ARUN MICROELECTRONICS LTD.

PRESSURE GAUGE CONTROLLER MODELS PGC4S, PGC4D AND PGC4Q.

INTERFACE MANUAL ISSUE 4

For use with Program Version 2.00 onward.

The information contained in this manual has been carefully checked and is believed to be correct. No responsibility is assumed for any errors. User comment and criticism is welcome: please write quoting the serial number of the instrument and the version number of the software as displayed by the instrument to:

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Please direct other enquiries to the distributor or agent from whom you purchased the instrument.

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1. GENERAL DESCRIPTION.

Up to 16 PGC4 instruments can be connected to a single serial line. Line conditions are in electrical accordance with RS232C or RS485, to order. Instruments compatible with RS485 are downwardly compatible with RS422, since the drivers and receivers are connected to separate balanced lines (i.e. no transceivers are used). PGC4S, PGC4D and PGC4Q instruments can be mixed on the same line. Each instrument is identified by a unique address code, selected from the numbers 0 to 15 inclusive and defined by internal links. The address code is shown momentarily on the main LED display each time the instrument is switched on. Instruments connected to a single serial line are allowed to send characters only when addressed by the host computer. Either a short report giving current measured pressures or a full report of the status of the PGC4 can be requested. Current pressures are reported in filtered form.

Because the transmission rate is high and the quantity of data low the host computer can poll all instruments faster than any significant event in the vacuum system. The response time of an instrument to a host request is generally less than 1 millisecond.

Remote control is established and relinquished via the serial interface. Either an individually addressed instrument or all instruments may be switched to remote or local control by a single command. The status of any instrument is unchanged in every other respect after a change in control status.

The host computer can control:

Trip setpoints
Cold cathode high voltage supply switching
Cold cathode gauge calibration parameters
Cold cathode gauge low pass filter time constant

and all commands may be directed to a single gauge or instrument or all instruments.

At switch-on or after a reset due to derangement of the embedded program or an external reset via the Auxiliary connector an instrument is reset into the local operation mode with the high voltage supplies switched off.

2. HARDWARE.

2:1 PGC4 Line Drivers and receivers.

The type of line drivers and receivers fitted to any particular PGC4D or PGC4Q instrument may be determined by inspecting the model number inscribed on the rear panel. If this contains the suffix "F" then the line interface circuits are compatible with RS422/RS485. Otherwise they are RS232 types. Although the Remote Connectors fitted to the rear panel are the same type for the two interfaces. **ALL INSTRUMENTS AND HOST COMPUTER CONNECTED TOGETHER MUST HAVE THE SAME TYPES OF LINE DRIVERS AND RECEIVERS.** Driving RS485 receivers with RS232 drivers may cause damage to one or the other.

The type of line drivers selected will depend on the distance between the host computer and the most remote PGC4, the number of PGC4s sharing the same interface lines and the speed of response desired. The speed of response will normally be dominated by the transmission times, the latency of the PGC4 and host program should be small in comparison. Generally speaking, if the maximum distance is over 15 metres or there are more than six instruments sharing the same interface then RS485 drivers should be used.

2:2 Converting from RS232 to RS485/RS422.

A conversion kit consisting of:

1 off PGCX RS485 PCB assemblyAML part no KPGCRS485PCB
(marked AML C723 on the underside)

1 off PGC4 remote cable assemblyAML part no KPGC4REM485

1 off M3 "Nyloc" nut

1 off M3 shakeproof washer

1 off M3 x 12 pan head screw

is required. A No.0 or No.1 point "Pozidriv" and a small flat-bladed screwdriver are also required.

Disconnect the power connector and remove the smaller screws at the sides of the instrument. Note that the ventilation slots are at the right side, when viewed from the front. Remove the cover in an upward direction. Remove the screws retaining the Remote Connector on the rear panel and locate the 5-way Molex connector at the other end of the remote cable. Disconnect the Molex connector by inserting a fingernail or screwdriver between the brown latch and clear connector body while pulling the body upward. Do not pull on the wires. Replace this cable assembly with the one supplied in the kit but do not insert the Molex connector. Fit the connector using the M3 x 12mm screw at one end. On the projecting end of this screw inside the case fit the soldertag on the flying lead followed by the shakeproof washer and "nyloc" nut.

