RPM1
Reference
Pressure Monitor

User's Manual

Document No. 550060
950500
Printed in the USA.

TABLE OF CONTENTS

(User Notes)

CHAPTER 1 - INTRODUCTION

1.1 PRODUCT OVERVIEW

The DH RPM1 Reference Pressure Monitor displays a direct digital pressure output in the user's choice of engineering units and enables the output to be read by a host computer.

The RPM1 receives commands and data requests via a two way RS232 port and returns data via the same bus. Up to 98 RPM1's can be attached to a single RS232 port.

Powerful, easy to use program commands allow the user to address any or all RPM1's on the bus and control data sampling rates, sample integration time, baud rate, and other operating parameters.

Pressure values are output in any of eight standard sets of engineering units or in user definable units.

Output pressure data is fully compensated for temperature effects over the range -54 to +100°C.

1.2 HARDWARE DESCRIPTION

The RPM1 measuring hardware consists of a high accuracy quartz pressure transducer and a digital interface board in an integral package. The digital board has a microprocessor-controlled counter and RS232 port. The microprocessor operating program is stored in permanent memory (EPROM) and user controllable parameters are stored in user writable memory (EEPROM). The user interacts with the transducer via the two-way RS232 interface.

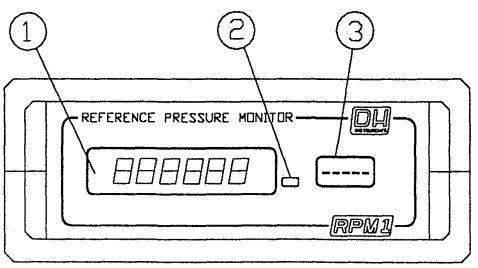
The pressure transducer provides two continuous frequency output signals, one corresponding to the pressure and the other to sensor internal temperature. The digital board uses these two signals to calculate fully temperature-compensated pressure. The equations used are described in Appendix A.7.

The microprocessor monitors incoming commands from the computer. When a sampling command is received, the microprocessor selects the appropriate frequency signal source and makes a period measurement using a 15 MHz timebase counter. The counter integration time is user selectable. Some commands require measurements of both temperature and pressure signals. In that case, the temperature period is measured first, followed by the pressure period. When the period measurement is completed, the microprocessor makes the appropriate calculations and loads the data onto the RS232 bus.

1.3 LOCATION OF THE COMPONENTS

FRONT PANEL

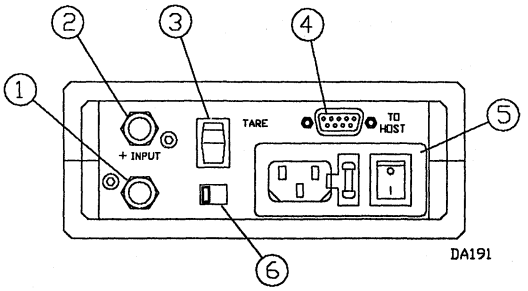
1) Digital display
2) Tare indicator
3) Range indicator



DA190

REAR PANEL

1) Pressure connector - 1/8" NPT Female (optional)
2) Pressure connector - 1/8" NPT Female
3) Tare button
4) Computer interface - 9 Pin D-Sub, RS 232
5) Power entry module
6) Voltage selector switch



1.4 SPECIFICATIONS

RS232 Bus:

- Baud Rates: user selectable from 150 to 19200 baud
- Input levels: any RS232 compatible level
- Output levels: ±5 VDC nominal
- Data framing: user selectable choices
  - 8 data bits, no parity, one stop bit
  - 7 data bits, odd parity, one stop bit
  - 7 data bits, even parity, one stop bit
- Handshaking: not supported.

Power:

- 115/230 VAC
  50/60 HZ 1.5 VA
  or
- 6 -12 VDC @ 250 mA

Sampling Modes:

- Single sample and send
- Synchronized sample and hold
- Continuous sample and send
- Special burst sampling modes

Sample Integration Time:

- User selectable in approximately 3 ms steps from 3 ms to 30 s.

Sample Speed:

- Depends on integration time
- Up to 15 samples/s in normal modes
- Up to 120 samples/s in burst sampling modes

Resolution:

- Depends on integration time
- User selectable in 15000 steps
- Typically 100 ppm full scale at 70 samples/s
  10 ppm at 8 samples/s
  1 ppm at approximately 1 sample/s
  0.1 ppm one every 15 s

Pressure Units:

- User selectable
- Choice of psi, mbar, bar, kPa, MPa, inches of Hg, torr, meters of water, or user definable

Sensor Performance:

- Repeatability: ±0.005% F.S.
- Hysteresis: ±0.005% F.S.
- Pressure Conformance: ±0.005% F.S.
- Acceleration Sensitivity: ±0.0038% F.S.
- Vibration Sensitivity: Negligible
- Sensor Accuracy: ±0.01% F.S.
- Absolute Accuracy: ±(0.01% F.S. + 0.005% of reading) for 90 days
  ±0.02% F.S. for one year

(User Notes)

CHAPTER 2 - INSTALLATION

2.1 HOW TO GET STARTED

This section concentrates on things a beginner needs to know and includes ample simple programs written in BASIC. Included with the RPM1 is a computer floppy disk with demonstration programs. This disk will run on any IBM PC, XT, AT, or other compatible computer with an RS232 serial port. One program that is especially useful is an interactive program which lets the user try any command and observe the results. Many terminal programs can also be used for testing. The programs on the disk work with DOS version 2.1 and higher and BASIC version 1.0 and higher. If trouble is encountered, check the programming hints in Appendix A.4 and study the sample program listings. The user should read through the preceding two sections to get an overview of the capabilities of the RPM1 and then hook up the unit as described in Appendices A.2 and A.3.

2.2 TYPES OF MEASUREMENTS

The RPM1 can make four types of measurement:

- Pressure
- Temperature (internal sensor temperature)
- Period of the pressure sensor
- Period of the temperature sensor

Pressure measurements are the most frequently used. The sensor internal temperature measurement is intended for thermal compensation of pressure. Because the sensor is thermally isolated, the internal temperature changes slowly and might be read only occasionally. The period measuring commands are used mainly for calibration or diagnostic test. They also can be used for high speed burst sampling.

2.3 TYPES OF SAMPLING

There are four types of sampling:

- Single measurement sample and send, e.g. command P3
- Single measurement sample and hold, e.g. command P5
- Continuous sample and send, e.g. command P4
- Special high speed burst sampling, e.g. command P7

The simplest commands to use are the single sample commands, and beginners should start with them.

Command	RPM1 Response
P3	Make one pressure measurement and send it to the computer
P5	Make one pressure measurement hold value until requested
DB	Send value being held to computer

The difference is that P3 sends data as soon as it is available and P5 holds the data until a DB (dump buffer) or DS (dump sequential) request is received. P5 is intended primarily for sampling simultaneously with several RPM1's and then reading them out one by one. The continuous and burst sampling procedures are described later. They are more complicated to use because data keeps coming in and user programs must keep up with it.

CHAPTER 3 - OPERATION

3.1 SET UP COMMANDS

Before a computer can talk to the RPM1, its baud rate (BR), parity (PT), and ID number must be known. RPM1's are shipped set to BR=1200, PT=N, and ID=1. Users may change these parameters but should record the new value. If the baud rate and parity of the RPM1 are not known, the computer will have to search all values to reestablish communication.

The command PR sets the counter integration time in multiples of about 0.003 seconds. This command determines the Pressure Resolution. The RPM1's are shipped set to PR=238, which gives a pressure resolution of about 1 ppm and a counter integration time of about 0.7 seconds. Users may select the value best suited for their applications. Larger values give higher resolution but take longer.

Once these parameters are set, you are ready to take data. The RPM1 will retain these parameters in EEPROM even if turned off. The simple programs in Sections 3.3 and 3.4 will help you to get started.

3.2 COMMAND FORMAT

All commands have the form *ddsscc_____<cr><lf>. Data framing is 8 data bits, no parity, with one stop bit or 7 data bits with even or odd parity, one stop bit. Set by command PT.

- Each line starts with an asterisk.
- The next 2 digits are the destination for the command (00-99). The controller (IBM PC, etc.) is address "00" and the units will be "01" through "98" with "99" for "global". An RPM1 responds only to its own address or "99".
- The next 2 digits are the source of the message (00-98)
- The next 2 characters specify the type of message, and may be followed by more characters in some messages. Characters must be upper case. Reply messages may substitute data for the "cc" characters.
- Each message line is terminated by a carriage return <cr> and a line feed <lf>.
- Undefined commands are absorbed.
- Commands arriving before a previous command is complete cancel the previous command.

