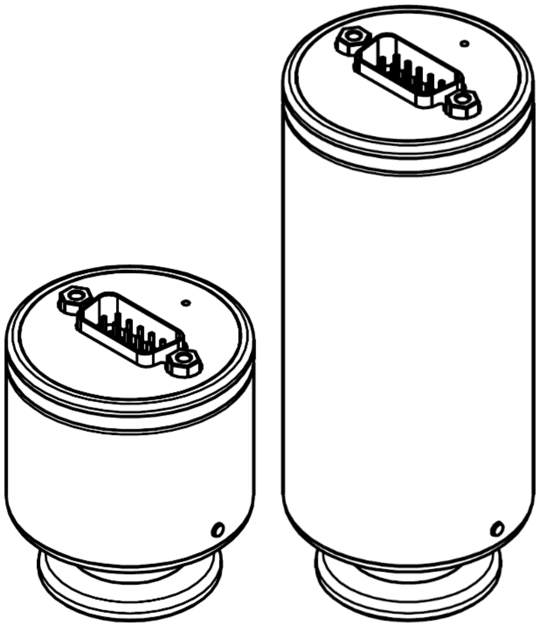


RS232 Communication Protocol

PTR 225 N S, PTR 90 N S, PTR 200 N S, TTR 911 N S, TTR 101 N S and TTR 200 N S

Communication Protocol 300544663_002_C0

Part Numbers:

89642V02
230088V02
230087V02
89660V02
230366V02

Contents

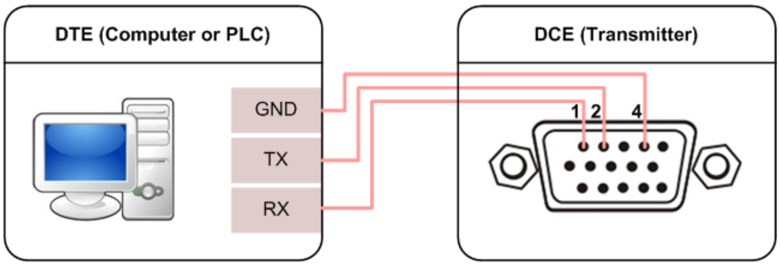
1 Introduction

This document describes in detail the digital protocol used in all RS232-equipped THERMOVAC and PENNINGVAC transmitters.

Besides from providing a digital means for acquiring pressure readings, the RS232 protocol adds lots of extra features to the transmitters. Many of these features are common to all transmitters, while others are specific for certain transmitter models. Settings and parameters like set point configurations and calibration data are stored in the transmitter's non-volatile memory.

2 Physical installation

Any device equipped with an RS232 interface can communicate with the transmitters. The below drawing illustrates how a transmitter (Data Circuit-terminating Equipment or *DCE*) is connected to a PC (Data Terminal Equipment or *DTE*). As the transmitters do not support data flow control, only three wires are needed to connect the two. In typical RS232 fashion, TX on the DTE is connected to RX on the DCE and vice versa, while GND on both devices is also connected.



PIN	Description
1	RS232 Transmit (TX)
2	RS232 Receive (RX)
3	Power + (9-30 VDC
4	Power -
5	Analog Output +
…	

In OEM applications, MEMS Pirani communication software routines are normally integrated with other system control software. The default communication parameters are listed below. Baud rate is user configurable while the other parameters are fixed.

Communication Parameters	
Baud rate	9600 (user-configurable)
Data bits	8
Parity	None
Stop bits	1
Flow control	None

The RS232 standard does not specify the maximum cable length, but length depends on environment, cable quality and communication speed. In general cable span shorter than 15 m (50 ft.) does not require any extra precautions.

Attention

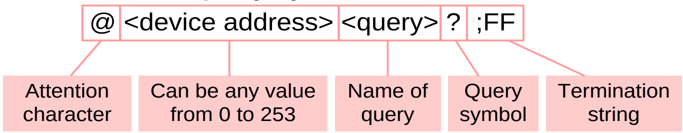
Always use high quality shielded data cables for serial communication. For long cable runs use twisted pairs

3 Query and Command syntax

Generally, *queries* are used to *get* information (such as the current pressure reading or setpoint configurations) from the transmitter, while *commands* are used to *change* information. Some parameters, such as setpoints, support both queries and commands, while other parameters support only queries or commands.

