GE
Sensing & Inspection Technologies

PACE

Pressure Automated Calibration Equipment

Heritage Communications Manual - Instrument Emulation K0469

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Introduction

This technical manual provides communication protocol instructions for the remote control of the PACE Series instruments when emulating older Druck instruments.

Safety

- The manufacturer has designed this product to be safe when operated using the procedures detailed in this manual. Do not use this product for any other purpose than that stated.
- This publication contains operating and safety instructions that must be followed to make sure of safe operation and to maintain the equipment in a safe condition. The safety instructions are either warnings or cautions issued to protect the user and the equipment from injury or damage.
- Use qualified* programming technicians and good engineering practice for all procedures in this publication.

Pressure

Do not apply pressure greater the maximum safe working pressure to the PACE Series.

Maintenance

The PACE Series must be maintained using the manufacturer's procedures and should be carried out by authorised service agents or the manufacturer's service departments.

Technical Advice

For technical advice contact the manufacturer or subsidiary.

* A programming technician must have the necessary specialist knowledge of programming, technical knowledge and documentation to carry out the required work on the PACE Series.

Associated Documents:

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Abbreviations

The following abbreviations are used in this manual; abbreviations are the same in the singular and plural.

a	Absolute
ASCII	American Standard Code for Information Interchange
e.g.	For example
Fig.	Figure
ft	Foot
g	Gauge
GPIB	General purpose interface bus
i.e.	That is
IEEE 488	Institute of Electrical and Electronic Engineers standard 488 (for programmable devices with a digital interface)
m	Metre
max	Maximum
mbar	Millibar
min	Minute or minimum
No.	Number
RS232	Serial communications standard
Rx	Receive data
SCPI	Standard commands for programmable instruments
Tx	Transmit data
+ve	Positive
-ve	Negative
°C	Degrees Celsius
°F	Degrees Fahrenheit

Pressure measurement units

The following units are used in this manual

ATM	atmosphere	KG/M2	kilogrammes per square metre
BAR	bar	KPA	kilo Pascals
CMH2O	centimetres of water at 20°C	LB/FT2	pounds per square foot
CMHG	centimetres of mercury	MH2O	metres of water
FTH2O	feet of water at 20°C	MHG	metres of mercury
FTH2O4	feet of water at 4°C	MMH2O	millimetres of water
HPA	hecto Pascals	MMHG	millimetres of mercury
INH2O	inches of water at 20°C	MPA	mega Pascals
INH2O4	inches of water at 4°C	PA	Pascals
INH2O60	inches of water at 60°F	PSI	pounds per square inch
INHG	inches of mercury	TORR	torr
KG/CM2	kilogrammes per square centimetre	MBAR	millibar

Pressure units and conversion factors

Pressure units	Factor (hPa)	Pressure units	Factor (hPa)
mbar	1.0	cmH_2O @ 20°C	0.978903642
bar	1000.0	mH_2O @ 20°C	97.8903642
Pa (N/m^2)	0.01	kg/m^2	0.0980665
hPa	1.0	kg/cm^2	980.665
kPa	10.0	torr	1.333223684
MPa	10000.0	atm	1013.25
mmHg @ 0°C	1.333223874	psi	68.94757293
cmHg @ 0°C	13.33223874	lb/ft^2	0.4788025898
mHg @ 0°C	1333.223874	inH_2O @ 4°C	2.4908891
inHg @ 0°C	33.86388640341	inH_2O @ 20°C	2.486413
mmH_2O @ 4°C	0.0980665	inH_20 @ 60°F	2.487641558
cmH_2O @ 4°C	0.980665	ftH_2O @ 4°C	29.8906692
mH_2O @ 4°C	98.0665	ftH_2O @ 20°C	29.836983
mmH_2O @ 20°C	0.097890364	ftH_20 @ 60°F	29.8516987

Unit Conversion

To convert FROM pressure VALUE 1 in pressure UNITS 1
TO pressure VALUE 2 in pressure UNITS 2, calculate as follows:

$$\text{VALUE 2} = \text{VALUE 1} \times \frac{\text{FACTOR 1}}{\text{FACTOR 2}}$$

Note:

The PACE instrument contains selectable pressure units and user defined units. Use the conversion factors to calculate a user defined unit from the table above. Refer to the data sheets SDS0001 or SDS0008 for the list of selectable pressure units.