A typical message from the PC to unit #1 asking for pressure: *0100P3 <cr><lf>

A typical reply from the RPM1 to the PC: *000114.573 <cr><lf>

(User Notes)

3.3 SAMPLE PROGRAM FOR SINGLE MEASUREMENTS

The following program is written in IBM DISK BASIC

```
                                                    COMMENTS
 10   REM ***SINGLE SAMPLE PROGRAM
 20   CLS                                           Clear screen.
 30   ON ERROR GOTO 130                             Set up exit in case of errors.
 40   OPEN"COM1:1200,N,8,1,CS,DS,LF"AS#1            Set up computer RS232 port #1. 1200
                                                    baud, no parity, 8 data bits, 1 stop bit,
                                                    no handshaking, send line feed.
 50   PRINT#1, "*0100VR"                            Send a command to stop any
                                                    commands in progress.
 60   CLOSE#1                                       Close channel to clear out buffer.
 70   OPEN"COM1:1200,N,8,1,CS,DS,LF"AS#1            Reopen channel, ready to go.
 80   PRINT#1, "*0100P3"                            Ask for one pressure reading.
 90   INPUT#1,A$                                    Read the data.
100   PRINT"DATA RECEIVED";A$                       Print the data.
110   CLOSE #1                                      Close channel.
120   END
130   PRINT "ERROR NR";ERR; "ON LINE";ERL           Error Exit. Print message.
140   RESUME 120
```

Lines 40-60 clear the RPM1 of previous commands. They halt any continuous data from the unit and clear out the computer input buffer. In lines 40 and 70, COM1 can be changed to COM2 to uses RS232 port #2 instead of port #1. Specify the baud rate for which the RPM1 is set.

Now try substituting the P1 or Q3 command for P3 in line 80.

Try adding the following to get continuous output: 105 GOTO 80

Press CTRL BREAK to halt the program.

Now add the following to strip off the address block *0001 from the reply: 95 A$ = MID$(A$,6)

3.4 SAMPLE PROGRAM FOR CONTINUOUS MEASUREMENTS

A variation of this program using the P4 continuous sampling command is given below:

```
                                                    COMMENTS
 10   REM ***CONTINUOUS SAMPLE PROGRAM
 20   CLS                                           Clear screen.
 30   ON ERROR GOTO 130                             Set up exit in case of errors.
 40   OPEN"COM1:1200,N,8,1,CS,DS,LF"AS#1            Set up computer RS232 port #1. 1200
                                                    baud, no parity, 8 data bits, 1 stop bit,
                                                    no handshaking, send line feed.
 50   PRINT#1, "*0100VR"                            Send a command to stop any
                                                    commands in progress.
 60   CLOSE#1                                       Close channel to clear out buffer.
 70   OPEN"COM1:1200,N,8,1,CS,DS,LF"AS#1            Reopen channel, ready to go.
 80   PRINT#1, "*0100P4"                            Ask for continuous pressure readings.
 90   INPUT#1,A$                                    Read the data.
 95   A$=MID$(A$,6)                                 Strip off address block.
100   PRINT"DATA";A$: GOTO 90                       Print the data. Loop to get more.
130   PRINT "ERROR NR";ERR; "ON LINE";ERL           Error Exit. Print message.
140   CLOSE#1:END                                   Close file.
```

This program in BASIC can keep up with approximately 15 samples per second on an IBM PC, or faster on an AT or other machine with a faster clock speed.

For fast samples, read the sections on resolution and high speed sampling and then try changing the PR and BR parameters.

3.5 COMMAND SUMMARY

P1 Sample and send one pressure sensor period.
P2 Continuously sample and send pressure periods.
P3 Sample and send one pressure.
P4 Continuously sample and send pressure.
P5 Sample and hold one pressure.
P6 Sample and hold one pressure period.
P7 Burst sample pressure: read temperature once; then continuously send pressure compensated using original temperature.
Q1 Sample and send one temperature period.
Q2 Continuously sample and send temperature periods.
Q3 Sample and send one temperature.
Q4 Continuously sample and send temperature.
Q5 Sample and hold one temperature.
Q6 Sample and hold one temperature period.

3.5 COMMAND SUMMARY (cont.)

DB Dump buffer. Sends values being stored.
DS Dump sequential. Sends stored values in sequential order.
BR Enter baud rate. Must be global "99" command.
ID Auto-number units in a loop. Must be global "99" command.
PT Sets unit parity. Must be global "99" command.
VR Read software version.
EW Enable EEPROM write for one command.

NOTE: All remaining commands either read the present values of operating parameters or store new values in EEPROM. These commands cannot be global. Any command to change values in EEPROM must be immediately preceded by an EW command.

PR Read/enter pressure resolution.
TR Read/enter temperature resolution.
UN Read/enter choice of pressure units.

0) user defined	3) bar	6) inch Hg
1) psi	4) kPa	7) torr or mm Hg
2) mbar or hPa	5) MPa	8) m H_2O

UF Read/enter user definable units conversion factor
MD Reads or sets power-up mode.

SPECIAL COMMANDS TO CONTROL DISPLAY

DC Display check.
DP Reads or sets number of display decimal places.
DR Display Right-adjusted data from computer.
DV Display Value from Computer, left-adjusted.

SPECIAL COMMANDS FOR THE RPM1

BP Sound over-pressure beeper.
OP Read/enter the over-pressure alarm setting.
ZL Read or set the zero lock state.
ZS Read or set the state of the zero set switch.
ZV Read or enter the zero value.

SPECIAL DIAGNOSTIC COMMANDS

MC Memory check. Checks program PROM.
CS Check stack of microprocessor.
CT Check counter timebase
CX Check crystal for microprocessor clock.

3.6 CALIBRATION COMMANDS

NOTE: REMAINING COMMANDS READ OR CHANGE CALIBRATION COEFFICIENTS. BE CAREFUL! Calibration Commands should never be sent as global commands.

SN	Read/enter RPM1 serial number.
PA	Read/enter pressure adder.
PM	Read/enter pressure multiplier.
TC	Read/enter timebase correction factor.
C1	Read/enter C1 pressure coefficient.
C2	Read/enter C2 pressure coefficient.
C3	Read/enter C3 pressure coefficient.
D1	Read/enter D1 pressure coefficient.
D2	Read/enter D2 pressure coefficient.
T1	Read/enter T1 pressure coefficient.
T2	Read/enter T2 pressure coefficient.
T3	Read/enter T3 pressure coefficient.
T4	Read/enter T4 pressure coefficient.
T5	Read/enter T5 pressure coefficient.
U0	Read/enter U0 temperature coefficient.
Y1	Read/enter Y1 temperature coefficient.
Y2	Read/enter Y2 temperature coefficient.
Y3	Read/enter Y3 temperature coefficient.

3.7 INDIVIDUAL COMMAND DESCRIPTIONS

P1

PURPOSE:	Sample and send one period measurement of the pressure signal in microseconds.
ACTION:	Start pressure count, read count when done, calculate period using timebase and integration time, send reading, await next command.
TYPICAL COMMAND:	"*0100P1"
TYPICAL REPLY:	"*000129.12345"

P2

PURPOSE:	Continuously sample and send pressure signal periods.
ACTION:	Start pressure count, read count when done, restart count, calculate period using timebase and integration time, send reading, read next count when available and loop until stopped.
TYPICAL COMMAND:	"*0100P2"
TYPICAL REPLY:	"*000129.12345" "*000129.12346" "*000129.12344", etc.

P3

PURPOSE:	Sample and send one compensated pressure.
ACTION:	Start temperature count, read count when done, start pressure count, correct temperature count for timebase and integration time, compute temperature compensated pressure coefficients, read pressure count when done, correct pressure count for timebase and integration time, calculate pressure, send reading, await next command.
TYPICAL COMMAND:	"*0100P3"
TYPICAL REPLY:	"*0001555.444"

P4

PURPOSE:	Continuously sample and send compensated pressure.
ACTION:	Start temperature count, read count when done, start pressure count, correct temperature count for timebase and integration time, compute temperature compensated pressure coefficients, read pressure count when done, restart temperature count, correct pressure count for timebase and integration time, calculate pressure, send reading, loop until stopped.
TYPICAL COMMAND:	"*0100P4"
TYPICAL REPLY:	"*0001555.444" "*0001555.447" "*0001555.444", etc.

P5

PURPOSE:	Sample and hold one compensated pressure.
ACTION:	Same as P3 except save reading and await "DB" command.
TYPICAL COMMAND:	"*0100P5"
TYPICAL REPLY:	None until "DB" command received.

P6

PURPOSE:	Sample and hold one pressure signal period.
ACTION:	Same as P1 except save reading and await "DB" command.
TYPICAL COMMAND:	"*0100P6"
TYPICAL REPLY:	None until "DB" command received.

P7

PURPOSE:	Burst sample pressure; read temperature once; then continuously send pressure compensated with original temperature reading.
ACTION:	Start temperature count, read count when done, start pressure count, compute temperature compensated pressure coefficients and save for repeated use, read pressure count when done, restart pressure count, correct pressure count for timebase and integration time, calculate pressure, send reading, wait for next pressure count and loop until stopped.
TYPICAL COMMAND:	"*0100P7"
TYPICAL REPLY:	"*0001555.444" "*0001555.447" "*0001555.444", etc.

Q1

PURPOSE:	Sample and send one temperature signal period.
ACTION:	Start temperature count, read count when done, correct for timebase and integration time, send reading, await next command.
TYPICAL COMMAND:	"*0100Q1"
TYPICAL REPLY:	"*00015.812345"

Q2

PURPOSE:	Continuously sample and send temperature signal periods.
ACTION:	Start temperature count, read count when done, restart count, correct count for timebase and integration time, send reading, get next count and loop until stopped.
TYPICAL COMMAND:	"*0100Q2"
TYPICAL REPLY:	"*00015.812345" "*00015.812346" "*00015.812347", etc.

