listed below are used along with the calibration procedure discussed in Section 6.5, "Calibration."

Message	Response

CZ,x,y Sets the zero value for the three point calibration.

1. If the PPG is not in the ZERO mode or the CAL mode, this message is ignored and error code 30 will be placed in the error buffer.
2. Interprets y to be the actual pressure applied to the test port in microns (x=0) or current units (x=1).
3. Checks that y is less than 1.5% FS and if not, aborts and adds error code 32 to error buffer.
4. Checks that the indicated (measured) pressure is less than 1% FS and if not, aborts and adds error code 31 to error buffer.
5. Performs zero adjust. Replaces coefficient CC,0 with a new value. Also saves indicated and actual pressures for 'CF' message.

CZ Returns 'CZ,y' where y was the value entered above (as entered in microns or current units). Returns 'CZ,?' if y not defined (y will not be defined if error code returned).

CM,y Sets the midpoint value for the three point calibration

1. If the PPG is not in the CAL mode, this message is ignored and error code 30 will be placed in the error buffer.
2. Interprets y to be in current units. Checks that y is within 2% of the indicated pressure and if not, aborts and adds error code 32 to error buffer.
3. Checks that the indicated (measured) pressure is within 10% of mid scale and if not, aborts and adds error code 31 to error buffer.
4. Saves indicated and actual pressures for CF message.

CM Returns 'CM,y' where y was the value entered above. Returns 'CM,?' if y not defined (y will not be defined if error code returned).

CF,y Sets the full-scale value for the three point calibration.

1. If the PPG is not in the CAL mode, this message is ignored and error code 30 will be placed in the error buffer.
2. Interprets y to be in current units. Checks that y is within 2% of the indicated pressure and if not, aborts and adds error code 32 to error buffer.
3. Checks that the indicated (measured) pressure is within 10% of full scale and if not, aborts and adds error code 31 to error buffer.

Message	Response
	4. Checks that all calibration points have been entered and if not, aborts and adds error code 33 to error buffer.
	5. Performs calibration. Replaces coefficients CC,0; CC,1; and CC,2 with new values.
CF	Returns 'CF,y' where y was the value entered above. Returns 'CF,?' if y not defined (y will not be defined if error code returned).
CC,x	Returns 'CC,x, y' where x is the calibration coefficient index (0, 1, or 2) and y is the value of that coefficient.

5.3.6 ADDITIONAL COMMANDS FOR DUAL SENSORS

Message	Response
PD	Returns 'PD,x' where x is the pressure difference of sensor A and sensor B.
PDT	Returns 'PDT,x' where x is the pressure difference of sensor A and sensor B less tare of A minus B.
PDZ	Sets the tare value to the current pressure of sensor A minus the current pressure of sensor B
KN	Return 'KN,x' where x is the calculated air speed (knots) which conforms to MIL-STD-1524.
RA	Returns 'RA,x' where x is the ratio of pressure A to pressure B.
XR	Returns 'XR,N', where n=0 indicates sensor A selected and n=1 indicates sensor B is selected.
XR,n	Selects sensor A (n=0) or sensor B (n=1). All sensor related readings apply to the selected sensor.

5.3.7 ERROR/STATUS

The remote interface will maintain a buffer of error/status codes. This buffer will be used only by the remote interface. Operator errors that are displayed on the front panel will not be stored in this buffer. The buffer has a capacity of at least 4 error/status codes. (See 'ER' in Section 5.3.4.) The host computer removes error/status codes from the buffer by reading them. They are read from the buffer in the same order they were inserted (Fifo).

An error/status code is inserted in the buffer as described for each error code in Table 5-1. If the buffer is full and another error/status code is to be inserted, the oldest code will be removed (lost) to make room for the new code.

Table 5-1 Error / Status Codes	
Error Code	**Description**
00	Status buffer empty.
01	Syntax error. Message received via remote interface not recognized.
02	The indicated pressure at the input port is greater than 120% full scale. This status code will be stored anytime the condition occurs. If the condition persists, another 02 status code will not be inserted in the buffer until the condition is removed and reoccurs. If it does reoccur, another 02 status code will not be inserted if the previous 02 has not been read.
03	Main board EPROM check failed on power up test or on self test commanded via remote interface. If self test was requested via front panel, results will displayed on front panel only and will not be stored in the status buffer.
04	Checksum error on sensor A coefficients.
05	Main board RAM check failed on power up test or on self test commanded via remote interface.
06	Pressure signal from sensor A was not detected.
07	Temperature signal from sensor A is out or range or not detected.
08	A/D check failed on power up test or on self test commanded via remote interface.
14	Checksum error on sensor B coefficients.
16	Pressure signal from sensor B was not detected.
17	Temperature signal from sensor B is out or range or not detected.
20	Front panel board EPROM check failed on power up test or on self test commanded via remote interface.
21	Front panel board RAM check failed on power up test or on self test commanded via remote interface.
22	Front panel not responding to messages from the main board.
30	Message valid only in calibration or zero mode. This error code is inserted for those messages that are not allowed if the PPG is not in the calibration or zero set mode. The PPG is put in the calibration or zero set mode with the CAL or ZERO button on the front panel. The CAL or ZERO indicator will be on when in the calibration or zero mode.
31	Measured pressure is not within acceptable limits for the zero or calibration procedure. This error will be stored only if attempt to zero or calibrate instrument was done via remote interface.
32	In the calibration mode, the actual pressure entered is not within acceptable limits. This error code will be stored only if actual pressure entered was done so via the remote interface.
33	Calibration is incomplete; all three calibration points have not been generated. This error code will be stored only if calibration of the last (full) point was attempted via the remote interface before the zero and mid points.

5.4 SERIAL INTERFACE DETAILS

The serial interface does not have a remote state. The front panel remains fully functional during serial communications.