Locate the integrated circuit U24 adjacent to the Molex connector and prise each end up in turn by inserting the flat-bladed screwdriver between the body of the IC and its socket. Keep the body of the IC reasonably parallel to the socket: this will ensure that the pins are not bent. When the IC is released

avoid touching the pins. Insert the pins of the interface PCB into the U24 socket with the overhanging part toward the rear of the instrument. Take care to engage all the pins correctly in the socket. The pins are brittle and will break if bent. Insert the integrated circuit previously removed into the socket on the interface PCB, aligning the notch with the notch shown on the PCB legend. Insert the free Molex connector on the new Remote cable assembly onto the Molex pin header on the interface PCB. Do not connect it to the header on the main PCB.

Before replacing the cover read the next section.

2:3 Setting the interface parameters.

Disconnect the power connector and remove the smaller screws at the sides of the instrument. Note that the ventilation slots are at the right side, when viewed from the front. Remove the cover in an upward direction and locate USRLK2 at the centre of the main PCB assembly. Spare links are stored on LKPARK2 which is adjacent to USRLK2. Links stored there do not affect anything else.

Baud Rate. Fit or remove links at **BR0** and **BR1** according to the following to specify the baud rate:
2400fit links to BR0 and BR1
4800fit link to BR1 only
9600fit link to BR0 only
19200fit no links

Unique Instrument address. The instrument is binary-coded on links ID1 to ID4 on USRLK2. The presence of a link denotes a binary "0" and the absence of a link denotes a binary "1". **Ensure that all instruments connected to the same serial interface have different addresses.**

Line termination. If the instrument has option "F" fitted it has RS485/RS422 driver and receivers. The instrument which is furthest from the host computer should have a termination resistor connected across the "Received Data" lines. This is accomplished by moving the link fitted to the interface PCB from the "OFF" or "NO" position to the "ON" or "85" position (only one of these alternative legends will be present, according to the issue of the PCB). **Only one PGC4 receiver termination should be fitted per serial interface, all others should have links in the "OFF" position.**

For compliance with RS485 conditions lines should be terminated at both extremities. Termination of the most remote PGC4 transmitter must be done outside the instrument.

If a PGC4 fitted with a RS485 interface is to be used without being connected to a host computer it is recommended that a termination be fitted in order to decrease its sensitivity to radiated noise.

2:4 Cable construction and installation.

Twisted-pair cables are recommended for both RS232 and RS422/RS485 lines. Pairs of 7 x 0.2mm ($0.22mm^2$) PVC equipment wire twisted about 1 revolution per 1 to 1½ cm are suitable. This results in a characteristic impedance of around 100 ohms and is a reasonable match to the RS422/RS485 terminations. An overall screen is recommended and should be connected to the signal ground pin on the connectors. There is a 100 ohm, 1 watt resistor included in series with this connection in order to limit circulating currents due to ground line differences. In order to eliminate ground currents completely you may, for example, connect the incoming screen and leave the outgoing screen disconnected at

each connector on the daisy-chain. The allowable common mode differences in the RS485 specification is 7 volts, and the PGC4 complies with this. Connector pin numbers are defined in Appendix C. Each used pin should be connected to all similarly-numbered pins at every PGC4 and host computer connector on the interface. The wiring should be daisy-chained from the host computer to each instrument in turn; no branches or spurs should be allowed. The most remote PGC4 should have a termination connected, as described in section 2:3, above.

2:5 Host computer line drivers and receivers.

It is advisable to check certain conditions in the host computer line drivers and receivers, even if these are guaranteed to comply with the relevant standards.

If facilities exist for terminating lines at the receiver this should be done. For compliance with RS485 the line driver should also be terminated.

Consideration should be given to the receiver output state when the all the PGC4s are silent and their lines are in the "TRI-STATE" condition.

For RS422/RS485 the commonly used DS75176, SN75176 and similar transceivers do not guarantee that the output state of a receiver is defined when the inputs are terminated, but undriven, because of the ±200 millivolt offset of the receiver. The claim on the data sheet that "The receiver incorporates a fail-safe feature which guarantees a high output state when the inputs are left open" refers to a condition without termination. Connection of a termination, external cables or a driver with its outputs in the "TRI-STATE" condition will give unpredictable results and result in transmission errors. Normally, a 1 kilohm pullup resistor connected between the RXD+ line and the receiver +5 volt supply and a 1 kilohm pulldown from RXD- to the 0 volt supply line will ensure a high output state under properly terminated conditions.