Q3

PURPOSE:	Sample and send one temperature in degrees C.
ACTION:	Start temperature count, read count when done, correct count for timebase and integration time, compute temperature and send, await next command.
TYPICAL COMMAND:	"*0100Q3"
TYPICAL REPLY:	"*000122.1234"

Q4

PURPOSE:	Continuously sample and send temperature.
ACTION:	Start temperature count, read count when done, restart count, correct count for timebase and integration time, compute temperature and send, await for next count and loop until stopped.
TYPICAL COMMAND:	"*0100Q4"
TYPICAL REPLY:	"*000122.1234" "*000122.1235" "*000122.1234", etc.

Q5

PURPOSE:	Sample and hold one temperature.
ACTION:	Same as Q3 except save reading and await "DB" command.
TYPICAL COMMAND:	"*0100Q5"
TYPICAL REPLY:	None until "DB" command.

Q6

PURPOSE: Sample and hold one temperature period.

ACTION: Same as Q1 except save reading and await "DB" command.

TYPICAL COMMAND: "*0100Q6"

TYPICAL REPLY: None until "DB" command.

DB

PURPOSE: Dump buffer. Send reading being stored.

ACTION: Send reading saved using P5, Q5, or Q6 command. The DB command must be the next command addresses to the RPM1 after a sample and hold. If the DB command arrives before the sample is ready, data is sent when ready.

TYPICAL COMMAND: "*0100DB"

TYPICAL REPLY: "*0001555.444"

DS

PURPOSE: Dump sequential. Usually a global command.

ACTION: Similar to DB command except guarantees that the data from multiple transducers come back in sequential order. Sends reading saved during a P5, P6, Q5, or Q6 sample and hold command and then sends a global DS command to trigger the next RPM1 in the loop. The DS command must be the next command sent after the sample and hold. If the DS command arrives before the sample is ready, data is sent when ready.

TYPICAL COMMAND: "*9900DS"

TYPICAL REPLY:
"*000114.576" first unit
"*000214.577" second unit
"*9900DS"

BR

PURPOSE: Enter baud rate. Must be a global "99" command.

ACTION: Sets baud rate. Does not require an EW command. Choices are 150, 300, 600, 1200, 2400, 4800, 9600, 19200 baud.

TYPICAL COMMAND: "*9900BR=2400" set BR=2400

TYPICAL REPLY: "*0001BR=2400"

NOTE: When the baud rate is changed, the confirming reply is sent at the original baud rate but all subsequent commands should be at the new baud rate.

ID

PURPOSE:	Auto-number RPM1's in a loop. Must be a global command.
ACTION:	Causes units to auto-number around a loop. Command begins at the PC with "*9900ID". The first unit sees that the previous unit was "00" and numbers itself "01" and stores the value in EEPROM. Unit sends out "*9901ID" which causes the next unit to number itself "02". The PC eventually will receive the message "*99nnID" where nn is the number of units in the loop.
TYPICAL COMMAND:	"*9900ID"
TYPICAL REPLY:	"*9900ID"

PT

PURPOSE: Sets monitor parity. Must be a global "99" command. Parameter PT controls parity sent by the unit. Parity on incoming messages is ignored. Choices are:

N	8 data bits, no parity, one stop bit
E	7 data bits, even parity, one stop bit
O	7 data bits, odd parity, one stop bit.

TYPICAL COMMAND:	"*9900PT=N" set to 8 data bits, no parity
TYPICAL REPLY:	"*9900PT=N"

VR

PURPOSE:	Read software version.
ACTION:	Unit sends the software version number stored in the program EPROM.
TYPICAL COMMAND:	"*0100VR"
TYPICAL REPLY:	"*0001VR=01.00"

EW

PURPOSE:	Enable EEPROM write for one command.
ACTION:	Set flag allowing EEPROM write on next command. Flag is cleared after next command is received.
TYPICAL COMMAND:	"*0100EW"
TYPICAL REPLY:	None

NOTE: ALL REMAINING COMMANDS EITHER READ THE PRESENT VALUES OF OPERATING PARAMETERS OR STORE NEW VALUES IN EEPROM. THESE COMMANDS SHOULD NOT BE SENT AS GLOBAL. ANY COMMAND TO CHANGE VALUES IN EEPROM MUST BE IMMEDIATELY PRECEDED BY AN "EW" COMMAND.

PR

PURPOSE:	Read/enter pressure resolution.
ACTION:	Same as other coefficients. PR=1 to 15000. Pressure integration time = 100*PR*period of pressure oscillator. TR is automatically set to 4*PR when PR is changed.
TYPICAL COMMAND:	"*0100PR"
TYPICAL REPLY:	"*0001PR=00100"
TYPICAL COMMAND:	"*0100EW*0100PR=200"
TYPICAL REPLY:	"*0001PR=00200"

TR

PURPOSE:	Read/enter temperature resolution.
ACTION:	Same as other coefficients. TR=1 to 60000. Temperature integration time = 100*TR*period of temperature oscillator. TR is automatically set to 4*PR when PR is changed but is overwritten by this command.
TYPICAL COMMAND:	"*0100TR"
TYPICAL REPLY:	"*0001TR=00400"
TYPICAL COMMAND:	"*0100EW*0100TR=800"
TYPICAL REPLY:	"*0001TR=00800"

UN

PURPOSE: Read/enter choice of pressure units.

ACTION: Selects units conversion factor by which all computed pressures are multiplied before output. UN=1 to 8 selects from eight standard sets of units. UN=0 chooses the user defined multiplier which is set with command UF.

UN	UNITS	MULTIPLY PSI BY
1	psi	1.000000
2	mbar or hPa	68.94757
3	bar	.0689476
4	kPa	6.894757
5	MPa	.0068948
6	in Hg	2.036021
7	mm Hg or torr	51.71493
8	m H_2O	.7030696
0	user defined	set by UF command

TYPICAL COMMAND:	"*0100UN"	What are units?
TYPICAL REPLY:	"*0001UN=4"	Units are kPa
TYPICAL COMMAND:	"*0100EW*0100UN=2"	Set to mbar
TYPICAL REPLY:	"*0001UN=2"	

UF

PURPOSE: Read/enter user defined units conversion factor.

ACTION: Allows users to convert pressure to any desired set of units by defining a conversion factor. Then, when UN=0 is selected, the output pressure will be psi*UF.

TYPICAL COMMAND:	"*0100UF"	present factor?
TYPICAL REPLY:	"*0001UF=1.000000"	
TYPICAL COMMAND:	"*0100EW*0100UF=144.0000"	Define units
TYPICAL REPLY:	"*0001UF=144.0000"	lb/ft^2

MD

PURPOSE: Read or set the mode parameter MD. This parameter controls the power-up state of the RPM1. The unit always responds to user commands, but it can also send data continuously on the RS232 bus in a background mode. These background tasks are turned on and off by the MD command.

	DISPLAY	CONTINUOUS RS232
MD=0	off	off
MD=1	on	off
MD=2	off	on
MD=3	on	on

Whenever the RPM1 calculates pressure in response to a user request, the data is also sent to any active background tasks. In addition, whenever the RPM1 is not servicing user requests, it measures pressure and sends it to any active background tasks. Background tasks are temporarily interrupted whenever the higher priority computer requests require attention. Users requiring maximum sample speed or minimum current drain should turn off any unneeded background tasks.

TYPICAL COMMAND:	"*0100MD"	What mode?
TYPICAL REPLY:	"*0001MD=0"	No background tasks
TYPICAL COMMAND:	"*0100EW*0100MD=1"	Turn on background display
TYPICAL REPLY:	"*0001MD=1"	Display active

SPECIAL COMMANDS TO CONTROL DISPLAYS

DC

PURPOSE: Display Check command. Causes display to cycle through all display segments to check display. Does not generate any replay.

ACTION: None

TYPICAL COMMAND: "*0100DC"

DP

PURPOSE: Decimal Point command.

ACTION: Reads or sets the number of decimal places shown on the display. If DP=6, the display automatically shows all significant digits, right-adjusted. If a user requests more decimal places than there is room to show, display will shift the decimal point so that the 6 most significant digits are shown. Values greater than 999999 or less than -999999 are shown as OF (overflow).

TYPICAL COMMAND: "*0100DP" How many decimal places?

TYPICAL REPLY: "*0001DP=2" Display shows 14.57

TYPICAL COMMAND: "*0100EW*0100DP=3"

TYPICAL REPLY: "*0001DP=3" Display shows 14.573

DR

PURPOSE: Display Right-Adjusted

ACTION: Displays any number specified by the computer on the display. Messages are right-adjusted and may be up to six characters plus a decimal point. Legal characters are 0 1 2 3 4 5 6 7 8 9 - and upper case letters A B C D E F. Decimal point position is determined by the DP command. The DR command does not generate any reply on the RS232 bus.

TYPICAL COMMAND: "*0100DR=14.543" Displays 14.543 (depends on DP)

TYPICAL REPLY: None

DV

PURPOSE: Display Value. Puts any value specified by the computer on the display. Messages are left-adjusted and may be up to six characters plus a decimal point. Legal characters are 0 1 2 3 4 5 6 7 8 9 - and upper case letters A B C D E F. Decimal point position is not affected by the DP command. The DV command does not generate any reply on the RS232 bus.

TYPICAL COMMAND: "*0100DV=14.543" displays 14.543
"*0001DV=23.25 F displays 23.25 F

For a special display with colons, try sending six characters followed by 0 or 1.

TYPICAL COMMAND: "*0100DV=1234560" displays 12:34:56
"*0100DV=1234561" displays 12:3456

SPECIAL COMMANDS FOR THE RPM1

BP

PURPOSE: Causes over-pressure warning beeper to sound for approximately one second.