5.4.1 CONFIGURATION

The serial interface is configured through the front panel. See Section 4.12 for instructions. The configuration includes the baud rate, the parity selection, the number of data bits, and the number of stop bits. The possibilities for each parameter are shown below.

Baud	1200, 2400, 9600, 19200
Parity	None, Even, Odd
Bits	7 or 8
Stop bits	1 or 2

5.4.2 INTERFACE CONNECTOR

The pin-out for the RS-232-C connector located on the rear panel is shown in Figure 5-1.

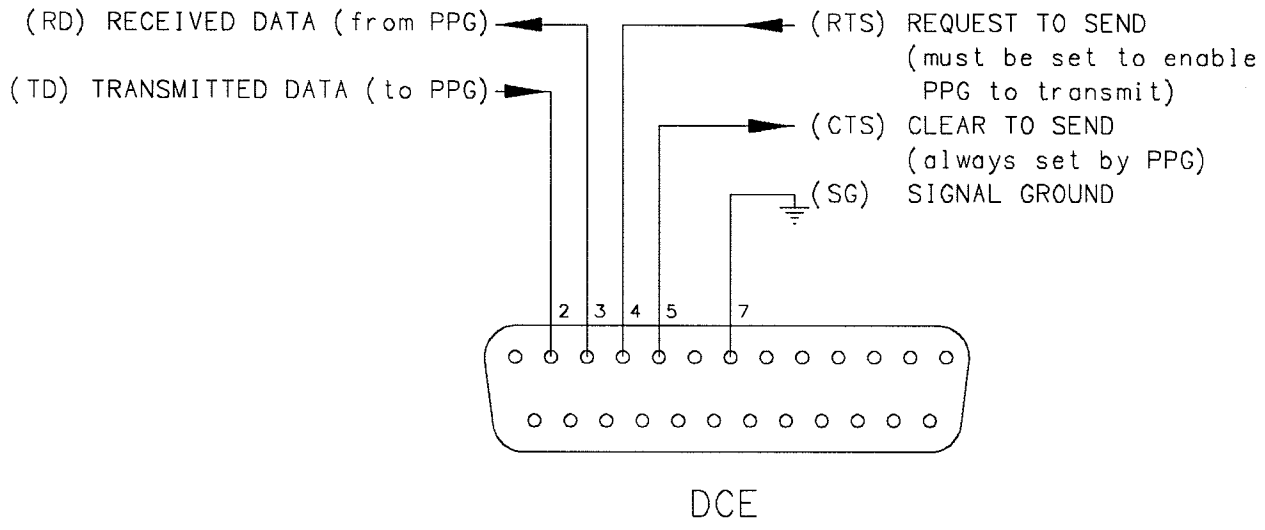
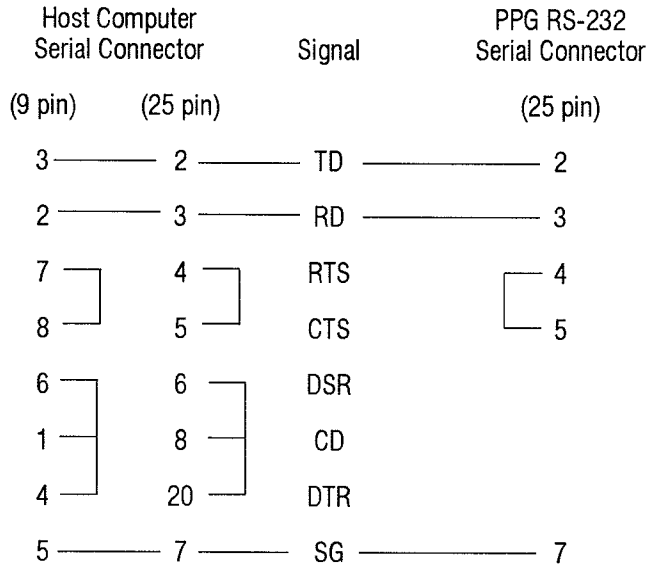


Figure 5-1
Interface Connector Pin Locations

5.4.3 SERIAL COMMUNICATIONS CONNECTIONS

When using any software that communicates with the serial communications port through the PC BIOS, connect the communication cable according to the table below. (An adaptor is available from Ruska: Part number 6220-ADP-001.)

Table 5-2
Communication Cable Connections



5.4.4 ERROR/STATUS

The serial interface will not respond to values being placed into the error/status buffer regardless of the cause, including syntax errors on received messages. The host computer must read the values from the status buffer with the 'ER' message.

5.5 IEEE INTERFACE DETAILS

This interface standard is described by the publication ANSI/IEEE Std 488-1987.1, IEEE Standard Digital Interface for Programmable Instrumentation, (hereafter referred to as IEEE-488 standard). This publication may be purchased from:

Institute of Electrical and Electronics Engineers, Inc

345 East 47th Street

New York, NY 10017

USA

It is assumed that the reader has some familiarity with the IEEE-488 interface. This section will describe the interface capabilities, remote/local operation, configuration and device dependent messages.

5.5.1 CAPABILITIES

The following identification codes define the interface capabilities of the PPG. Their meaning is described in the IEEE-488 standard.

Code	Description
SH1	Source Handshake, Complete Capability
AH1	Acceptor Handshake, Complete Capability
T2	Basic Talker, Serial Poll
L2	Basic Listener
SR1	Service Request, Complete Capability
RL1	Remote-Local, Complete Capability
PP0	Parallel Poll, No Capability
DC1	Device Clear, Complete Capability
DT0	Device Trigger, No Capability
C0	Controller, No Capability

5.5.2 REMOTE/LOCAL OPERATION

In local mode, the PPG is operated manually through the front panel. Section 4, "Local Operation," covers local operation. The PPG always powers up in local mode.