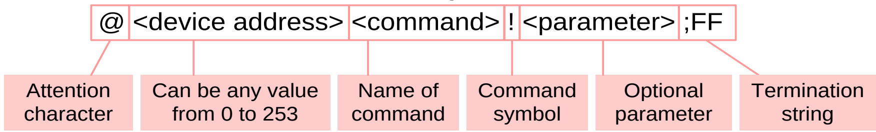
Each query or command must begin with the attention character '@' followed by the transmitter's address, just as all queries and commands must end with the ';FF' termination string. The below figure illustrates the syntax for queries and commands, respectively. Both upper and lower case ASCII characters are allowed.

Query syntax



Example: **@253SP1?;FF (read current setpoint 1 value)**

Command syntax



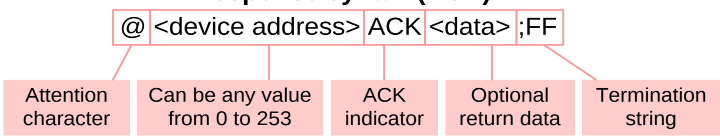
Example: **@253SP1!3.50E-2;FF (change setpoint 1 value to 3.50E-2)**

Response syntax

Just like the queries and command strings, the response strings begin with a '@' followed by the transmitter's address. Whether the query or command was successfully processed is indicated with either ACK (acknowledged) or NAK (not acknowledged).

In the ACK case, the response string may contain relevant data like this:

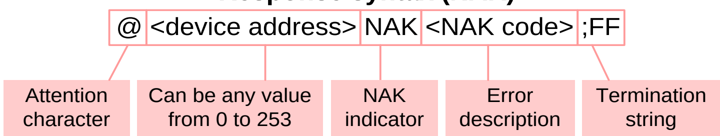
Response syntax (ACK)



Example: **@253ACK19200;FF (baud rate changed to 19200)**

In the NAK case, the response string includes a NAK code indicating the nature of the error.

Response syntax (NAK)



Example: **@254NAK160;FF (syntax error)**

NAK Codes

NAK Codes		
8	Zero adjustment at too high pressure	@253VAC!;FF
9	Atmospheric adjustment at too low pressure	@253ATM!7.60;FF
160	Unrecognized message	@253S%;FF
169	Invalid argument	@253EN1!of;FF
172	Value out of range	@253SP1!5.00E+9;FF
175	Command/query character invalid	@253FV!;FF
180	Not in setup mode (locked)	-

Baud rate
The baud rate represents the communication speed. The transmitter supports 4800, 9600, 19200, 38400, 57600, 115200 and 230400 baud rates. The transmitter is always delivered with factory default baud rate value: 9600.

Change of Baud rate:

Command:	@253BR!19200;FF
Command values:	4800, 9600, 19200, 38400, 57600, 115200, 230400
Command reply:	@253ACK19200;FF
Factory default:	9600

The MEMS Pirani will reply in the current baud rate and then change to the new value.

Addressing
The transmitter uses an addressable communication protocol.
The address can be set from 001 to 253. Address 254 and 255 are universal addresses that cannot be changed. Commands sent with address 255 will be executed, but the transmitter will not transmit a reply. For example, use address 254 to communicate with a device if its address is unknown.

Change of Address:

Command:	@253AD!123;FF
Command values:	001 to 253
Command reply:	@253ACK123;FF
Query:	@253AD?;FF
Query reply:	@253ACK253;FF
Factory default:	253

Communication delay
If the transmitter replies too fast the first character(s) will not be received as the following example illustrates:

Sending pressure request: @254PR1?;FF
Receiving data: .23E-4;FF (Correct data: @253ACK1.23E-4;FF)

The RS delay introduces a delay between the receive and transmit sequence to prevent loss of data in the receiving string.

Communication delay:

Command:	@253RSD!ON;FF
Command values:	ON, OFF, 5- 500 (unit is milliseconds)
Command reply:	@253ACKON;FF
Query:	@253RSD?;FF
Query reply:	@253ACKON;FF
Factory default:	ON