TYPICAL COMMAND: "*0100BP"

no reply

OP

PURPOSE: Read or enter the value of the over-pressure parameter. Any pressure reading in excess of this value triggers the over-pressure beeper.

TYPICAL COMMAND: "*0100OP"

TYPICAL REPLY: "*00010OP=10200.0"

ZL

PURPOSE: Zero Lock. If ZL=0 the tare button on the rear of the RPM1 is active and may be used to initiate a tare function. If ZL=1 then the tare button is disabled until a ZL=0 command is issued. The ZL setting is stored in EEPROM.

TYPICAL COMMAND: *0100ZL

TYPICAL REPLY: *0001ZL=0

TYPICAL COMMAND: *0100EW*0100Z0=1

TYPICAL REPLY: *0001ZL=1

ZS

PURPOSE:

Read or set the value of the zero switch, a logic switch stored in RAM. ZS has three possible values.

ZS=0 when tare is off
ZS=1 when taring has been requested, but not active
ZS=2 when taring is in effect.

ZS is set to 0 on power up. Taring can be requested either with a ZS=1 command or by toggling the tare button on the rear panel of the RPM1. The next pressure reading following a tare request will be stored in RAM (ZV) and will be subtracted from all subsequent pressure readings until taring is turned off. When the value is stored in RAM, ZS is automatically set to 2 to indicate that taring is in effect. The value that is stored in RAM can be read using the ZV command.

If taring is already in effect when a ZS=1 command is issued, a new zero value is set after the next pressure reading and taring continues using the new value.

Changing the value of ZS by software requires an EW command, even though ZS is stored in RAM rather than EEPROM.

TYPICAL COMMAND: *0100ZS

TYPICAL REPLY: *0001ZS=1

TYPICAL COMMAND: *0100EW*0100ZS=0

TYPICAL REPLY: *0001ZS=0

ZV

PURPOSE:

Zero value. Stored in RAM. Read or enter the value to be used for taring. A specific value may be set if taring is presently in effect (ZS=2). A ZS=1 command or toggling the tare button will overwrite the value that was set.

Changing the value of ZV by software requires an EW command, even though ZV is stored in RAM rather than EEPROM.

ZV is set to 0 on power up.

TYPICAL COMMAND: *0100ZV

TYPICAL REPLY: *0001ZV=14.5037

TYPICAL COMMAND: *0100EW*0100ZV=20.000

TYPICAL REPLY: *0001ZV=20.000

SPECIAL DIAGNOSTIC COMMANDS

MC

PURPOSE: Memory check. Checks integrity of PROM program. Returns "Y" if correct, "N" if error.

TYPICAL COMMAND: "*0100MC"

TYPICAL REPLY: "*0001MC=Y" program correct

CS

PURPOSE: Check stack. Returns number of unused bytes in microprocessor operations stack since power was last applied.

TYPICAL COMMAND: "*0100CS"

TYPICAL REPLY: "*0001CS=5"

CT

PURPOSE: Check counter timebase. Puts counter timebase divided by 512 onto display clock line (pin 6 on nine-pin connector or pin 11 on 25-pin connector). Cancelled by next command. The counter timebase is very stable; however, several microseconds of jitter appear on the output waveform because the microprocessor interrupts which generate the divided output are asynchronous relative to the counter timebase.

TYPICAL COMMAND: "*0100CT"

no reply

CX

PURPOSE: Check crystal. Puts microprocessor clock divided by 480 onto display clock line (pin 6 on nine-pin connector or pin 11 on 25-pin connector). Cancelled by next command.

TYPICAL COMMAND: "*0100CX"

no reply

CALIBRATION COMMANDS

CHANGING THESE VALUES PERMANENTLY ALTERS THE CALIBRATION. The commands below are used to read or change the RPM1 calibration coefficients. Altering values requires a prior "EW" command. These commands cannot be global "99" commands.

SN

PURPOSE:	Read/enter unit serial number.	
ACTION:	Same as other coefficients. S/N is 6 digits long.	
TYPICAL COMMAND:	"*0100SN"	Read present value
TYPICAL REPLY:	"*0001SN=004876"	
TYPICAL COMMAND:	"*0100EW*0100SN=004444"	Change value
TYPICAL REPLY:	"*0001SN=004444"	

PA

PURPOSE:	Read/enter pressure adder in units selected by UN setting.

PM

PURPOSE:	Read/enter pressure multiplier.
ACTION:	Same as other coefficients. Intended for offset and span adjustments to calibration. Output P = PM*(Pcalc + PA), where Pcalc is pressure calculated using original calibration data and UN.
TYPICAL COMMAND:	"*0100PA"
TYPICAL REPLY:	"*0001PA=0000000"
TYPICAL COMMAND:	"*0100EW*0100PM=1.00002"
TYPICAL REPLY:	"*0001PM=1.000020"

TC

PURPOSE: Read/enter timebase correction factor.

ACTION: Same as other coefficients. TC = 10 MHz/TCXO freq.

TYPICAL COMMAND: "*0100TC"

TYPICAL REPLY: "*0001TC=.6666667"

TYPICAL COMMAND: "*0100EW*0100TC=.6666666"

TYPICAL REPLY: "*0001TC=.6666666"

C1

PURPOSE: Read/enter C1 pressure coefficient, as above.

C2

PURPOSE: Read/enter C2 pressure coefficient, as above.

C3

PURPOSE: Read/enter C3 pressure coefficient, as above.

D1

PURPOSE: Read/enter D1 pressure coefficient, as above.

D2

PURPOSE: Read/enter D2 pressure coefficient, as above.

T1

PURPOSE: Read/enter T1 pressure coefficient, as above.

T2

PURPOSE: Read/enter T2 pressure coefficient, as above.

T3

PURPOSE: Read/enter T3 pressure coefficient, as above.

T4

PURPOSE: Read/enter T4 pressure coefficient, as above.

T5

PURPOSE: Read/enter T5 pressure coefficient, as above.

U0

PURPOSE: Read/enter U0 pressure coefficient, as above.

Y1

PURPOSE: Read/enter Y1 pressure coefficient, as above.

Y2

PURPOSE: Read/enter Y2 pressure coefficient, as above.

Y3

PURPOSE: Read/enter Y3 pressure coefficient, as above.

3.8 RESOLUTION, INTEGRATION TIME, AND SAMPLING SPEED

The resolution of the internal transducer is determined by the counter integration time. Users can adjust the integration time to optimize resolution, noise rejection, and sample rate for a wide variety of applications by using the PR command. The RPM1 is shipped with the value PR=238 in EEPROM.

The relationship between PR, pressure resolution, integration time, and maximum sampling rate is shown in the table below.

PR	PRESSURE RESOLUTION FS	PRESSURE SIGNAL INTEGRATION TIME	P2(period) MAX SAMPLES/S	P4(pressure) MAX SAMPLES/S
10000	0.05 ppm	28.0 s	0.036	0.02
2380	0.1	6.7	0.15	0.08
1190	0.2	3.3	0.30	0.16
476	0.5	1.3	0.74	0.40
238	1	0.67	1.5	0.8
119	2	0.33	3.0	1.6
48	5	0.13	7.3	4.0
24	10	0.07	14.3	8.0
12	20	0.033	27	16
6	40	0.017	51	19
4	60	0.011	71	19
3	80	0.0084	89	19
1	240. ppm	0.0028 s	120	19

The values above are for a typical RPM1 with a pressure signal period (Pper) of 28 microseconds and a temperature signal period (Tper) of 5.8 microseconds. Values may vary by about 10% from unit to unit.

Resolution, integration time, and maximum samples rates may be calculated as follows, where sensor periods are in microseconds:

$$\text{Resolution/F.S.} = \frac{1}{150 * PR * Pper}$$

$$\text{Pressure Sensor Integration Time} = \frac{PR * Pper}{10,000} \text{ sec.}$$

$$\text{P2 Command Max Samples/s} = \frac{10,000}{(PR + 1) * Pper}$$

$$\text{P4 Command Max Samples/s} = \frac{10,000}{(PR + 1) * Pper + (4PR + 1) * Tper}$$

At very short counter integration times, sample rates are limited by internal microprocessor speed or baud rate rather than by integration time.

3.9 HIGH SPEED SAMPLING

High speed sampling requires special attention to baud rate, sample integration time, and programming.

Assuming a typical message at high speed of 14 characters, the maximum number of data values/second at various baud rates is tabulated below.

BAUD RATE	MAXIMUM SAMPLES/SEC
300	2.1
600	4.3
1200	8.6
2400	17
4800	34
9600	69
19200	137

Thus, high baud rates must be used for fast sampling.

At very high speeds, programs written in BASIC may not be able to keep up with incoming data, particularly if they try to do many calculations or screen display while data is coming in. If programs are limiting your speed, possible ways to speed them up are:

- Avoid calculations while data is coming in. Store it for later processing.
- Increase the size of the communications RS232 input buffer in the computer. (For example, on an IBM PC, use the /C option when loading BASIC).
- Use a basic compiler.
- Use a faster language such as Pascal or Fortran.

Assuming that the baud rate and computer are fast enough, the RPM1 operating parameters which affect speed are the PR command and the sampling mode chosen. For large values of PR, the sample rate is limited by the counter integration time. As PR is made smaller, the sample rate increases. Somewhere around 15 samples/s, the speed begins to be limited by the microprocessor calculation speed. Generally, the continuous send commands are somewhat faster than repeated individual commands because counting of the next sample proceeds while the previous one is being calculated.