In remote mode, the PPG is operated by a computer connected to the IEEE-488 interface. Most functions that can be performed in local mode can also be performed remotely. The remote mode is entered automatically when the host computer addresses the PPG to Listen with REN (Remote Enable) true. When in the remote mode, the front panel continues to display pressure/rate as in local mode; however, the buttons become inoperative and the PPG will not respond to local commands with the exception of the CAL and ZERO buttons. Also, the Remote indicator will be on. If the interface is in the RWLS (remote with lock out state), then the Lock indicator will also be on. When the remote mode is first entered, all variables maintain their present values.

The PPG can be returned to the local mode by one of the following methods.

1. Remote computer issues the Go To Local (GTL) interface message. This will put the PPG in local mode without changing any variables. This is the preferred method since there is no remote/local switch on the PPG.
2. Remote computer makes REN (remote enable interface message) false. This will have the same effect as the Go To Local interface message above.
3. Remote computer issues the Device Clear (DCL) interface message. This will put the PPG in local mode but will also reset the PPG to its power on default state.
4. By manually powering the PPG off and on. The PPG will power up in the local mode but will also be reset to its power on default state.

5.5.3 CONFIGURATION

The only configuration required for the IEEE-488 interface is the setting of the PPG device address. The PPG uses a single address for both receiving (LISTEN) and sending (TALK) messages. The address may be set to any value between 0 and 30 inclusive. The address may be

observed on the front panel by using the AUX menu (see Section 4.11); however, the address must be physically set on the DIP switch on the IEEE-488 plug-in board.

To set the IEEE-488 address:

1. Turn the PPG off.
2. Remove the IEEE-488 plug-in board. This is the board that has the IEEE connector.
3. Locate SW1 and set positions 4 thru 8 to the desired address. Figure 5-2 shows the switch positions, weighting and polarity.

   SW1 positions 1 thru 3 are presently not used but should be set false (0) in the event that future software revisions assign meaning to them.

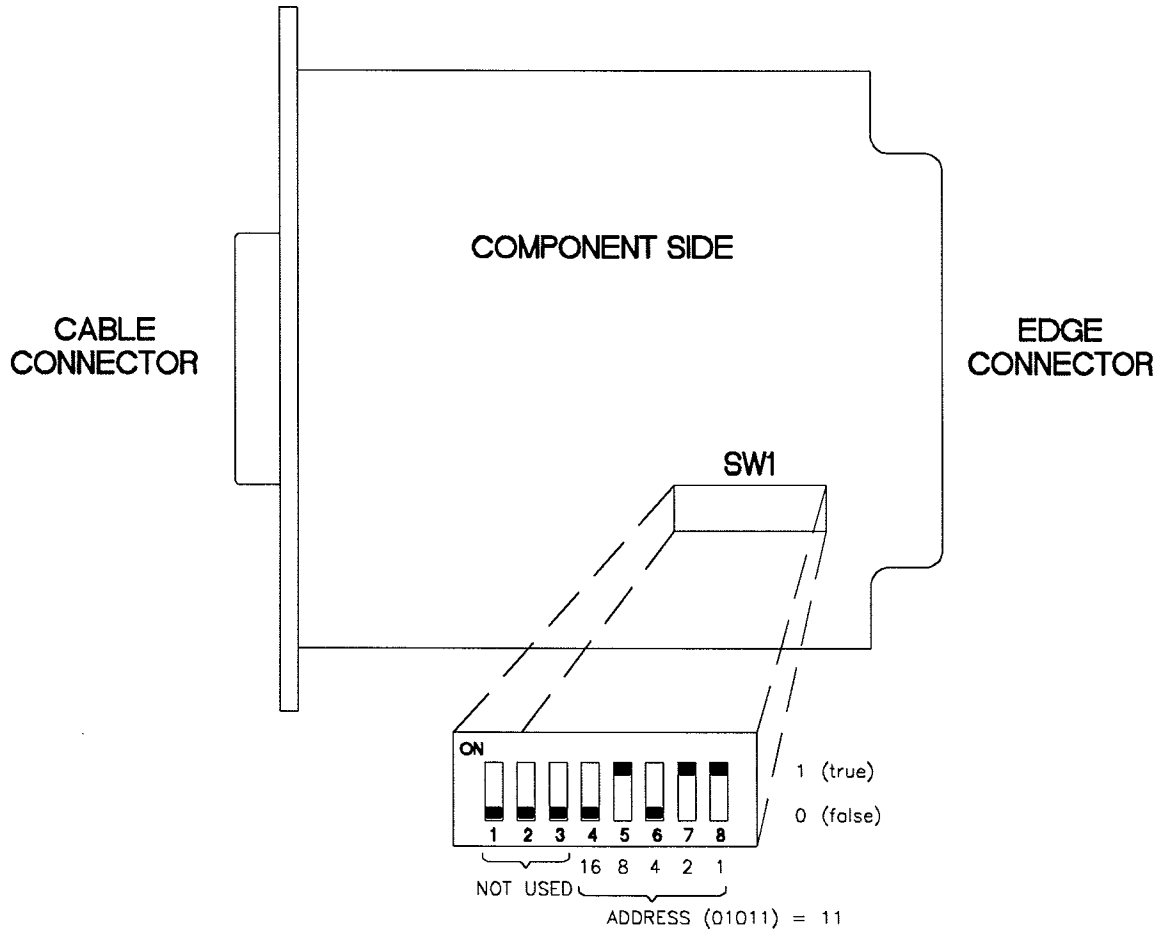


Figure 5-2
IEEE-488 Plug-In Board

5.5.4 DEVICE DEPENDENT MESSAGES

Device dependent messages include all transfers of data between the host computer and the PPG. Device dependent message syntax for the IEEE-488 interface is the same as for the serial interface and is covered in Section 5.3.