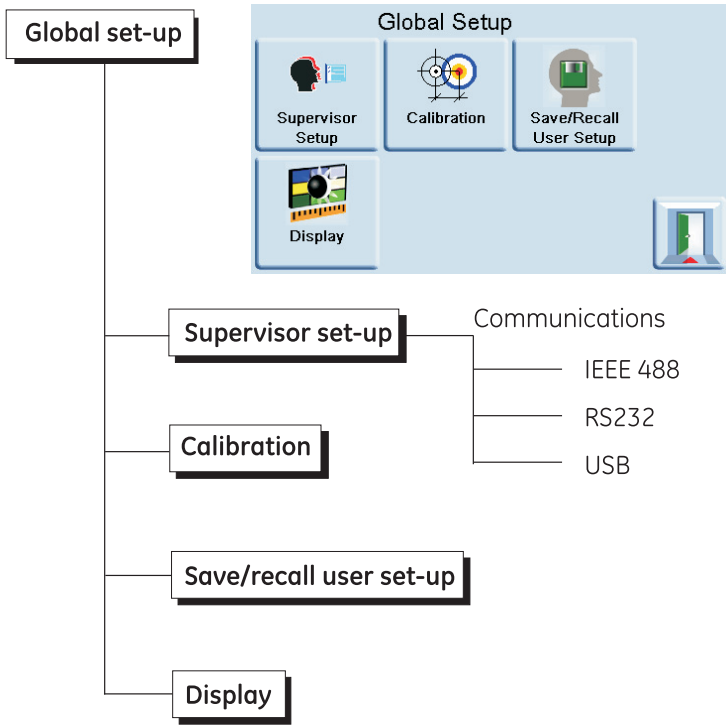
1 Setting the Communications

Access through Supervisor Set-up

The Supervisor menu provides facilities for programming settings. These are usually made during installation as follows:

Important Note:

A PIN protects the Supervisor menu against unauthorised use. Each instrument on delivery contains the factory set PIN (0268). To continue protecting the supervisor set-up menu the PIN should be changed as soon as possible.



Comms

Selects a communication port and parameters for simultaneous operation of the RS232, IEEE 488 and USB interfaces.

The appropriate settings can be selected in this menu for communicating with the control computer (PC) and the required command protocol.

Note:

The recommended remote communication protocol for PACE instrument is SCPI, refer to publication K0472, SCPI Remote Communications Manual.

RS232

Located on the rear panel an external RS232 connection requires:

Connector	=	9-way 'D' female wired as per Figure 1
Communications	=	RS232 point-to-point only (DPI 520 daisy chain is not supported)
Baud Rate power-up default	=	9600, no parity & handshake = xon/xoff.
Baud rates selectable	=	2400, 4800, 9600, 19k2, 38k4, 57k6 & 115k2
Parity	=	None, Odd & Even
Flow control	=	None, Hardware & xon/xoff
Protocols	=	5000=SCPI, DPI500, DPI520 6000=SCPI, DPI500, DPI510
New data up-date rate	=	refer to data sheet

Built-in EMC Filtering and Transient voltage protection.

IEEE

Located on the rear panel an external IEEE 488 connection requires:

Connector	=	24-way 'D' female wired as IEEE 488 standard
Communications	=	IEEE488 GPIB
Default Address	=	16
Protocols	=	5000=SCPI, DPI500, DPI520 6000=SCPI, DPI500, DPI510
New data up-date rate	=	refer to data sheet

Built-in EMC filtering and transient voltage protection.