Two special burst sampling procedures can be used to obtain faster sample rates.

The P7 command allows up to about 45 samples/s. With this command, temperature is measured once and that value is used for the temperature correction of all subsequent pressure measurements. This is faster because time is saved by not having to count the temperature signal on every reading and because many of the temperature correction terms are calculated only once and then stored. This command is intended for relatively short bursts. If internal sensor temperature changes rapidly during the data run (more than about 0.3°C), small errors will be introduced in the data because all temperature corrections are being made with the temperature measured at the start of the run. In more rapidly changing thermal environments, errors can be minimized by reissuing the P7 command periodically to force an update of the temperature being used.

The fastest sampling method uses period measurement commands Q1 and P2 and can achieve sample rates up to 120 samples/s. The RPM1 reports period data directly, and calculation of pressure is done in the user's computer. Typically, the user takes a single temperature period with command Q1, a burst of pressure periods with command P2, and then another temperature with Q1. The user interpolates the before and after temperature periods to get a temperature period

corresponding to each pressure period measurement and uses this pair of periods to calculate the corrected pressure using the equation in Appendix A.7. Note that the transducer calibration coefficients needed can be obtained via bus commands.

The mode parameter MD can affect sampling speed. When doing high speed sampling at greater than about 15 samples per second, sample rates using commands P3, P4, or P7 will be slightly slower in mode MD=1 or MD=3 than in mode MD=0 or MD=2 because of the extra time required for the display. Other commands are not affected. For example, a P4 command that gives 19 samples/sec for MD=0 will run about 5% slower for MD=1, and a P7 command giving 48 samples/sec for MD=0 will run about 20% slower for MD=1.

3.10 GLOBAL COMMANDS

Sometimes it is convenient to have a single command affect all RPM1 units in a loop. For certain instructions, using the destination address "99" causes all the units in the loop to respond.

Some commands can only be sent with a global address. They are:

BR
ID
PT

The global address is often used with the sample and hold commands when there are multiple RPM1's in a loop. The global address synchronizes them to take measurements at the same time. The sample and hold commands are:

P5
P6
Q5
Q6

All of the sampling commands and a few other commands may be either individually or globally addressed.

P1 through P7
Q1 through Q6
DB
DS
VR
EW

The remaining commands should not be sent as global commands.

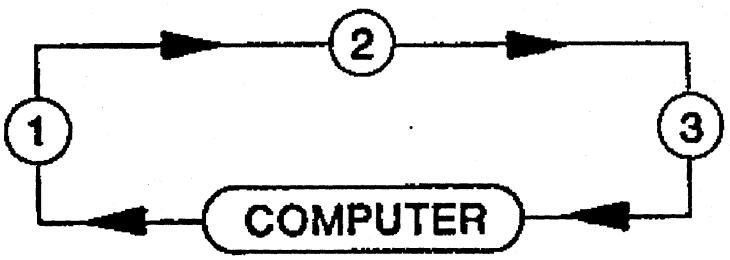
PR
TR
UN
UF
All calibration coefficients commands.

When an RPM1 recognizes a global command, it relays it to the next RPM in the loop before acting on it. The result is that the global command echoes around the loop and comes back to the computer in addition to the RPM1 responses. For all global commands except the VR command, the echoed command precedes the responses.

3.11 MULTIPLE RPM1'S ON THE RS232 BUS

The addressable command structure allows use of up to 98 units simultaneously in a loop on a single RS232 port. Global commands (destination address 99) allow all RPM1's to be addressed with a single command. Keep in mind that the maximum number of messages per second on the bus is limited by the baud rate (See Section 3.9). For loops with multiple RMP1's, the higher baud rates are recommended.

Logically, the structure of the bus is a one way circle. A typical three unit loop is shown below.



All messages move clockwise around the loop, relayed from one RPM1 to another. Each RPM1 picks off the messages addressed to it and relays responses or other messages onward.

When setting up a loop:

1) Set all RPM1's to the same baud rate before installing them in the loop. Two units at different baud rates cannot communicate. Although there are ways to synchronize afterwards, they involve a lot of EEPROM writing. When all units are at the same baud rate, a new baud rate can be chosen with a global BR command.

2) Use the global ID command *9900ID to auto-number units around the loop and find out how many there are (from the source address of the command coming back to the computer).

3) The serial number of each RPM1 can be checked by polling it with the SN command.

4) The easiest way to take data is with a global sample and hold "*9900P5" followed by a global dump sequential command "*9900DS". This keeps samples synchronized and keeps the data sorted out at the computer.

5) It is possible to have several RPM1's simultaneously in continuous send mode, but because exact integration time varies from unit to unit, the data can come back in a chaotic order and must be sorted out according to source address.

6) The wiring diagram for loop interconnections is shown in Appendix A.2. Note that only 4-wire cabling is required, or only 3-wire cabling if RPM1 power is not bussed. The terminator block after the last RPM1 wraps the transmit data line back to the computer input. With this arrangement, any unit can be removed from the loop either by unplugging it and replacing it with a terminator jumper or by removing the y-adapter and plugging the two extension cables together.

3.12 DISPLAY MODES

The mode parameter MD controls operation of the display and other background tasks. It is stored in EEPROM in the RPM1, and can be changed by user command over the RS232 data bus.

For most users, mode MD=1 is the standard mode. When powered up in this mode, the RPM1 resets and begins displaying pressure. In this mode, priority attention is given to computer requests but the display is supported as a secondary or background task. Whenever the RPM1 sends a pressure measurement to the computer in response to a user request, the RPM1 also displays the value. In addition, whenever the RPM1 is not occupied servicing user request, it measures pressure and sends the value to the display. The display update rate depends upon the PR parameter. These background measurements are interrupted whenever the higher priority computer requests require attention. Under all normal conditions, this protocol assures frequent display update.

When MD=0 or MD=2, the display is controlled only by an on-line user computer. The value displayed is changed only in response to specific user requests via the DV ("Display Value") or DR ("Display Right-adjusted") commands. These commands send data calculated in the host computer to the transducer, which in turn sends it to the display. Elaborate user programs are possible which collect data from the RPM1 and other sources, calculate derived quantities, and send them to the display. Modes MD=0 and MD=2 are used primarily for special purposes in computer-based data acquisition systems.

3.13 DISPLAY INTERRUPTION BY A USER COMPUTER

Because computer requests have priority, there are three unusual special situations when display updating can be interrupted for significant amounts of time by host computer requests:

- If an on-line computer keeps the RPM1 fully occupied carrying out commands other than pressure measurements (for example, rapidly repeated period measurements with a P1 command). This would not normally be done except for diagnostic checks. While this occurs, the display is frozen at the last value sent and no warning is given.
- If a display and hold command is issued (P5, P6, Q5, Q6), the data is held and display is suspended until a DB or DS command to send the data is received. If no DB or DS command arrives within 2 seconds, the display reads "------" to warn that the display is not current. Normal operation resumes when the next command arrives or power is interrupted. It is good programming practice when using sample and hold commands to set up an error exit routine to issue a command (such as *9900VR) that restores normal display operation upon exit.
- If the continuous period measuring commands (P2 or Q2) or continuous temperature measuring commands (Q4) are executed, the display reads "------" to warn that the display is not being updated. Normal operation is restored when the next command is received or power is interrupted. Again, it is good programming practice to set up an error exit to restore normal display operation upon exit.

3.14 DISPLAY HANGUPS

If the display does not show pressure when power is first applied, it is probably because a user computer program has set the display mode to MD=0. Reset the mode to MD=1 with the MD command.

On-line user computer programs which issue sample and hold commands (P5, P6, Q5, Q6) and exit without a DB or DS command or which issue continuous sampling commands (P2, P7, Q2, Q4) and exit without terminating them can leave the display in the "------" state. Users should set up error exit routines to avoid exiting in undefined states. Normal operation is restored when the next command is received or power is interrupted.

APPENDICES

APPENDIX A.1

USING THE RPM1 WITH A PPC1

The RPM1 can be used with any PPC1. The PPC1 can be configured to use the RPM1 as the external pressure reference to achieve a sophisticated high accuracy pressure controller.

The RPM1 can be plugged into the COM2 port of the PPC1 to allow the PPC1 to use this pressure reference instead of the internal transducer.

INITIAL SET UP

When the RPM1 is used with a PPC1, there are a few procedures that must be followed.

1) The PPC1 must be put into DEVICE=RPM mode. This notifies the PPC1 that it is to use the RPM that is plugged into the COM2 port as the pressure reference.

2) The serial communication parameters must be configured the same. The default parameters for the PPC1 are:

BAUD	:	2400
PARITY	:	E
DATA	:	7
STOP	:	1

The default parameters for the RPM1 are:

BAUD	:	1200
PARITY	:	N
DATA	:	8
STOP	:	1

3) Before the two devices can work together properly, the configuration of one or both devices must be changed. This can be done by the "COM2=" command of the PPC1 and/or the "BR" and "PT" command of the RPM1.

When the RPM1 is used with a PPC1, no external power supply is required. The PPC1 supplies +12V on 9 of COM2.