5.5.4.1 Sending Messages to the PPG

Messages are sent to the PPG by addressing it to Listen and sending it one of the messages described in Section 5.3. For example, to set the units to inHg, address the PPG to listen and send the message 'UN,0' followed by a carriage return or line feed.

5.5.4.2 Reading Values From the PPG

The PPG sends, or outputs, messages when it is addressed to talk. The host computer should first specify the output by addressing the PPG to Listen and sending it the message desired and then addressing the PPG to Talk. For example, to read the current units, address the PPG to Listen, and send 'UN' followed by a line feed. Then address the PPG to Talk and the PPG will respond with the message 'UN,x'.

If the output message is not specified, the PPG will by default send the pressure value (PB,x,y).

5.5.4.3 Continuous Transmission of Pressure/Rate

Turning on continuous transmission of pressure and rate is valid under the IEEE-488 interface. The PPG will respond by sending a Service Request each time the pressure/rate is ready. The remote computer can then read the pressure/rate as described in Section 5.5.4.2.

5.5.5 ERROR/STATUS

When a status or error code is placed in the status buffer (see Section 5.3.6), a service request will be generated on the IEEE-488 interface.

5.5.6 SERIAL POLL/SERVICE REQUEST

The status byte returned by the PPG during a serial poll has the following meaning. The PPG will buffer a maximum of 4 service requests. They are returned in the order of occurrence. If 4 service requests are stored and another occurs, it will be lost.

Status			Condition
ASCII	DEC	HEX	
0	48	30	No special conditions, did not request service.
A	65	41	Error/status condition occurred. The condition can be read using the 'ER' message.
B	66	42	Next pressure value available in continuous pressure transmission mode. Pressure value can be read using the 'PB' message.
C	67	43	Next rate value available in continuous rate transmission mode. Rate value can be read using the 'RS' command.

SECTION 6

PREVENTIVE MAINTENANCE

6.1 INTRODUCTION

The PPG contains no user-serviceable parts and is virtually maintenance free. In fact, rezeroing the unit is the only routine process needed to keep the PPG operating within specifications. The rezeroing procedure, along with recommended intervals, is discussed in Section 6.4. This is followed by a discussion of the calibration procedure, in Section 6.5.

If instrument failure is suspected, the user is advised to test the main board and front panel as described in Sections 6.2 and 6.3.

If there is any other failure in the instrument, do not attempt to correct it. Instead, contact Ruska to report the problem.

NOTE: When contacting Ruska, be prepared to furnish the model number, serial number, pressure rating, and both software versions (see Section 4.10, "Observing the Status of the PPG").

6.2 TESTING THE MAIN BOARD

At the user's request, the PPG tests the EPROM, EEPROM, RAM, sensor frequencies and battery voltage associated with the main board. This procedure is part of the same test that occurs during the power-on procedure (Section 3.7) with the exception that this procedure returns an "error" message even if all systems pass.

1. Press **MENU** until the word **TEST** appears in the lower display. During this time, the **MENU** indicator on the lower display will be lit.
2. Press **OPTION** until **Main** appears in the lower display.
3. To test the main board, press **ENTER**. The **TEST** indicator will light up, and the word **WAIT** will appear in the upper display while the unit tests the main board.
4. When the test is complete, an error message will appear in the display.
5. An error message of EE-000 indicates that the main PC board has passed its test. Press **MENU** then **ENTER** to return the PPG to its previous state.
6. If an error message other than EE-000 appears, consult Section 6.2.1, "Main Board Error Messages."
7. To exit this procedure without running a test, press **MENU** then **ENTER**. The **MENU** indicator will turn off, and the lower display will return to its previous state.

6.2.1 MAIN BOARD ERROR MESSAGES

The error messages that may be encountered during the main board test are listed in Table 6-1. With the exception of EE-008, which may indicate low battery voltage, the user should not attempt to troubleshoot or repair the unit.

Table 6-1 Main Board Error Messages	
Code	**Meaning and Corrective Action**
EE-003	An error has been detected in the main board EPROM*. Use the AUX menu (see Section 4.10) to find out the release number of the main board software .
EE-004	Checksum error on sensor A coefficients.
EE-005	An error has been detected in the main board RAM*.
EE-006	Pressure signal from sensor A was not detected.
EE-007	Temperature signal from sensor A is out of range of not detected.
EE-008	Either the battery voltage is out of range, or an error has been detected in the A/D converter* on the main board. Check the battery voltage using the AUX menu (see Section 4.10). If the battery voltage is below 11.75 V, recharge the battery as described in Section 3.5.3. If the battery voltage is at or near 12 VDC, report an error in the A/D converter.
EE-014	Checksum error on sensor B coefficients.
EE-016	Pressure signal from sensor B was not detected.
EE-017	Temperature signal from sensor B is out of range or not detected.

* This component cannot be serviced in the field. Prepare the PPG for shipment as discussed in Section 8.

6.3 TESTING THE FRONT PANEL

At the user's request, the PPG tests all display chips and the EPROM and RAM associated with the front panel. This procedure is part of the same test that occurs during the power-on procedure (Section 3.7) with the exception that this procedure returns an "error" message even when all systems pass.

1. Press **MENU** until the word **TEST** appears in the lower display. During this time, the **MENU** indicator on the lower display will be lit.
2. Press **OPTION** until **Pnl** appears in the lower display.
3. To test the front panel, press **ENTER**. The **TEST** indicator will light up, and the word **WAIT** will appear in the upper display while the unit tests the front panel.
4. When the test is complete, an error message will appear in the display.
5. An error message of EE-000 indicates that the front panel has passed its test. Press **MENU** then **ENTER** to return the PPG to its previous state.
6. If an error message other than EE-000 appears, consult Section 6.3.1, "Front Panel Error Messages."
7. To exit this procedure without running a test, press **MENU** then **ENTER**. The **MENU** indicator will turn off, and the lower display will return to its previous state.