2 Communications - Instrument Emulation

The PACE instrument can be operated in remote mode either via the IEEE 488, RS232 serial interface ports or the USB. Ports share a common communication language based on the ASCII character set. However, due to the physical differences between these interfaces there are additions to the RS232 and USB command set for emulating the hardware features of the IEEE interface.

Local Mode

This mode is entered as soon as the instrument is switched on and before any control codes have been issued. If the instrument is currently operating in the remote mode, to return the instrument to Local mode, either a **RO** or **M** command must be issued over the communications interface.

In Local mode, the instrument touch screen is enabled. Some communications commands are operational in Local mode, as they request data and do not affect operation.

Control Codes

Control codes sent to the instrument cause it to respond in accordance with the command sent. Control codes are sent to the instrument over the communications interfaces. The control codes consist of shared codes, that are common to all and other codes that are either interface specific. Table 1 gives a list of shared control codes.

The communication protocol on the instrument have a user selectable checksum option. This increases the validity of data transfer. The checksum protocol is bi-directional, the instrument can generate checksums for outgoing data and check checksums for incoming data.

Control Code Format

All values are coded as the ASCII equivalent commands and may be sent individually or in strings. Symbols used to describe these ASCII codes are:

< > contain a parameter which is further defined.
[ ] additional optional values - command specific
contain actual ASCII characters to be transmitted.

The string format is:

<CONTROLCODE>[<CONTROLSELECTION>][<CONTROLVALUE] <TERMINATOR><DELIMITER>

Where:

<CONTROL CODE> is a single alpha character i.e. **"R"**. This code must always be included.

[<CONTROL SELECTION>] is an integer value, which in conjunction with the **<CONTROL CODE>** specifies the operation of the command. This is a command specific value and for some commands is completely omitted.

[<CONTROL VALUE>] supplies any numeric values required for the command.
The values take on the following format:

"="<SIGN><VALUE>

Where:
"=" is not mandatory.

<SIGN> is **"+"** or **<SPACE>** or no character for positive values and **"-"** for negative values.

<VALUE> is ASCII numeric value.

<TERMINATOR> is <CR>, carriage return.
<DELIMITER> is not mandatory but can be any of the following:
"," ";" ":" <SPACE>.

Example "R1,S0,P=123.45,W20"<CR>

Sets remote mode, units as scale 0 (bar), pressure set-point 123.45, wait time 20 sec.

Implementation of Checksums

Data from the instrument would be sent as follows: **-0.001 REMR1S0D0|22**

22 is the checksum.

The communication protocol on the instrument have a user selectable checksum option. This increases the validity of data transfer. The checksum protocol is bidirectional, the instrument can generate checksums for outgoing data and check checksums for incoming data.

Checksum definition

The checksum used is an ASCII character addition, mod 100, two digit (ASCII representation) checksum. This makes decoding by the host computer relatively simple.

Example

The code to place the instrument into remote mode is R1. This can be broken down as follows:

R - ASCII code 82

1 - ASCII code 49

Total = 131

Mod 100 = 31

Therefore, to send R1 with the checksum, R1|31 should be sent.

The | signifies the start of the checksum.

Data from the instrument would be sent as follows:

-0.001 REMR1S0D0|22

22 is the checksum

Checksum set-up

Accessed by selecting Global set-up/Supervisor set-up/Communications/RS232, IEEE 488 or USB/Checksums set the following:

Off- No checksum is used. This is equivalent to the communications on the DPI 510 pressure controller.

Auto- This causes the instrument to always send the checksum. However, on reception the checksum is only checked if appended to the command. If the checksum is incorrect then the command is not executed and a checksum error is generated.

On- This is the most secure method, the instrument always generates a checksum, and always expects to see a checksum appended to the command. If the checksum is incorrect or the checksum is missing then the command is not executed and a checksum error is generated.

Checksum Errors

Checksum errors are generated by setting the 1st and 8th bit of the status byte (programming error and checksum bit).