For RS232 receivers an open-circuit input normally ensures a high output state. If this is not the case then adding a 10 kilohm pulldown resistor between the received data line and the receiver negative supply voltage will correct this.

Because the number of PGC4 instruments driving an interface may be between 1 and 16 it is not possible to fit these additional components on the drivers in the PGC4.

2:6 Demonstration software.

Two demonstration programs are available for IBM PC XT, AT or compatible computers. The computer requires DOS 3.0 or higher, a colour display and a free serial port. The baud rate (2400, 4800, 9600 or 19200 baud) and serial port (COM1: or COM2:) are selectable.

PGC4DEMO.EXE:
This program is used to control a single PGC4 instrument (although other instruments may be connected to the party line). The PC displays the pressures of all active gauges and the status of relays, and can assume control of the instrument in order to switch gauges, change setpoints, display messages, etc. The instrument type, ROM version/date and internal settings can be displayed.

PGCMULTI.EXE:
This program logs the status of up to 16 instruments on a party line. Pressures, relay status and errors are displayed, and the internal settings can be shown. To physically identify an instrument, it can be instructed to display its ID. The program does not control individual gauges but has the ability to start or stop all gauges in all instruments.

3. INTERFACE PROTOCOL.

Up to sixteen instruments can be connected to a single RS232 or RS422/RS485 party line. Instruments of different types can be connected on the same line, but all instruments must have their internal links set to

(a) the same baud rate
(b) a unique instrument address

Each instrument maintains its transmit line in a high-impedance state except when transmitting data in response to a request from the host computer. Each instrument has a unique address, set internally by links.

3:1 General Command and Response formats.

3:1.1 Host Computer Commands.

The host computer sends commands to instruments in the following format:

First byte: '*' (ASCII 47)

Second byte:Command character. All commands are represented by a single character.

Third byte:Instrument address. Instruments are identified by a single character from '0' - '9' and 'A' to 'F', corresponding to addresses 0 - 15. Some commands can be addressed to all connected instruments by 'X'.

Optional ASCII parameters: Additional command parameters may be single ASCII characters, or character strings (a series of ASCII characters followed by a delimiting character (any of ASCII 0, 13, or ',').

3:1.2 PGC4 response.

If the command was addressed to all instruments there is no response. Otherwise, the instrument addressed responds with a status byte and an error byte (see next page) followed by a CR-LF (ASCII 13, 10). If a status report was requested the status and error bytes are followed by the report, a checksum and then the CR-LF.

Instrument status byte coding:

Status byte: Bits 3-0 : Instrument type

0001_2 - PGC4S
0010_2 - PGC4D
0011_2 - PGC4Q
0110_2 - PGC6
0111_2 - RESERVED

Bit 4 : 0 = local mode, 1 = remote mode
Bit 5 : 1
Bit 6 : 0
Bit 7 : 0

Error byte:
Bit 0 : gauge - specific error
Bit 1 : instrument battery low
Bit 2 : internal settings were lost and restored to factory default
Bit 3 : command referenced a non-existent gauge or relay
Bit 4 : parameter was out of range
Bit 5 : command not accepted (where none of the above are applicable)
Bit 6 : always set to 1

Any bits set in the error byte are maintained until reset by a <reset error> command.

3:1.3 Timing of Next Command.

The host computer must not begin transmitting a new command until a CR-LF has been received, signalling the end of transmission, or two instruments may conflict on the serial line.

3:2 PGC4 Response time.

For the commands <poll>, <control>, <release>, <long>, <short> and <reset error>, which do not require any extra parameters, the instrument addressed will begin transmitting a response within about 200 µs. The response to other commands is sent as quickly as possible (typically 1 - 5 ms) but a minimum response time cannot be specified. The transmission time taken for a report to be sent is determined by the system baud rate.

3:3 Local/remote control.

An instrument starts operation in local control, i.e. using the front panel. In local mode the instrument responds only to commands without parameters (<poll>, <control>, <long>, <short> and <reset error>). The <control> command puts the instrument into remote mode, and all the other commands can then be used. The front panel can still be used to change the display but not to start gauges or change setpoints.