COMMUNICATIONS

When the two devices are communicating properly, any RPM1 command can be sent to the PPC1 and in return, the PPC1 will pass it on to the RPM1. The proper format for the command is "#cccccccc". When the command is preceded by "#", the character will be stripped off and the remainder of the command will be sent out the COM2 port of the PPC1 (i.e., to read a single pressure from the RPM1, the command would be "#*0100P3"). If the PPC1 is in the DEVICE=1 mode, any corresponding reply from the RPM1 will be received by the PPC1 and echoed back to the host computer. If the PPC1 is in the DEVICE=2 mode, any corresponding reply from the RPM1 will be absorbed by the PPC1 and no reply will be echoed back to the host.

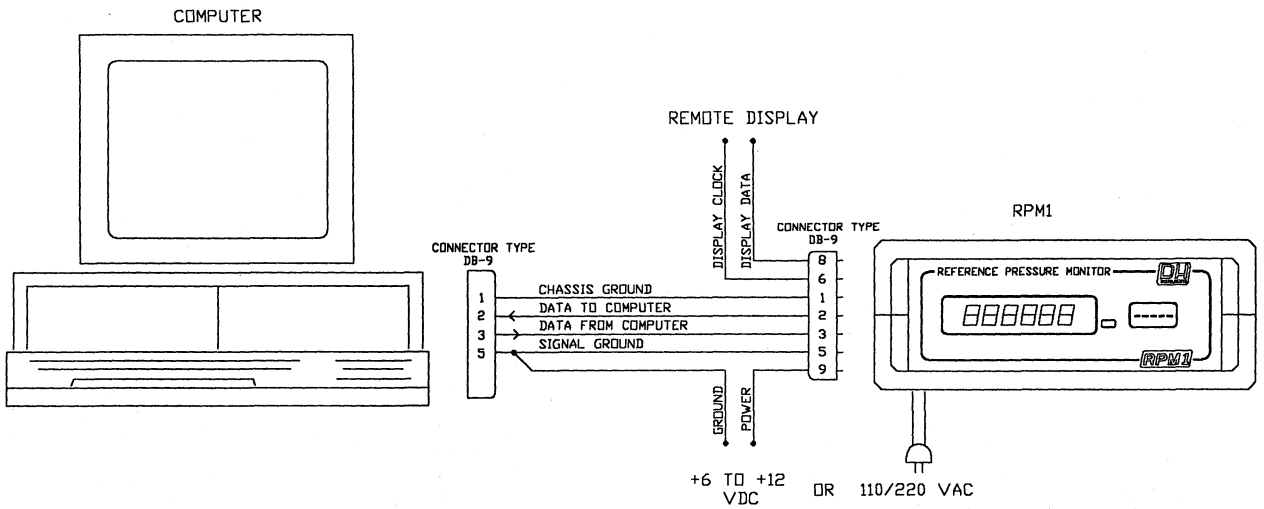
HOOKUP

If a cable was not purchased with the RPM1, the following diagram will be helpful in making your own cable.

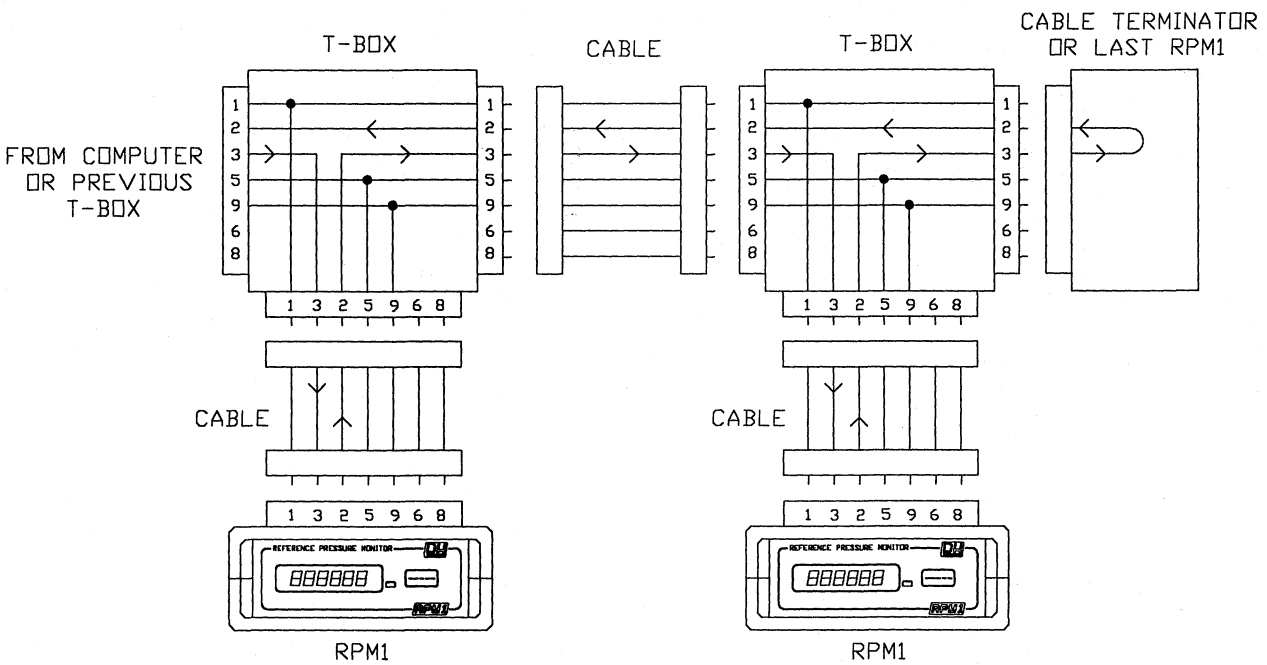
PPC1 to RPM1				
RxD	2	<----------	2	TxD
TxD	3	---------->	3	RxD
Gnd	5	<---------->	5	Gnd
+12V	9	<---------->	9	+V

APPENDIX A.2

RS232 WIRING AND CONNECTORS



DA188

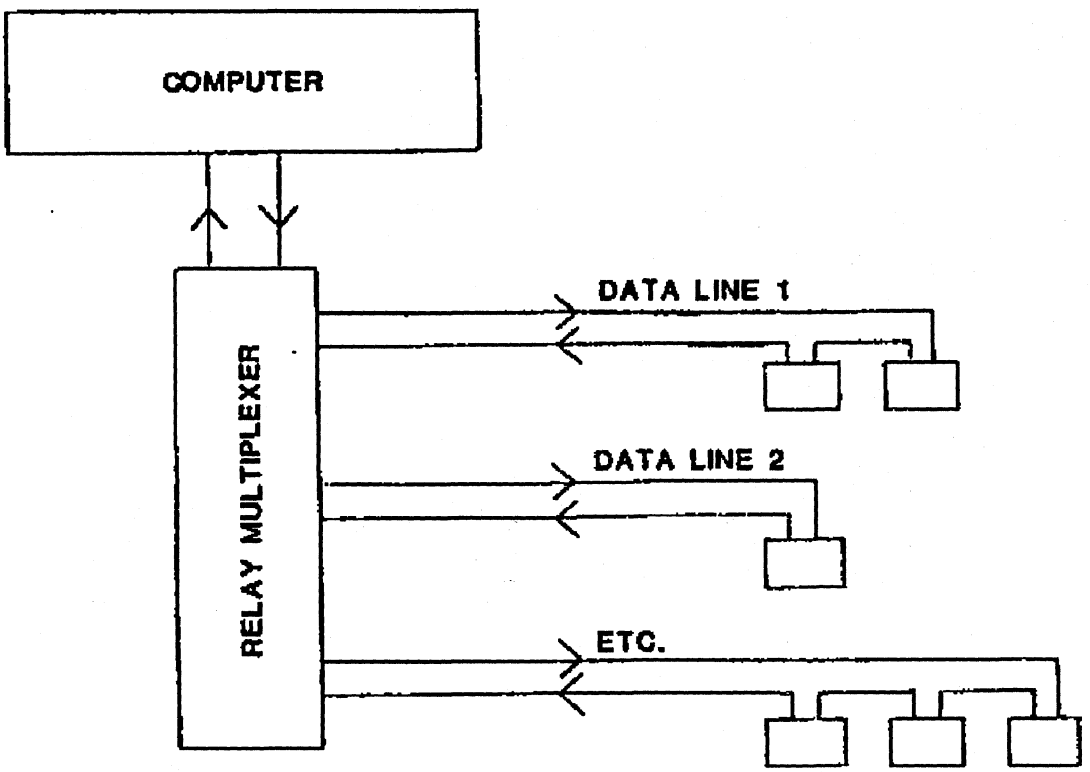


DA189

TRANSMITTER CONNECTOR	
PIN NO.	**DESCRIPTION**
1	CHASSIS GROUND
2	DATA TO COMPUTER
3	DATA FROM COMPUTER
5	SIGNAL GROUND
6	DISPLAY CLOCK
8	DISPLAY DATA
9	POWER

MULTIPLEXER SYSTEM FOR HIGH SECURITY APPLICATIONS

For high security applications with a large number of RPM1's, it may be desirable to use a relay multiplexer as a switching hub to select separate data lines running out to individual units or clusters of RPM1's. With this configuration, there is no limit to the total number of units in the system. Loss of any one data line through accident or failure will affect only the cluster on that data line.



APPENDIX A.3

HOOKUP HINTS

A simple diagram showing the hookup requirements for a single RPM1 shown in Appendix A.2. Multiple interconnections are also shown.

A pigtail connector is provided which mates with the RPM1. Hookup consists of attaching power leads from the unit to a power supply and running receive and transmit data lines to the computer RS232 output connector or using the supplied 6VDC adapter. If the RPM1 is used as device 2 with a PPC1, power is supplied from the PPC1.