NOTE: *In DPI 520 mode all the status bits can be displayed since the status is displayed as a 2 digit hexadecimal number. In DPI 500 and DPI 510 mode only, the first six status bits are displayed (2 digit octal).*

Function	Command	Checksum	Action	Available In
Mode Select	M	77	Local Control	Remote/Local
	R0	30	Local Control	Remote/Local
	R1	31	Remote Control	Remote/Local
Scale	S0	31	bar	Remote/Local
	S1	32	psi	Remote/Local
	S2	33	kPa	Remote/Local
	S3	34	Units as defined by U command	Remote/Local
Units	U1 to U24	34-87	S3 Units selection	Remote/Local
Data Select	D0	16	Selects data source for N0/N1	Remote/Local
	D1	17	Selects data source for N0/N1	Remote/Local
	D2	18	Selects data source for N0/N1	Remote/Local
Notation	N0	26	Selects output data format	Remote/Local
	N1	27	Selects output data format	Remote/Local
	N2	28	Selects output data format	Remote/Local
	N3	29	Selects output data format	Remote/Local
	N5	31	Selects output data format	Remote/Local
	N7	33	Selects output data format	Remote/Local
	N8	34	Selects output data format	Remote/Local
Interrupt	I0	21	No Interrupt	Remote/Local
	I1	22	Error	Remote/Local
	I2	23	In Limit	Remote/Local
	I3	24	In Limit and Error	Remote/Local
	I4	25	End of Conversion	Remote/Local
	I5	26	Error and End of Conversion	Remote/Local
	I6	27	In Limit and End of Conversion	Remote/Local
	I7	28	In Limit Error and End of Conv.	Remote/Local
Wait Value	W<Value>	87 + Value	Wait value	Remote/Local
Controller	C0	15	Controller OFF	Remote
	C1	16	Controller ON	Remote
Set-point	P<Value>	80 + Value	Set-point value	Remote
Ratio	/0 to /11	95-45	Set-point ratio	Remote
Preset	*0 to *11	90-40	Set-point preset	Remote/Local
Error	@0	12	Disable error reporting	Remote/Local
	@1	13	Enable error	Remote/Local
Rate	J0	22	Rate	Remote
	J1	23	Maximum rate - no over shoot	Remote
	J2	24	Maximum rate - with over shoot	Remote
Rate Value	V<Value>	86 + Value	Rate value	Remote
Zero	01	28	Zero	Remote
Tare	B<Value>	66 + Value	Tare value	Remote
	T0	32	Tare OFF	Remote
	T1	31	Tare ON	Remote
Isolation Valve	E0	17	Close isolation valve	Remote
	E1	18	Open isolation valve	Remote
	F20	68	Close isolation valve	Remote
	F21	69	Open isolation valve	Remote

Table 1, Command Summary

Command Description
The following sections describe the commands in the order listed in Table 1.

Set to Local Mode - "M"
This command places the instrument into local mode.
Example **"M"** puts the instrument into local mode (see also R command).

Set Mode - "R"
This command places the instrument into either local or remote mode and turns the controller off.
On an instrument with a single controller (e.g. PACE5000). Value = 0 sets the instrument to Local and value =1, to remote mode.
Example "R1" puts the instrument into remote mode.
On an instrument with two controllers (e.g. PACE6000) R0 = local, R1 = 1st controller, R2 = controller 2.
Example "R2" puts the 2nd controller into remote mode and then a command identified with *, acts only on the 2nd controller.

*Set Scale Units - "S"
This command selects the pressure units. It takes the value 0 to 3. **S0 to S2** select bar, psi and kPa respectively. **S3** selects the units configured by the U command.
Example "S2" selects kPa.

*Units - "U"
Used in conjunction with the **S3** command, this command allows any of the instrument's units to be selected. The command takes a value which defines the required unit. See Table 2 for available units.
Example "S3,U4" selects **mbar** pressure units.

Data Select - "D"
The D command determines the source of data returned following a data request for Notations N0 and N1. It takes the value 0 to 2 as follows:

0 send current pressure
1 send current set-point (pressure demand)
2 send the reading on the display

Example "D1" sets the data source as current set-point.