6.3.1 FRONT PANEL ERROR MESSAGES

The error messages that may be encountered during the front panel test are listed in Table 6-2.

Table 6-2
Front Panel Error Messages

Code	Meaning and Corrective Action
EE-020	An error has been detected in the display board EPROM*. Use the AUX menu (see Section 4.10) to find out the release number of the display board software.
EE-021	An error has been detected in the display board RAM*.

* This component cannot be serviced in the field. Do not attempt to troubleshoot or repair the component. Instead, prepare the PPG for shipment as discussed in Section 8.

6.4 ZEROING THE UNIT

6.4.1 RECOMMENDED INTERVALS

If the instrument is calibrated once a year, overall drift will remain below 0.01%FS between calibrations (since setting zero is part of the calibration operation). Setting zero once a month can minimize overall drift effects.

6.4.2 THE ZERO PROCEDURE

STEP 1. If dual sensor operation, use menu to select sensor A or B for upper display.

STEP 2. Choose the units of pressure desired during the zero procedure. Non-linear units of altitude cannot be used.

STEP 3. Enter the zero mode by pressing the recessed ZERO button on the front panel. The upper display will continue to show the measured pressure. The lower display will be blank with the word ZERO in the alpha display and the Menu and Zero indicators on. To exit zero mode, press **OPTION** until **Canc** (cancel) appears in lower display, and then press **ENTER**.

STEP 4. Press **OPTION** until the desired units are displayed.

STEP 5. Apply a known and stable pressure which is less than 1.5% FS to the PPG. A primary standard, transfer standard, or a quality vacuum gage can be used to measure the pressure. The accuracy of the pressure gage must be appropriate for the task.

If the measured pressure shown in the upper display disagrees with the applied pressure by more than 1% of full scale, then check for problems and repeat this portion of the procedure. If there is no improvement, abort the procedure and contact Ruska Instrument Corporation. Possible problems include leaks, invalid calibration coefficients, incorrect units of measure, incorrect applied pressure, or a faulty sensor.

For gage pressure transducers, a convenient "zero" pressure is atmospheric pressure.

CAUTION: For oil-filled sensors, vacuum pressures must *not* be applied to the pressure port.

STEP 6. Enter the applied pressure on the lower display as follows.

1. To enter the applied pressure, press **INCR DIGIT** until the desired number (0 through 9) replaces the blinking digit. The digit will still be blinking.
2. To select the blinking number, press **SELECT DIGIT**. The number selected will stop blinking, and the next digit will start blinking.
3. Repeat the previous steps until the applied pressure appears in the lower display.
4. To position the decimal point, first press **SELECT DIGIT** until the decimal point is blinking. Then press **INCR DIGIT** until the decimal point moves to the desired position. Press **SELECT DIGIT** again. The decimal point will be set in place.
5. To select the applied pressure defined in steps 1 through 4, press **ENTER**. The PPG will then calculate a new CC,0 coefficient that will take effect immediately.
6. To exit this option without defining the applied pressure, press **OPTION** until **Canc** (cancel) appears in lower display, and then press **ENTER**.

This completes the zero procedure.

6.5 CALIBRATION

A three point calibration can be performed either remotely or entirely from the front panel. Remote calibration, which is covered in Section 5, is recommended for its ease of use.

Calibrating the PPG is done by applying three known pressures to the PPG near zero, mid scale, and full scale. The PPG then takes these known pressures along with the measured pressures at these points and adjusts the coefficients CC,0; CC,1; and CC,2. The applied pressure should be generated with a suitable primary or transfer pressure standard. If an error should occur during the calibration procedure, consult Section 6.5.3, "Error Codes."

6.5.1 CALIBRATION INTERVAL

Calibration is recommended at least once a year to verify the instrument's specified long-term stability.

6.5.2 THE CALIBRATION PROCEDURE

STEP 1. Set up

1.1 If dual sensor operation, use menu to select sensor A or B for upper display.

1.2 Choose the units of pressure desired during the calibration. If this procedure is being performed remotely, use the UN,x command given in Section 5.3.3. Non-linear units of altitude cannot be used for calibration.

1.3 Enter the calibration mode by pressing the recessed CAL button on the front panel. (This cannot be done remotely.) The upper display will continue to show the measured pressure. The lower display will be blank with the word **CAL** in the alpha display and the Menu and Cal indicators on. To exit calibration mode, press **OPTION** until **Canc** (cancel) appears in lower display, and then press **ENTER**.

STEP 2. Zero point

2.1 If this procedure is being performed remotely, skip to step 2.3. Otherwise press **OPTION** until the word **Zero** is displayed. Then press **ENTER** to select the zero point. The Zero indicator will turn on.

2.2 Press **OPTION** then apply a known pressure as explained in Section 6.4.2, **STEP 5** of the Zero Procedure.

2.3 If this procedure is being performed remotely, use the CZ,x,y command given in Section 5.3.5. Otherwise enter the applied pressure on the lower display as described in Section 6.4.2, **STEP 6.**

STEP 3. Mid point

3.1 If this procedure is being performed remotely, skip to step 3.2. Otherwise, if necessary, press **OPTION** until **Mid** appears in the lower display. Press **ENTER** to select the mid-scale point.

3.2 Apply a known and stable absolute pressure to the PPG that is within 2% of mid scale pressure (between 48% and 52% of full scale). It is important that there is minimal pressure overshoot when applying pressure to the PPG. This is necessary to minimize potential hysteresis effects. The measured pressure should be between 40% and 60% of full scale. If it is not, then abort the procedure and contact Ruska Instrument Corporation. Enter the applied pressure value.