3:4 Host Computer Command Format.

Gauges within the instrument are addressed by a numeric character, found from the status report. For example, in a PGC4D instrument the two cold-cathode gauges are numbered '1' and '2', the two pirani gauges '3' and '4' and the capacitance manometer gauge, if fitted, by '5'. 'X' may be used where applicable to address all gauges within the instrument.

Relays are addressed by uppercase letters starting with 'A'. A PGC4Q instrument contains relays 'A' to 'L'. Again, 'X' may be used where applicable.

Command parameters may be single printable ASCII characters or ASCII strings (terminated by a delimiter). Numbers in scientific notation must be sent as ASCII strings of the form "9.9E±99,"; other ASCII strings can be of any length, including zero.

Bits 3-6 of the error byte should be checked after sending a command to ensure that the command has been understood and carried out. Bit 0 may be set if a gauge-related command cannot be carried out, e.g. pirani interlock, external inhibit.

In the following tables, the different parameter types are called 'Char' (single character, no terminator), 'Value' (ASCII string with terminator) and 'SN Value' (ASCII string with terminator in scientific notation form).

Command	Char	Parameters	Description
<short>	S	Instr	Request a short status report from an instrument reporting operating status of all gauges
<gauge>	G	Instr Gauge	Request status and pressure of a single gauge.
<long>	L	Instr	Request a long status report from an instrument.
<Gauge on>	N	Instr[1] Gauge[2]	Switch on gauge(s).
<Gauge off>	F	Instr[1] Gauge[2]	Switch off gauge(s).
<setpoint>	K	Instr Relay SN Value	Change a relay setpoint pressure.
<override>	O	Instr[1] Relay[2]	Permanently energise relay. Command <setpoint> restores normal operation.
<inhibit>	I	Instr[1] Relay[2]	Permanently de-energise relay. Command <setpoint> restores normal operation.
<filter>	f	Instr[1] Gauge[2] Char	Set low-pass filter time constant for a gauge. Permitted values are '0', '1', '2', '4' and '8' seconds.
<over-pr>	p	Instr[1] Gauge[2] SN Value	Set the maximum pressure for a cold-cathode or BA gauge. Units are mbar.
<calibrate>	Z	Instr[1] Gauge[2] Char	Select cold-cathode gauge calibration method. '0' :gauge type determined by internal links '1' :calibration table follows: See appendix A for details of calibration.

[1] these instrument addresses may be global, i.e. 'X'. [2] these gauge addresses may be global.

Name	Char	Parameters	Description
<gas factor>	g	Instr[1] Gauge[2] SN Value	Set pirani gauge gas factor, range 1.0E+00 to 9.9E+00
<bakeout>	B	Instr	Start bakeout using gauge 1 and current bakeout overpressure, temperature and time. Can be cancelled before end of the cycle by the <gauge off> command. (PGC6 only).
<bake temp>	T	Instr[1] Value	Set bakeout temperature setpoint (°C). (PGC6 only)
<bake time>	t	Instr[1] Value	Set bakeout cycle time (minutes). (PGC6 only)
<bake ovp>	b	Instr[1] SN Value	Set bakeout overpressure setpoint. (PGC6 only)
<reset error>	E	Instr[1]	Reset an instrument's error flags.
<display>	D	Instr[1] Value	Put a message on instrument's LED display. An empty string restores the default display, as does turning the front panel switch.
<sound>	n	Instr[1] "divisor" "time"	Make a sound for "time" msec by dividing a 920 KHz clock by "divisor". "divisor" can range from 40 to 10000, and "time" from 5 to 32000.

[1] these instrument addresses may be global, i.e. 'X'.
[2] these gauge addresses may be global.

Examples:

*C2 control instrument 2
*CX control all instruments
*S0 get a short status report from instrument 0
*N0X turn on all gauges in instrument 0
*F11 turn off gauge 1, instrument 1
*KBE2.0E-10, setpoint relay E, instrument 11 2.0e-10 mbar
*n8920,1000, instrument 8 sounds a 1 Khz tone for 1 second
*D0CHECK CABLE 1, flash "CHECK" and "CABLE 1" on instrument 0

3:5 Status reports.