Output Data Format - "N"
Notation code selection. Selects the format of the data when data is requested from the instrument. The command takes the value 0 to 8 according to the required format.
Example "N1" sets the data format to reading only.

Unit Symbol	Unit	U <argument>
Pa	Pascal	1
kPa	kilo-Pascal	2
MPa	mega-Pascal	3
mbar	millibar	4
bar	bar	5
kg/cm²	kilogram per square centimetre	6
kg/m²	kilogram per square metre	7
mmHg	millimetre of mercury	8
cmHg	centimetre of mercury	9
mHg	metre of mercury	10
mmH_2O	millimetre of water	11
cmH_2O	centimetre of water	12
mH_2O	metre of water	13
torr	1/760 x 1 atm (1 mm mercury	14
atm	atmosphere	15
psi	pound per square inch	16
lbf/ft²	pound force per square foot	17
inHg	inch of mercury	18
"H_2O04	inch of water @ 4°C	19
'H_2O04	feet of water @ 4°C	20
SPEC'	Special unit (user defined value 1)	21
"H_2O20	inch of water @ 20°C	22
'H_2O20	feet of water @ 20°C	23
hPa	hecta-Pascal	24
"H_2O60	inch of water @ 60°F	25
'H_2O60	feet of water @ 60°F	26
USER2	user defined value 2	27
USER3	user defined value 3	28
USER4	user defined value 4	29

Table 2 - Scale Units

Interrupt - "I"

The interrupt command sets the instrument to return a message when a specified event has occurred. It takes the value 0 to 7 to determine the event as follows:

0 No interrupt - all interrupts are disabled.
1 Interrupt on "In limit".
2 Interrupt on "Error".
3 Interrupt on "In limit" and "Error".
4 Interrupt on "End of Conversion".
5 Interrupt on "Error" and "End of Conversion".
6 Interrupt on "In limit" and "End of conversion".
7 Interrupt on "In limit", "Error" and "End of conversion".

Error

This occurs when a command's syntax is not understood or the command's parameters are out of range.

In-Limits

When a new set-point is entered the wait timer is reset (see W command). When the reading is within adjustable limits (defined in set-up) of the set-point, the wait timer is decremented once a second (if outside these limits then the timer is reset to its original value). When the timer reaches zero then in-limits signal is generated.

End of Conversion

Each time the instrument has a new reading (approximately 0.25 second) this event is generated.

Example "I5" sets an interrupt on error and end of conversion.

*Wait - "W"

Selects the wait time before the in-limits signal is active. It takes a value which is the wait time in seconds (0 to 100).

Example "W12" sets the in-limits wait time to 12 seconds

*Controller On/Off – "C"

Turns the controller on/off, it takes the value 0 or 1 as follows:

0 controller off
1 controller on

Example "C1" Turns the controller on

*Pressure Set-Point - "P"
This command allows a new pressure set-point to be entered. Its value is the new set-point in the current units. The control value is a number corresponding to the new set-point demand pressure in the current units.

Example "P=10.5" Sets the set-point to 10.5 in the currently selected units.

*Ratio - "/"
This command sets one of the preset division ratios. When in the divider task the instrument can divide a pressure range into a number of equal divisions. The number of divisions is set through the front panel. The command takes the values 0 to ^-1.

Example
If the 'high set-point' to 20 bar, the 'low set-point' is 0 and there are 11 points, then issuing the command to:

"/5"

Sets the set-point pressure to 10 bar (50% of 20 bar).

Preset - ""
This command selects one of twenty five preset values. It takes the value 0 to 24.

Example "*5" Selects preset 5.

Error Reporting On/Off - "@"

This command turns error reporting on or off. It takes the value 0 for OFF and 1 for ON. When turned ON, errors are reported as part of data output as defined in the output code format.

Example "@1" Enables error reporting.

*Rate - "J"
Selects the rate of change of pressure used to achieve set-point. The rate is as programmed on the function keys.

0 Rate programmed by the **V** command .
1 Maximum rate - no over shoot
2 Maximum rate - with over shoot

Example "J2" Selects the maximum rate over shoot allowed.