3.3 If this procedure is being performed remotely, use the CM,y command given in Section 5.3.5. Otherwise, enter the applied pressure on the lower display as described in Section 6.4.2, **STEP 6.**

STEP 4. Full point

4.1 If this procedure is being performed remotely, skip to step 4.2. Otherwise, if necessary, press **OPTION** until **Full** appears in the lower display. Press **ENTER** to select the full-scale point.

4.2 Apply a known and stable absolute pressure to the PPG that is within 2% of full scale pressure (between 98% and 102% of full scale). It is important that there is minimal pressure overshoot when applying pressure to the PPG. This is necessary to minimize potential hysteresis effects. The measured pressure should be greater than 90% of full scale. If it is not, then abort the procedure and contact Ruska Instrument Corporation. Enter the applied pressure value.

4.3 If this procedure is being performed remotely, use the CF,y command given in Section 5.3.5. Otherwise enter the applied pressure on the lower display as described in Section 6.4.2, **STEP 6.**

STEP 5. Exiting CAL mode from the remote calibration procedure

5.1 Press **OPTION** until **Canc** appears in the lower display, then press **ENTER**. The lower display will return to its previous state.

This completes the calibration procedure. Upon completion of step 4.3, the PPG calculated new values for the calibration coefficients CC,0; CC,1; and CC,2. The user may wish to record these values for future reference. To do this, use the CC,x command given in Section 5.3.5. The coefficients CC,0 and CC,2 should be at or near 0, and CC,1 should be at or near 1.

6.5.3 ERROR CODES

The error codes listed in Table 6-3 may be encountered during the calibration procedure.

Table 6-3
Calibration Error Messages

Code	Meaning
EE-030	(Serial Interface only) Transmitted message valid only in CAL or ZERO mode. To transmit one of the commands listed in Section 5.3.5, first enter CAL mode as described in Section 6.5.2, step 1.4.
EE-031	The indicated (measured) pressure is not within acceptable limits. Acceptable limits are discussed in Section 5.3.5, 6.4.2, and 6.5.2.
EE-032	The entered pressure (read from the primary or transfer standard) is not within acceptable limits. Acceptable limits are discussed in Sections 5.3.5, 6.4.2, and 6.5.2.
EE-033	Calibration not complete. Zero and/or mid-scale pressure points not entered.
EE-034	Entry to the Zero or Calibration mode was attempted while the current units were altitude. Press **SELECT UNITS** until units other than feet or meters appear in the upper display, and reenter zero or cal mode.

SECTION 7

SPECIFICATIONS

7.1 INTRODUCTION

This portion of the manual discusses the parameters which can affect the unit's precision of measurement. Sections 7.2 through 7.7 discuss parameters such as warm-up time and tilt sensitivity.

7.2 WARM-UP TIME

After the instrument has been removed from storage, it is important to maintain the instrument within the operating temperature range for at least one hour.

After the instrument has been turned on, it will take less than 30 minutes for it to indicate pressure to rated accuracy. Typically, at room temperature, the instrument will exhibit the specified accuracy within 15 to 20 minutes.

7.3 TILT SENSITIVITY

If the instrument is calibrated in the same position that it is used, then there will be no additional errors introduced due to positioning.

7.4 CALIBRATION PERIOD

It is recommended that the instrument be calibrated against a suitable pressure standard at least once per year.

7.5 TEMPERATURE EFFECTS

The instrument will measure pressure to within rated accuracy if operated between 0 and 50°C. There is absolutely no temperature compensation that the user needs to calculate.

The instrument may not indicate pressure to rated accuracy if the ambient temperature is changing by more than 20 Celsius degrees per hour or more than 1 Celsius degree per 3 minutes.

When the instrument is subjected to a temperature shock of more than 5 Celsius degrees, a "soak time" of 15 minutes for every 5°C temperature shock must be allowed. Thus, for a temperature shock of 20 Celsius degrees, a soak time of 1 hour must be allowed.

7.6 LONG-TERM STORAGE

The PPG should be stored in a cool, dry place, with the battery or power supply removed. Refer to Section 8 for instructions.

7.7 SENSOR SPECIFICATION

See Appendix C for sensor specifications.

SECTION 8

PREPARATION FOR STORAGE/SHIPMENT

8.1 DISCONNECT INSTRUCTIONS

NOTE: It is essential that the procedures mentioned in Sections 8.1 through 8.3 be strictly adhered to in order to prevent damage to the instrument. Failure to follow these procedures may result in damage during shipment that will not be covered by the carrier's insurance.

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1. Relieve all pressure from the PPG.
2. Turn the power switch off.
3. Disconnect the power cable from the power receptacle.
4. Remove the battery or power supply from the power source enclosure.
5. Plug or cap ports.

8.2 PACKING INSTRUCTIONS

The instructions below must be strictly followed in order to prevent damage to the instrument.

The main principle behind a successful shipment is that of minimizing shocks to the pressure transducers. This is accomplished by cradling the device within a box such that the PPG is restrained but still has resilience. The two most successful materials for this purpose are rubber foam and flexible polyurethane foams. Styrofoam, poured "foam in place" mixtures, and other rigid foams are not suitable. Even polyfoam or rubber foam should be cut into strips so that it will not present a large rigid surface to the PPG.

Ruska has found that corrugated cardboard boxes provide the best packing. The boxes sometimes arrive damaged, but the contents are usually intact. A minimum of 1 inch of foam should separate the inner surface of the box and any portion of the PPG. Wood or metal boxes do not absorb shock when dropped and therefore are not recommended.

If the original packing and shipping materials were retained, use them for packing the PPG. If the PPG is being packed for long-term storage (more than 30 days), place a desiccant bag with the unit inside a plastic bag. The PPG should be stored in a cool, dry place, with the battery or power supply removed.

8.3 PREPARATION FOR SHIPMENT

In general, prepare the PPG for shipment as follows.