There are three types of status report. The **short** status report gives the operating status and pressure of each gauge in the instrument. The **single gauge** report does the same for a specified gauge. The **long** status report lists the configuration of each gauge, each relay and the instrument. The information given by the long status report only needs to be read once after taking control of an instrument; its information may change during operation, but only predictably in response to host computer commands. The short or single gauge reports can be requested as often as required.

Pressures.

The pressure measurement for each gauge in the instrument is updated 4 times a second. Pirani and capacitance manometer gauge pressures are displayed and reported without filtering. Ion gauge pressures can be filtered with a time constant of 1, 2, 4 or 8 seconds, but filtering can be turned off if desired. The pressure field for a non-operating gauge is filled with spaces.

Status report formats.

All status reports begin with the status and error characters described on Page 2, and terminate with a checksum and CR-LF combination. The checksum is formed by adding all the preceding bytes, starting with the status byte, taking the two's complement of the least significant 8 bits. It is sent in hexadecimal as two characters, the most significant 4 bits first.

Status reports can be read in two ways:

(a) because the CR-LF terminator can only occur at the end of a report the report can be read into a buffer until the terminator is seen. The report is then decoded into gauge, relay or system records. This is the best approach on slower machines (such as IBM PCs).

(b) alternatively, the report can be read intelligently and decoded record by record. As each record has a header character ('G', 'R' or 'S'), and the records are of fixed length, the first character of the checksum signals the end of the report.

The overall length of a short or long status report depends on the instrument type and the number of gauges and relays installed in the instrument.

3:5.1 Short status report.

Status byte.

Error byte.

Two relay status bytes:

Each relay status byte is of the form $01XXXXXX_2$, where the least significant 6 bits indicate the state of each relay (1 = energised). The first relay status byte indicates the status of relays 'A' to 'F', with relay 'A' indicated by the least significant bit. The second relay byte indicates relays 'G' to 'L' where applicable. Any bits corresponding to non-existent relays are set to zero. The status of a relay assigned to a gauge which is switched off is determined by the positioning of an internal link; this setting is given in the long status report (see below).

Then, for each gauge in the instrument, a gauge record:

Byte	Name	Details
1	Header byte	'G'
2	Gauge type	'C' : cold-cathode 'I' : Bayard-Alpert 'P' : Pirani 'M' : capacitance manometer 'T' : trigger Penning
3	Gauge number	'1' ...
4	Gauge status	Bit 6: always set to 1 Bit 5: gauge externally inhibited Bit 3: gauge in degas Bit 2: gauge controlling bakeout Bit 1: gauge starting Bit 0: gauge operating
5	Gauge error	**Cold-Cathode Gauge error:** Bit 0 : low pressure Bit 1 : gauge is disconnected Bit 2 : pirani interlock prevents starting Bit 3 :maximum pressure exceeded Bit 6 : 1 Bit 7 : 0 **Bayard-Alpert Gauge error:** Bit 0 : gauge filament open-circuit Bit 1 : gauge overemission Bit 2 : gauge underemission Bit 3 : maximum pressure exceeded Bit 4 : pirani interlock prevents starting Bit 6 : 1 Bit 7 : 0 **Pirani Gauge error:** Bit 0 : Pirani gauge open-circuit Bit 6 : 1 Bit 7 : 0
6-13	Pressure	Comma delimited string in scientific notation, e.g. "1.3E-07,". If the gauge is not operating the string consists of spaces only, i.e. " ,"

Two-byte checksum.

CR, LF

3:5.2 Single Gauge Status Report Format.

A single gauge status report consists of the 4 status, error and relay status characters followed by one gauge record as per the short status report, a checksum and a CR-LF.

3:5.3 Long Status Report Format.

Status byte.

Error byte.