*Zero Instrument - "O1"
This command initiates a manual zero on the currently selected pressure range.

Example "O1" Zero's the current pressure range.

*Rate Value - "V"
Sets the rate to a value in current units per second. The rate is automatically set to variable rate.

Example "V=1.2" Sets rate to 1.2 units per second.

*Isolation Valve Open/Close - "E"
Controls the state of the isolation valve. It takes the value 0 for closed and 1 for open.

Example "E1" Opens the isolation valve.

*Open Isolation Valve - "F"
This command has been implemented for compatibility with the Druck DPI 510 pressure controller. It takes the value of either **20** (isolation valve closed) or **21** (isolation valve open). Functionally, it controls the state of the isolation valve in the same way as the "E" command:

Example "F21" (Functionally the same as **"E1"**) Opens isolation valve.

Tare Value - "B"

This command sets a value to be tared from the measured pressure. It takes the value of the tare in current units.

Example "B1013" sets the tare value to 1013 in current units.

*Tare On/Off - "T"
This command initiates the subtraction of the tare value from the measured pressure. It takes the value 0 for OFF and 1 for ON.

Example "T1" turns on the tare.

Output Code Format
The data sent consists of a data string of ASCII characters followed by the terminating characters programmed from the front panel.
The general format is:

<DATA><TERMINATOR>

Where:

<DATA>depends on Notation code/secondary address

<TERMINATOR> is one of the following, set from the front panel SET-UP:

<CRLF>
<CR>
<LF>

Error conditions are indicated by "@" <Value>. The complete parameter is omitted in the absence of error or error reporting if disabled (control code @0).

The format depends on the preceding notation code.

NOTE: *The numbers in brackets ( ) are the number of characters per item.*

Notation Codes

Notation Code = N0

Format:

<value(7)><mode(3)><range(2)><scale(2)><value source(2)>
<error/status code(3)><terminator>

Example "0.00007REMR1S2D1@01"

If no errors occur or error reporting is disabled then the error/status code is omitted.

Notation Code = N1

Format:

<value(7)><error/status code(3)><terminator>

Example "0.00007@01"

If no errors occur or error reporting is disabled then the error/status code is omitted.

Notation Code = N2

Format:

<mode(3)><range(2)><scale(2)><value source(2)>
<controller status(2)><interrupt code(2)>
<isolation valve status(3)><terminator>

Example "LOCR0S1D2C0I3F21"

Notation Code = N3

Format:

<In limit status(1)><error/status code(3)><terminator>

Example "0@01"

If no errors occur or error reporting is disabled then the error/status code is omitted.

Notation Code = N4

Format:

<error status(2)><terminator code(2)><rate(2)>
<variable rate(8)><units(7)><terminator>

Example "@1E1J2V 0.0025U mbar"

Notation Code = N5
Format:
"DPI520" <accuracy(3)><fullscale(12)":">
<serial number(7)><terminator>

Example "DPI520 A1 70.0000 barg: 2222"

Notation Code = N7
The status condition of the instrument is sent as:
<mode(3)><range(2)><scale(2)><value source(2)>
<controller status(2)><interrupt code(2)>
<notation code(2)><wait time(4)><terminator>

Example "REMR1S3D1C0I0N4W002"

Notation Code = N8
The full status condition of the instrument is sent as:

<mode(3)><range(2)><scale(2)><value source(2)>
<controller status(2)><interrupt code(2)><notation code(2)>
<wait time(4)><error status(2)><terminator code(2)><rate(2)>
<variable rate(B)><units(7)><tare(2)><tare value(8)><terminator>

Example "REMR1S3D1C0I0N4W002@1E1J0V+000001.U PaT18+000010"