Most computer RS232 ports have either male or female 25 pin connectors. Generally, on the computer connector, receive data (incoming) goes to pin 3, transmit data (outgoing) comes out pin 2, signal ground is pin 7 and chassis ground is pin 1. These standard assignments are shown in Appendix A.2; however, the user should check his computer manual to verify them.

These connections are all that the RPM1 requires; however, depending on the user computer and how a program opens up the RS232 port, the user may need to provide handshaking signal levels by jumpering pins on the computer 25 pin connector. If you can't seem to get any messages back from the unit, first make sure that the baud rate is correct and that the communications channel is set up for 8 data bits, no parity, 1 stop bit. Then try a global command (*9900VR) to make sure the ID is correct. If that doesn't work, the computer may be waiting for handshake signals (CTS, DSR, CD) which the RPM1 does not provide. On the IBM PC and most other computers, you can choose to ignore these signals when you open up the communications channel. See the programming examples in the text. If your computer insists on these signals, you can provide them by jumpering back the DTR signal (often on pin 20 of the computer 25 pin connector) to the CTS, DSR, and CD pins on the same connector (often on pins 5, 6, and 8).

The IBM PC AT uses a 9 pin serial port connector. Pin connections are tabulated below.

IBM PC AT 9 pin	STANDARD RS232 25 pin
3 Data from computer	2 Data from computer
2 Data to computer	3 Data to computer
5 Signal ground	7 Signal ground
4 DTR	20 DTR
8 CTS	5 CTS
6 DSR	6 DSR
1 CD	8 CD
	1 Frame ground

APPENDIX A.4

PROGRAMMING HINTS

- Sometimes it is hard to be sure exactly what your computer is sending out. One trick is to disconnect the RPM1 and replace it with a connector which wraps the computer transmitted data back to the computer receive line. Then by looking at the data in the receive buffer, you can find out exactly what was sent.

- If you can't seem to get any messages back from the RPM1, first make sure that the baud rate is correct and that the communications channel is set up for 8 data bits, no parity, 1 stop bit. Then try a global command (*9900VR) to make sure the ID is correct. If that doesn't work, the computer may be waiting for handshake signals (CTS, DSR, CD) which the RPM1 does not provide. On the IBM PC and most other computers, you can choose to ignore these signals when you open up the communications channel. See the programming examples in the text. If you computer insists on these signals, you can provide them by jumpering back the DTR, signal (often on pin 20 of the computer 25 pin connector) to the CTS, DSR, and CD pins on the same connector (often on pins 5, 6, and 8).

- If the RPM1 sends data continuously without being asked whenever powered up, check the setting of the MD parameter.

- Almost all commands generate a reply, but for long integration times some replies may take several seconds.

  Exceptions:
  a) An undefined (garbage) command addressed to a specific sensor will be absorbed. Example: "*0100ZQ"
  b) Sample and hold commands generate no response.

- Global commands echo back the command in addition to whatever response they produce. The reason is that each RPM1 passes on the command to the next RPM1 in the loop before acting on the command.

  Example: command: "*9900P1"
  "*9900P1"
  "*000128.12345"

- The computer receive buffer should be cleared after applying power to the RPM1. Turning on power to the RPM1 causes the output lines to go from zero to defined voltage levels. This produces a garbage character in the input buffer of some computers. Alternatively, when getting data from the input buffer, throw away leading characters until you come to an "*". All legitimate RPM1 replies begin with "*".

- At the start of all programs, send a command (*9900VR is a good choice to terminate whatever the RPM1 may have been doing and then clear out the RS232 receive buffer on your computer. Remember that when a "continuous send" command is given, the RPM1 continues to send data even after the computer is halted. If you restart the program, the RPM1 will still be sending data whether it is expected or not.

- Do not routinely rewrite EEPROM at the start of every program. Check the values and change only what needs changing. A given register in EEPROM is guaranteed only for 10,000 rewrites.

- When writing control parameters in EEPROM, (e.g., BR=, PR=, UN=, etc.), always wait for the reply before sending other commands addresses to the same RPM1. The sensor ignores commands addressed to it until its EEPROM write is completed (about 0.1 seconds). Commands for other RPM1's are relayed properly. No wait is required when reading EEPROM.

- In IBM BASIC, the function LOC (file number) will tell how many bytes are in receive buffer.
- Although the standard versions of IBM BASIC which have been tested did not officially support 19200 baud, they worked with acceptable error rates on an IBM PC (4.77 MHz clock) as long as screen printing was minimized when reading incoming data at fast sampling rates.

APPENDIX A.5

SAMPLING COMMANDS

			Approx. Maximum Samples/sec.
STANDARD SAMPLING COMMANDS			
Pressure	P3	single sample and send	13
	P4	continuous sample and send	19
	P5 DB	single sample and hold send stored value	12
Temperature	Q3	single sample and send	24
	Q4	continuous sample and send	57
	Q5 DB	single sample and hold send stored value	23
PERIOD SAMPLING COMMANDS			
P period	P1	single sample and send	31
	P2	continuous sample and send	120
	P6 DB	single sample and hold send stored value	23
T period	Q1	single sample and send	26
	Q2	continuous sample and send	120
	Q6 DB	single sample and hold send stored value	23
BURST SAMPLING COMMANDS			
Pressure Burst	P7	continuous sample and send	45
Period Burst	Q1, P2, Q1	command sequence	120
	P5 DB	single sample and hold send stored value	12
Temperature	Q3	single sample and send	24
	Q4	continuous sample and send	57
	Q5 DB	single sample and hold send stored value	23

APPENDIX A.6

USEFUL IBM BASIC INSTRUCTIONS

References: IBM BASIC REFERENCE MANUAL, especially Appendix C
IBM BASIC HANDBOOK, Chapter 2

When calling BASIC from the system, the communications buffer size can be changed using the /C option.

Example: BASICA/C:2048 sets buffer to 2048 bytes

In BASIC, the following instructions are useful:

OPEN"COMn"	opens communications file n
CLOSE n	closes file n
LOC(n)	function to find out how many characters are in the input buffer for file n
INPUT#	input up to <cr> or comma
LINE INPUT#	input up to <cr>
INPUT$	input a specified number of characters
PRINT#	send data from computer
WRITE#	send data from computer. NOT RECOMMENDED Inserts quotes around strings
GET	get specific number of characters from buffer
PUT	put specific number of bytes into output buffer
ON COM(n)	detects activity on communications port

STRING MANIPULATION INSTRUCTIONS:

INSTR LEFT$ RIGHT$ MID$	find specific character of string
VAL	convert a string to a numeric value
STR$	convert numeric value to a string

APPENDIX A.7

CALCULATION OF PRESSURE AND TEMPERATURE FROM PERIOD MEASUREMENTS

The RPM1 calculates temperature and pressure from period measurements to two frequency signals. The equations used in the calculations are given below:

$$\text{temperature} = Y_1U + Y_2U^2 + Y_3U^3 \qquad \text{deg C}$$

$$P = C(1 - T_0^2/Tau^2)[1 - D(1 - T_0^2/Tau_20] \qquad \text{psi}$$

where: Tau = pressure period in microseconds
U = (temp period) - U_0 microseconds

$$C = C_1 + C_2U + C_3U^2$$

$$D = D_1 + D_2U$$

$$T_0 = T_1 + T_2U + T_3U^2 + T_4U^3 + T_5U^4$$

These equations express temperature and pressure in terms of the transducer calibration coefficients:

Temperature coefficients:

U_0 Y_1 Y_2 Y_3

Pressure coefficients:

C_1 C_2 C_3 D_1 D_2 T_1 T_2 T_3 T_4 T_5

These coefficients are stored in EEPROM and can be obtained from the RPM1 via the RS232 bus.

Final output pressure is computed from the above using the following equation:

$$P_{output} = PM\ [(\text{units multiplier}) \times P + PA]$$

When units are changed using the UN command, Pa is automatically recalculated to be correct in the new units.

APPENDIX A.8

ZERO AND SPAN ADJUSTMENTS

Commands PA and PM can be used for minor RPM1 zero and span adjustments. Normally the pressure adder PA is set to zero and the pressure multiplier PM is set to 1.0.

Adjusted pressure is calculated using the equation:

$$P_{adjusted} = PM * (P + PA)$$

where P is the pressure calculated using the original calibration coefficients and the selected units factor. The user enters PA in the selected units. The RPM1 converts the entered value to psi before storing it. Whenever the unit is asked to send the value of PA, it will be reconverted and sent in the units in effect at the time of the request.

The PA parameter can also be used to offset absolute pressure readings to read gauge pressure.

Be very careful when using the PA and PM commands because they directly affect the RPM1 calibration. Inaccurate values will result in inaccurate data.