1. In order to minimize turn-around time, Ruska should be notified of the return of equipment prior to shipment (contact customer service). When notifying Ruska please include the part number, serial number, purchase order number, billing and ship to address, and the buyer's name and phone number. This information should be

duplicated and included with the shipment when the goods are returned. There will be a minimal charge for inspection and/or evaluation of returned goods.

2. Enclose the PPG in plastic or any good water barrier material. Anti-static material is advisable.
3. Carton (size 12 x 12 x 6 inches): Cover top, bottom and sides with polyfoam.
4. Inside the carton, include the following:
   a. Statement of the problem or service needed. Be specific. Include any local or remote error codes that occurred during operation, and if possible, mention the component suspected of failure. Also include the name and telephone number of a knowledgeable technician for consultation.
   b. The part number, serial number, return address, and purchase order number.
5. Seal the carton, using gummed tape.
6. Address the carton to:

RUSKA INSTRUMENT CORPORATION
3601 Dunvale
Houston, TX 77063

7. Labels recommended are THIS SIDE UP, HANDLE WITH CARE, DO NOT DROP, and FRAGILE.

8.4 SHIPPING INSTRUCTIONS

Ruska recommends the use of air freight for transportation. Surface transportation subjects the shipment to more frequent handling and much more intense shock.

Again, it is essential that the procedures mentioned in Sections 8.1 through 8.4 be strictly adhered to in order to prevent damage to the instrument.

APPENDIX A

ERROR CODES

Error Codes (Local)	
Code	**Meaning and Corrective Action**
EE-000	No errors encountered during main board / front panel self-test.
EE-002	The pressure at the test port is greater that 120%FS. Reduce the total pressure to below 120%FS.
EE-003	An error has been detected in the main board EPROM*. Use the AUX menu (see Section 4.10) to find out the release number of the main board software .
EE-004	Checksum error on sensor A coefficients.
EE-005	An error has been detected in the main board RAM*.
EE-006	Pressure signal from sensor A was not detected.
EE-007	Temperature signal from sensor A is out of range or not detected.
EE-008	Either the battery voltage is out of range, or an error has been detected in the A/D converter* on the main board. Check the battery voltage using the AUX menu (see Section 4.10). If the battery voltage is below 11.75 V, recharge the battery as described in Section 3.5.3. If the battery voltage is at or near 12 VDC, report an error in the A/D converter.
EE-014	Checksum error on sensor B coefficients.
EE-016	Pressure signal from sensor B was not detected.
EE-017	Temperature signal from sensor B is out of range or not detected.
EE-020	An error has been detected in the display board EPROM*. Use the AUX menu (see Section 4.10) to find out the release number of the display board software.
EE-021	An error has been detected in the display board RAM*.
EE-034	Entry to the Zero or Calibration mode was attempted while the current units were altitude. Press **SELECT UNITS** until units other than feet or meters appear in the upper display, and reenter zero or cal mode.
EE-035	The pressure detected at the test port corresponds to an altitude greater than 200,000 feet (61.0 km). Reduce the altitude by increasing the pressure at the test port, or press **SELECT UNITS** until units other than feet or meters appear in the upper display.
EE-036	The transducer* is not being detected.
EE-055	Temporary power failure or software failed to reset watchdog.

Main Board Error Messages	
Code	**Meaning and Corrective Action**
EE-003	An error has been detected in the main board EPROM*. Use the AUX menu (see Section 4.10) to find out the release number of the main board software .
EE-004	Checksum error on sensor A coefficients.
EE-005	An error has been detected in the main board RAM*.
EE-006	Pressure signal from sensor A was not detected.
EE-007	Temperature signal from sensor A is out of range or not detected.
EE-008	Either the battery voltage is out of range, or an error has been detected in the A/D converter* on the main board. Check the battery voltage using the AUX menu (see Section 4.10). If the battery voltage is below 11.75 V, recharge the battery as described in Section 3.5.3. If the battery voltage is at or near 12 VDC, report an error in the A/D converter.
EE-014	Checksum error on sensor B coefficients.
EE-016	Pressure signal from sensor B was not detected.
EE-017	Temperature signal from sensor B is out of range or not detected.
Front Panel Error Messages	
Code	**Meaning and Corrective Action**
EE-020	An error has been detected in the display board EPROM*. Use the AUX menu (see Section 4.10) to find out the release number of the display board software.
EE-021	An error has been detected in the display board RAM*.
Calibration Error Messages	
Code	**Meaning and Corrective Action**
EE-030	(Serial Interface only) Transmitted message valid only in CAL or ZERO mode. To transmit one of the commands listed in Section 5.3.5, first enter CAL mode as described in Section 6.5.2, step 1.4.
EE-031	The indicated (measured) pressure is not within acceptable limits. Acceptable limits are discussed in Section 5.3.5, 6.4.2, and 6.5.2.
EE-032	The entered pressure (read from the primary or transfer standard) is not within acceptable limits. Acceptable limits are discussed in Section 5.3.5, 6.4.2, and 6.5.2.
EE-033	Calibration not complete. Zero and/or mid-scale pressure points not entered.
EE-034	Entry to the Zero or Calibration mode was attempted while the current units were altitude. Press **SELECT UNITS** until units other than feet or meters appear in the upper display, and reenter zero or cal mode.