Parameter Definitions

Value		Value selected by the" D" command, signed integer or floating point. When the instrument value is sent, the format in a 6 digit value plus decimal point. The value can be preceded by spaces to complete the 6 digit value. If the value is negative, a -ve sign is placed at the front of the value.
Mode	=	REM or LOC, remote or local
Range	=	R0 or R1 local or remote
Scale		S0 to S3 reports "S" status
Value source		D0 to D2 reports "D" status
Terminator	=	<CR><LF><SPACE>
Error/status code	=	present if error reporting is enabled and error present ("@" command)

Error code is stored as bits in a byte:

Bit 0 Command not accepted
Bit 1 Secondary address not available
Bit 2 Data string not valid
Bit 3 Reading in limits
Bit 4 Over range (reading exceeds transducer range or 99999)
Bit 5 End of conversion
Bit 6 Valve over temperature
Bit 7 Checksum error

Controller status		C0 or C1, reports "C" status
Interrupt code	=	I0 to I7 reports "I" status
Isolation valve status	=	F20 Isolation valve off F21 Isolation valve on

Notation code = N0 to N8 reports "N" status

Error reporting = @0 or @1 reports "@" status

Wait time "W" followed by 3 digit ASCII value

Limit status = 0 or 1, 0 = out of limit, 1 = in limit

Terminator code = String terminator

where:

E0 CR, LF
E1 CR
E2 LF

Rate Rate mode

where:

J0	variable rate
J1	auto rate
J2	max rate

Variable rate = "V" + variable rate

Units = "U" + units in text

Accuracy = " " - standard
"A1" - medium accuracy
"A2" - high accuracy

Full-scale = full-scale of instrument in bar.
The string also include the units and type:
g - gauge
a - absolute
d - differential

Serial number = configured serial number of instrument

Error/status Code

In the N0, N1 and N3 notation code settings, any error or status information changes occurring, if error reporting is enabled by control code @1, is indicated by the addition of @ value at the end of the data string.

Bit 0	Command not accepted - a command syntax error has occurred.
Bit 1	Secondary address not available. The instrument was addressed with a secondary address that it did not understand.
Bit 2	Data string not valid - The value returned by the instrument is not yet valid. This reading should be ignored (occurs when changing units and the instrument has not yet performed a new conversion).
Bit 3	Reading in limits - within the adjustable limits (defined in set-up) - including wait time.
Bit 4	Over range (reading exceeds transducer range or 99999).
Bit 5	End of conversion - a new reading is available.
Bit 6	Valve over temperature - one of the valves has overheated and shut down. The controller will not operate correctly until the valve has cooled down.
Bit 7	Checksum error - the checksum sent to the instrument was incorrect. Therefore the command was not executed.

In DPI 520 mode, the error/status code is sent as an hexadecimal number representation of the error/status byte. In the DPI 500 and DPI 510 modes, bits 6 and 7 are not available and the error/status code is sent as an octal number.

Example @01 indicates the code sent to the instrument was not executed.

"Data string not valid" and "Over-range" error flags are set and only reset when the error has been cleared.

RS232 Specific

When using RS232, the instrument is connected by a point-to-point connection to an "intelligent" controller (control computer).

Operation Using RS232

To use the system:

Determine the **Handshaking Method** required:

(a) Software Handshaking

RTS and CTS are not connected which reduces the number of connections between instruments. Refer to Section 2 for installation details.

OR

(b) Hardware Handshaking

This system uses the RTS and CTS signals from the instruments to control data flow. All control codes are acted upon as soon as they are interpreted. In addition sending <CR> will return a reading. The format of the returned data depends on the 'D' and 'N' command.

Operation Using IEEE 488

The IEEE 488 port allows up to 15 instruments to be controlled by a single computer over an IEEE 488 bus. Each instrument has a user configurable address. Commands are addressed over the bus. The instrument can transmit data (requested to TALK) or receive data (requested to LISTEN).

When the IEEE 488 bus is connected, the current instrument pressure reading or status information is obtained by addressing the instrument to "TALK".

The information sent back depends on the last notation code sent to the instrument. N0 is the power-up default.

The instrument will exit local control and enter remote control after receiving the control code R1. The instrument will return to local control after receiving the control code R0 or M. The IEEE 488 bus command "GTL" will also return the instrument to local mode.