APPENDIX A.9

SOFTWARE AND HARDWARE VERSIONS

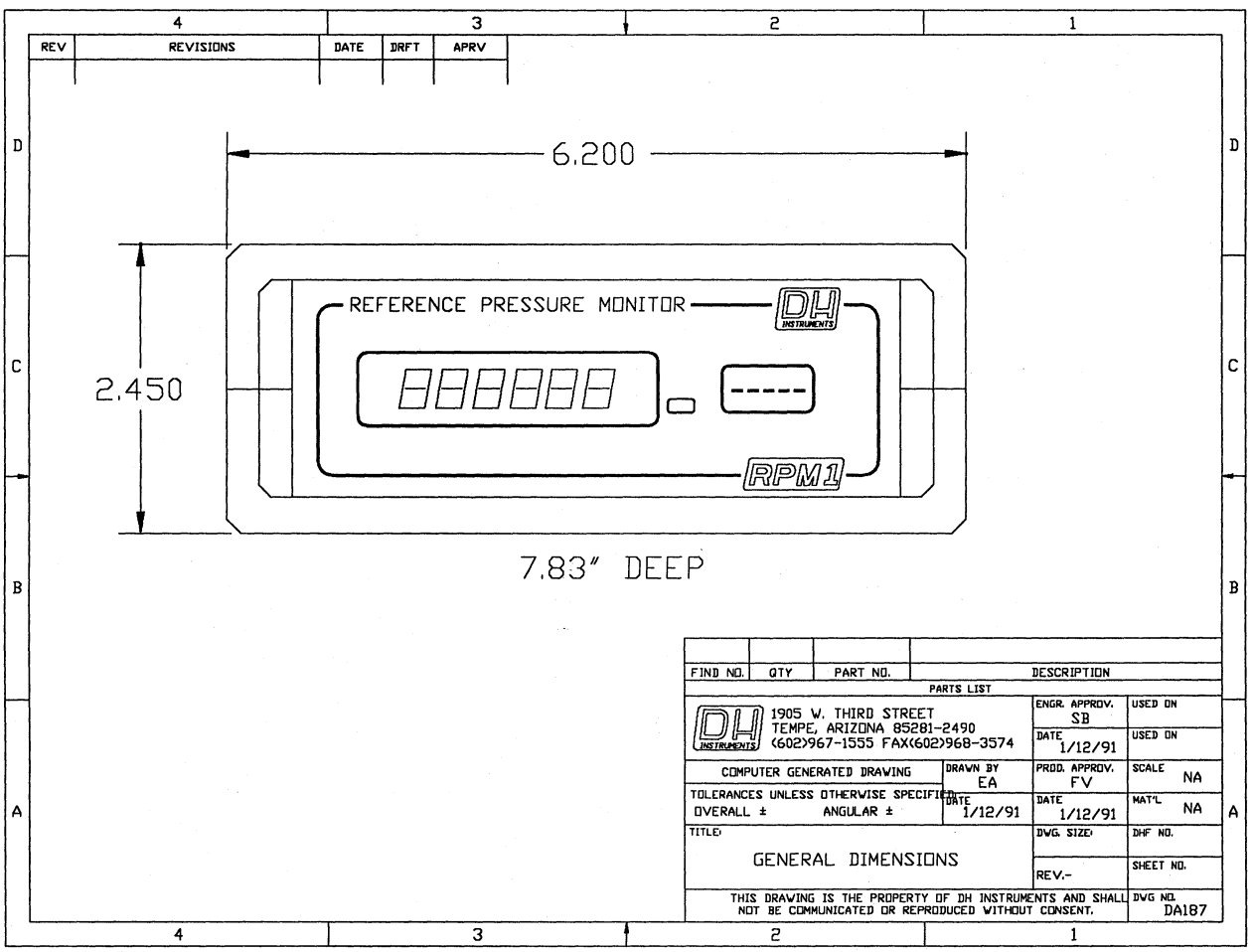
A number of evolutionary improvements have been made to the hardware and software in the RPM1 to add display capability and extra commands and features. We have maintained full forward compatibility, so that user programs written for one version operate properly with all later versions, and different versions can be mixed on the same loop.

The hardware and software version of any RPM1 can be determined with the VR command. If desired, any unit can be upgraded to support all of the latest features. Design changes are summarized below:

Software version	1.00	Original series. Upgrade requires circuit board replacement.
	2.00	Commands added: none. Hardware changes: input selection modified for future flexibility. Upgrade for all software features except display driving requires PROM replacement. Adding display capability requires circuit board modification.
	3.00	Display capability added. Commands added: MD, DV, DC. Hardware changes: display driving. Upgrade requires PROM replacement.
	4.00	Refinements to display capability, parity, sequential dump. Commands added: DP, DR, DS, MC, PT. No hardware changes.

APPENDIX A.10

DIMENSIONAL DRAWING



APPENDIX A.11

RPM RANGER SOFTWARE

RPM RANGER is intended to allow the user a simple, straight forward way of selecting different ranges for a given transducer. Each transducer has a corresponding disk file that contains all information pertaining to each range. The user may modify these files at any time with the understanding that the values entered directly effect the calibration and stated accuracy of the RPM. The RPM "Ranges" window pertains to the available calibrated ranges for the RPM. The RPM "Status" window displays the current RPM settings that effect each unit. These settings are automatically read from the RPM and displayed.

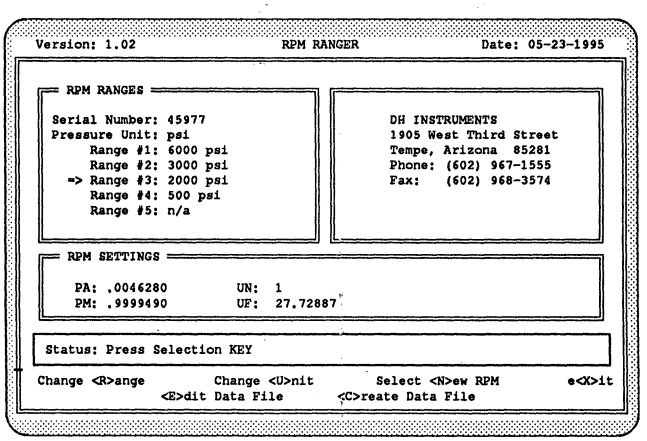
CHANGING RANGES

The executable file, RANGER.EXE, and all related data files, "*.SEN", should be located in the same subdirectory or on the same floppy disk.

To change ranges for a given transducer, the following sequence of events must occur:

- an RPM must be attached to the COM1 port of the computer
- the required data must be read from an RPM before changing its range. This includes the serial number and other important information. The serial number will be used to locate the appropriate data file for the RPM.
- the new range must be selected. All range specific information will be automatically written to the RPM.

To initiate the software, key "ranger" at the DOS prompt. After the initial opening screen, the user is prompted to attach an RPM to the COM1 port of the computer. If [Enter] is pressed, all required information will be read from the RPM and displayed on the screen. Pressing [Esc] or [Tab] followed by [Enter] will bypass reading of the RPM data.



From the main operating screen, the following keys have special functions:

R After the data from an RPM has been read and the information from the corresponding data file has been retrieved, pressing [R] will display a pop-up window that allows the user to select the desire range in the current pressure unit of the RPM. The [↑] and [↓] keys can be used to highlight the appropriate selection. When the desired range is highlighted, pressing [Enter] will write this new information to the RPM.

U The pressure unit of the RPM may be changed by pressing [U]. A pop-up menu will be displayed allowing the user to select a new unit. The [↑] and [↓] keys can be used to highlight the appropriate selection. When the desired unit is highlighted, pressing [Enter] will write this new information to the RPM.

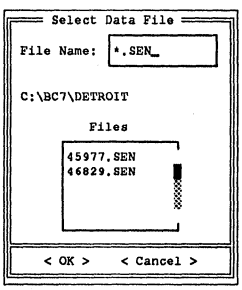
N This allows an easy way to change ranges on another RPM or re-read the current RPM data. After pressing (N), the user will be prompted to attach an RPM to the COM1 port of the computer. This is the same process as described when the software is first initiated.

E An existing data file may be edited. See the following section for details on the data file and its structure.

C A new data file may be created if one does not exist. See the following section for details on the data file and its structure.

X Pressing (X) will terminate the operation of the program and return the user to the DOS prompt.

CREATING/EDITING DATA FILES

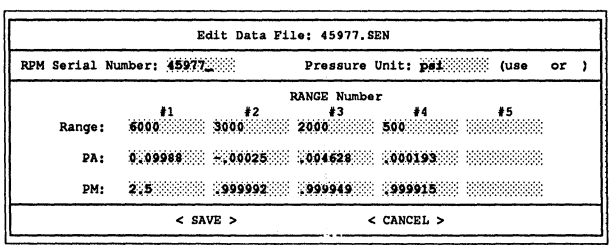


Before editing an existing disk file, a file must first be selected. A pop-up window will appear and display the available disk files. The desired file may be typed into the edit window or the [Tab] key may be pressed and the appropriate field may be selected using the [↑] and [↓] keys. Once the proper file is highlighted, pressing [Enter] will select it and the file may now be edited.

When editing or creating a data file, it is important that all information be verified prior to saving the file, as this data directly effects the calibration of the RPM.

The data file is stored to the disk using the serial number of the RPM. Therefore, it is important that the serial number be entered correctly since the data file will be read automatically after the serial number is read from the RPM.

The PA (Pressure Adder) for the RPM is unit dependent. If the pressure unit of the RPM changes, the PA value will also change. For consistency, the PA and range values for each RPM will be stored in the same pressure unit that they are entered and converted to the appropriate unit when required. The PM (Pressure Multiplier) value is not unit dependent and is not effected by changing units.



The following keys can be used when editing or creating a data file:

[Tab] will move the cursor to the next available edit field

[Shift]+[Tab] will move the cursor to the previous edit field

[↑] / [↓] will move up or down within a given range field

[Enter] will move to the next available edit field. It is not possible to move to the next data field unless the previous one has been completed.

[Esc] will exit the edit/create function without changing or saving any data

(User Notes)

(User Notes)