For each gauge, a gauge configuration record:

Byte	Name	Details
1	Header byte	'G'
2	Gauge type	'C' : cold-cathode 'B' : Bayard-Alpert 'P' : Pirani 'M' : capacitance manometer 'T' : trigger Penning
3	Gauge number	'1' ...
4	LP filter TC	'0','1','2','4' or '8' (seconds)
5-8	Unused	
9	Calibration	'0' : AML '1' : Balzers '2' : ESRF '3' : To be defined '9' : downloaded calibration curve
10-17	Maximum pressure (mbar) (cold-cathode and BA gauges) OR Gas factor (Pirani gauges)	"N.Ne-NN,"

For each relay, a relay configuration record:

Byte	Name	Details
1	Header byte	'R'
2	Relay letter	'A' - 'L'
3	Status	'0' : associated with gauge '1' : inhibited (de-energised) '2' : over-ride (energised)
4-11	Setpoint	Pressure in scientific notation "N.NE±NN,"
12	Associated gauge	'1' ...

System configuration record:

Byte	Name	Details
1	Header byte	'S'
2	Pirani 1 interlock	'0' : disabled '1' : enabled
3	Relay configuration	'0' :relay de-energised when gauge is off '1' : relay is energised
4	Instrument default cold-cathode gauge type	'0' : AML '1' : Balzers '2' : ESRF '3' : To be defined
5-9	ROM version	4-character ASCII string, e.g. "1.03,"
10-18	ROM date	8-character ASCII string, i.e. "DD/MM/YY,"
19-40		Additional system parameters may be defined in future

Two-byte checksum.

CR, LF

Appendix A. Format for downloading cold-cathode gauge calibration tables

A calibration table consists of from 2 to 32 pairs of current - pressure coordinates which define points on the gauge calibration curve, with the current values in descending order. Between these points the slope is assumed to be linear. The format is as follows:

Highest current (A) "9.9E-99,"
Highest pressure (mbar) "9.9E-99,"
.
.
Lowest current "9.9E-99,"
Lowest pressure "9.9E-99,"

Checksum : 2 ASCII digits representing the 2's complement in hexadecimal of an 8-bit sum of all characters in the downloaded table (the command characters "*ZNNN" are **not** included in the checksum).
CR, LF

A parameter error flag will be set if any of the following are true:

Number of values read is odd.
Number of pairs < 2 or > 32.
Any value does not conform to scientific notation format.
Any current value higher than its predecessor.

The value of the final current/pressure pair determine the lowest valid pressure. At currents below this value, the measured pressure remains at the final value and a low-pressure error is sent in the gauge status record.

Appendix B. Example of a host/PGC4 dialogue.

Source	ASCII	Hex	Description
Host	*P5	2A 50 35	Host polls instrument 5
Instr 5	#@	23 40	PGC4Q under local control
Host	*P1	2A 50 31	Host polls instrument 1
Instr 1	1A	31 41	PGC4 under host control, Gauge-specific error occurred
Host	*S1	2A 53 31	Host requests short report
Instr 1	1A m@ GC1 A B 2.7E-03, GP2 A@ 7.5E-03, GP3 A@ 1.0E+03, 8D __	31 41 6D 40 47 43 31 41 41 32 2E 37 45 2D 30 33 2C 47 50 32 41 40 37 2E 35 45 2D 30 33 2C 47 50 33 41 40 31 2E 30 45 2B 30 33 2C 38 44 0D 0A	Status and error bytes Relays A,C,D energised Gauge : Cold-cathode gauge 1 HV on Error = low pressure Pressure Gauge record : Pirani Gauge 1 running Gauge record : Pirani Gauge 2 running at atmosphere Checksum End of report
Host	*E1	2A 45 31	Host acknowledges and clears Instr 1 error flag
Instr 1	1@	31 40	Instrument clears its error byte and indicates readiness to accept a new command
Host	*F1	2A 46 31	Host removes HV supply from Cold-cathode gauge
Instr 1	1@	31 40	Instrument 1 status byte. No error
Host	*d1Check HV,	2A 64 31 43 68 65 63 6B 20 48 56 2C	Flash "Check" "HV" on instrument 1 LED
Instr 1	1@	31 40	Instrument 1 status byte No command or gauge error

Appendix C. Remote connector.

This is a 9 way "D" type male connector. Used pin connections and signal names for **RS232** are:

3 Received Data
2 Transmitted data
5 Signal ground

If option F is present (as indicated by the suffix F in the model number on the rear panel) then the pin connections and signal names are compatible with **RS422 or RS485** as follow:

6Received data +
7Received data -
8Transmitted data +
9Transmitted data -
5Signal ground
1Protective ground

END.