Serial Poll

The PACE instrument will TALK in response to standard serial poll techniques. A single byte is sent whenever the instrument is programmed to TALK and the serial poll enable has been sent over the IEEE 488 data bus. The serial poll disable command discontinues the mode. The instrument activates the SRO (service request) line of the IEEE 488 data bus when particular events occur. For example, if a programming error is made or if the pressure controller has reached a stable "in limit" condition. The trigger event is set by the 'I' command.

GTL	**GO TO LOCAL** - Local control (manual) [default].
IFC	**Interface clear** - Instrument not reset.
DCL	**Device clear** - Reset instrument to default settings as follows:

Error status	@00
Notation code	N0
Display code	D0
Interrupt code	I0
Error reporting	Enabled
Wait time	W002

IEEE Bus Time-out

When the instrument receives the command to TALK, the transmit data is prepared before exchanging data with the control computer. The time-out value, the time that the control computer waits for the transmitted data, is selected and enabled in the control computer program.

It is recommended that the time-out value should be selected to greater than 50 milliseconds to correspond with the beginning of read back character transmission. If the TALK command is preceded by other commands then there will be a greater delay before the read back character transmission commences. The extra delay is related to the execution of the preceding commands. For a multiple command string e.g. R1 S0P200.0W20C1 allow a delay of approximately 1 second before requesting read back data. For much longer multiple command strings, the delay should be further increased.

DPI 500 Mode

The DPI 500 Mode enables the PACE instrument to become compatible with existing DPI 500 instruments. When YES is selected, the decimal point is not sent in data from the PACE instrument.

ASCII Values

Decimal	ASCII	Decimal	ASCII
0	NUL	33	!
1	SOH (CTRL-A)	34	"
2	STX (CTRL-B)	35	#
3	ETX (CTRL-C)	36	$
4	EOT(CTRL-D)	37	%
5	ENQ (CTRL-E)	38	&
6	ACK (CTRL-F)	39	' (apostrophe)
7	BEL (CTRL-G)	40	(
8	BS (CTRL-H)	41	)
9	TAB (CTRL-I)	42	*
10	LF (CTRL-J)	43	+
11	VT (CTRL-K)	44	, (comma)
12	FF (CTRL-L)	45	- (minus)
13	CR (CTRL-M)	46	. (full stop)
14	SO (CTRL-N)	47	/
15	SI (CTRL-O)	48	0
16	DLE (CTRL-P)	49	1
17	DC1 (CTRL-Q)	50	2
18	DC2 (CTRL-R)	51	3
19	DC3 (CTRL-S)	52	4
20	DC4 (CTRL-T)	53	5
21	NAK (CTRL-U)	54	6
22	SYN (CTRL-V)	55	7
23	ETB (CTRL-W)	56	8
24	CAN (CTRL-X)	57	9
25	EM (CTRL-Y)	58	: (colon)
26	SUB (CTRL-Z)	59	; (semi-colon)
27	ESC (CTRL-[)	60	<
28	FS (CTRL-\)	61	=
29	GS (CTRL-])	62	>
30	RS (CTRL-^)	63	?
31	US (CTRL-_)	64	@
32	(SPACE)		

Table 3, ASCII Values

Decimal	ASCII	Decimal	ASCII
65	A	97	a
66	B	98	b
67	C	99	c
68	D	100	d
69	E	101	e
70	F	102	f
71	G	103	a
77	H	104	h
73	I	105	i
74	J	106	j
75	K	107	k
76	L	108	l
77	M	109	m
78	N	110	n
79	O	111	o
80	P	112	P
81	Q	113	q
82	R	114	r
83	S	115	s
84	T	116	t
85	U	117	u
86	V	118	v
87	W	119	w
88	X	120	x
89	Y	121	y
90	Z	122	z
91	[	123	{
92	\	124	l
93		125	}
94	^	126	~
95	_ (underline)	127	DEL
96	' (back quote)		

Table 3 (cont.), ASCII Values

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