Remote Error / Status Codes	
Code	**Meaning**
00	Status buffer empty.
01	Syntax error. Message received via remote interface not recognized.
02	The indicated pressure at the input port is greater than 120% full scale. This status code will be stored anytime the condition occurs. If the condition persists, another 02 status code will not be inserted in the buffer until the condition is removed and reoccurs. If it does reoccur, another 02 status code will not be inserted if the previous 02 has not been read.
03	Main board EPROM check failed on power up test or on self test commanded via remote interface. If self test was requested via front panel, results will displayed on front panel only and will not be stored in the status buffer.
04	Checksum error on sensor A coefficients.
05	Main board RAM check failed on power up test or on self test commanded via remote interface.
06	Pressure signal from sensor A was not detected.
07	Temperature signal from sensor A is out of range or not detected.
08	A/D check failed on power up test or on self test commanded via remote interface.
14	Checksum error on sensor B coefficients.
16	Pressure signal from sensor B was not detected.
17	Temperature signal from sensor B is out of range or not detected.
20	Front panel board EPROM check failed on power up test or on self test commanded via remote interface.
21	Front panel board RAM check failed on power up test or on self test commanded via remote interface.
22	Front panel not responding to messages from the main board.
30	Message valid only in calibration or zero mode. This error code is inserted for those messages that are not allowed if the PPG is not in the calibration or zero set mode. The PPG is put in the calibration or zero set mode with the **CAL** or **ZERO** button on the front panel. The **CAL** or **ZERO** indicator will be on when in the calibration or zero mode.
31	Measured pressure is not within acceptable limits for the zero or calibration procedure. This error will be stored only if attempt to zero or calibrate instrument was done via remote interface.
32	In the calibration mode, the actual pressure entered is not within acceptable limits. This error code will be stored only if actual pressure entered was done so via the remote interface.
33	Calibration is incomplete; all three calibration points have not been generated. This error code will be stored only if calibration of the last (full) point was attempted via the remote interface before the zero and mid points.

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APPENDIX B

OPENING THE ENCLOSURE

Normally, the user should not need to open the PPG enclosure. However, if it becomes appropriate to open the unit (for example, to change the software), the following procedure is recommended. (Note that to change software, complete disassembly is not required — do not proceed past the removal of the front panel, step G.)

A. Remove the small screw above the battery holder in the rear panel and set it aside for later use.

B. Place the unit on a soft surface to protect its finish. Stand it on its back panel, with the bottom sheet metal panel facing you.

C. Remove the four screws securing the tilt-up stand to the unit. Set the stand components aside.

D. Loosen (but do not remove) the two screws securing the soft rubber feet to the bottom of the unit.

E. Grasp the unit on both sides at the top. Use your thumbs to press the upper portion of the sheet metal bottom toward the interior of the unit, so that it deflects inward about 1/4 inch.

F. While continuing to press the bottom inward, slide your thumbs upward to push the nearer edge of the bezel up and away from its locking pins. Rotate the bezel upward and separate it from the unit. Set it aside.

G. Disconnect the display board connector from the main board, and set the display board aside.

H. Remove the two soft rubber feet and set them aside for later use.

I. While holding the rear bezel flat on the work surface, push the upper portion of the sheet metal top away from you, separating it from the assembly. Set the top aside.

J. Lay the bottom and bezel flat on the work surface, and set them aside for later use.

To reassemble, reverse this procedure.

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APPENDIX C

SENSOR SPECIFICATIONS

Models 6220 and 6222 Specifications (in % Full Scale)							
Ranges psia kPaa	0-19 0-130	0-38 0-260	0-50 0-345	0-75 0-517	0-150 0-1034	0-500 0-3445	0-750 0-5000
Linearity	≤ 0.003	≤ 0.003	≤ 0.003	≤ 0.003	≤ 0.006	≤ 0.006	≤ 0.006
Repeatability	≤ 0.002	≤ 0.002	≤ 0.002	≤ 0.002	≤ 0.004	≤ 0.004	≤ 0.004
Hysteresis	≤ 0.002	≤ 0.002	≤ 0.002	≤ 0.002	≤ 0.004	≤ 0.004	≤ 0.004
Temperature Compensation	≤ 0.004	≤ 0.004	≤ 0.004	≤ 0.004	≤ 0.008	≤ 0.008	≤ 0.008
Accuracy*	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.02	≤ 0.02	≤ 0.02
Overpressure	1.2 X FS	1.2 X FS	1.2 X FS	1.2 X FS	1.2 X FS	1.2 X FS	1.2 X FS
Stability / year	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Maximum Error	0.02	0.02	0.02	0.02	0.04	0.04	0.04
Output Signals							
Nominal Pressure Frequency	4.4 KHz	5.5 KHz	5.9 KHz	6.6 KHz	7.6 KHz	10.4 KHz	23 KHz
Temperature Output Voltage	0.8 to 0.4	0.8 to 0.4	0.8 to 0.4	0.8 to 0.4	0.8 to 0.4	0.8 to 0.4	0.8 to 0.4
Medium	Air or Nitrogen only						

* Defined as the combined effects of linearity, hysteresis, and repeatability.

Models 6230 and 6232 Specifications (in % Full Scale)		
Ranges **psi** **kPa**	**15 - 1000 psi** **100 - 7000 kPa**	**2000 - 10,000 psi** **14 - 70 MPa**
Repeatability	< .005	< .01
Hysteresis	< .005	< .01
Temperature Sensitivity	< .001 per deg C	< .001 per deg C
Accuracy	< .01	< .015
Overpressure	1.2 x FS	1.2 x FS
Stability/year	0.01	0.015
Maximum Error/year	0.02	0.03
Operating Temperature	0-50 deg C	0-50 deg C
Wetted Materials	304L, 316L SS, Nickel, Gold, Solder	304L, 316L SS, Inconel 718
Output Signals		
Output Pressure Frequency	36 to 40 KHz	10 to 60 KHz

Model 6250 Specification (in % Full Scale)	
Ranges	**STANDARD RANGE 0.1 TO 50 inWC**
Linearity	< .15% (Best Fit)
Repeatability	< .03%
Hysteresis	< .02%
Temperature Sensitivity	Zero (max) .015% FS/deg F Span (max) .015% Rdg/deg F
Accuracy	< .35%
Overpressure	10 psig
Stability/year	.25%
Maximum error/year	.5%
Operating Temperature	0-50 deg C

This unit requires daily rezeroing.

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