4 Command overview

Parameter name	Query	Command	Description	Parameter value	PTR 225 N S	PTR 90 N S	PTR 200 N S	TTR 911 N S	TTR 101 N S	TTR 200 N S	Chapter ref.
Common for all transmitters											
AD	●	●	Transmitter's device address	1 - 253	●	●	●	●	●	●	3
AO1	●	●	Curve used for scaling the analog output	1 – 49	●	●	●	●	●	●	14
BR	●	●	Baud rate of RS232 interface	4800 - 230400	●	●	●	●	●	●	3
DT	●		Device type (e.g. THERMOVAC)	-	●	●	●	●	●	●	13
FD		●	Factory default	ALL,!,ATS,ATZ,ATD,ATM,VAC,SPN, ZER,VAC2,MZL,VAC3,CFS,LOCK,UNLOCK,SAVE	●	●	●	●	●	●	9
FV	●		Firmware version	-	●	●	●	●	●	●	13
FVD	●		Firmware build date	-	●	●	●	●	●	●	13
FVP	●		Firmware part number	-	●	●	●	●	●	●	13
HV	●		Hardware version	-	●	●	●	●	●	●	13
MD	●		Model number (e.g. PTR 90 N)	-	●	●	●	●	●	●	13
MF	●		Manufacturer (LEYBOLD)	-	●	●	●	●	●	●	13
PN	●		Part number (e.g. 230070V02)	-	●	●	●	●	●	●	13
PRx	●		Current pressure reading (x may be 1-5)	-	●	●	●	●	●	●	0
RSD	●	●	RS232 communication delay	ON,OFF,5 - 500	●	●	●	●	●	●	3
SN	●		Serial number	-	●	●	●	●	●	●	13
SW	●	●	Switch enabled	ON,OFF	●	●	●	●	●	●	11
T	●		Transmitter status	-	●	●	●	●	●	●	13
TIM	●		Hours on	-	●	●	●	●	●	●	13
TST	●	●	Blink LED	ON,OFF	●	●	●	●	●	●	12
U	●	●	Pressure unit	MBAR,TORR,PASCAL	●	●	●	●	●	●	8.2
UT	●	●	User tag (default = LEYBOLD)	<name>	●	●	●	●	●	●	9
Absolute piezo-specific commands											
VAC2 /ZER	●	●	Absolute piezo vacuum adjustment	-					●		8.5.2
SPN	●	●	Absolute piezo Span calibration	666 - 1066					●		8.5.4
MEMS Pirani-specific commands											
ACP	●	●	Differential piezo auto calibration point	0.14 - 33			●			●	8.6.4
GT	●	●	Gas type	NITROGEN,AIR,ARGON,HYDROGEN, HELIUM,H2O,NEON,CO2,XENON		●	●	●	●	●	8.3
MZL	●	●	MEMS Pirani zero limit	1.33E-6 - 6.66E-4		●	●	●	●	●	8.7.1
ATM	●	●	Atmospheric adjustment of MEMS Pirani.	534 - 1066		●	●	●	●	●	8.4.2
TEM	●		Transmitter temperature	-		●	●	●	●	●	13
VAC	●	●	MEMS Pirani vacuum adjustment	<none> or less than 6.66E-3		●	●	●	●	●	8.4.1
SHP	●	●	Smoothing high limit for MEMS Pirani/cold cathode	6.66E-5 - **SLC**		●	●				7.8.3

Command	Query	Command	Description	Parameters	PTR 225 N S	PTR 90 N S	PTR 200 N S	TTR 911 N S	TTR 101 N S	TTR 200 N S	Chapter ref.
Cold cathode-specific commands											
CFS	●	●	Cold cathode full-scale adjustment.	1.34E-4 - 6.66E-3	●	●	●				8.7.5
ENC	●	●	Enable control setpoint for cold cathode.	ON,OFF	●	●	●				7.8.7
FP	●	●	Cold cathode filament power	ON,OFF,ALWAYSON	●	●	●				7.8.9
FS	●		Cold cathode filament status	-	●	●	●				13
PD	●	●	Pressure dose setpoint	1.00E-6 to 100	●	●	●				7.6
PRO	●	●	Cold cathode protection setpoint	0 - 999	●	●	●				7.7
SHC	●	●	Cold cathode turn off setpoint	1.34E-4 - 6.66E-3	●	●	●				7.8.1
SHP	●	●	Smoothing high limit for MEMS Pirani/cold cathode	6.66E-5 - **SLC**		●	●				7.8.3
SLC	●	●	Cold cathode turn on setpoint	1.34E-4 - 6.66E-3		●	●				7.8.1
TIM2	●	●	Cold cathode hours on	-	●	●	●				13
TIM3	●	●	Cold cathode pressure dose	-	●	●	●				13
VAC3	●	●	Cold cathode vacuum calibration	Less than 1.34E-6	●	●	●				8.7.4
Setpoint-specific commands											
ENx	●	●	Enable / disable Setpoint x (x may be 1-3)	PIR,PZ,DIFF,CC,CMB,ON,OFF	●	●	●	●	●	●	6.1
SDx	●	●	Setpoint direction (x may be 1-3)	ABOVE,BELOW	●	●	●	●	●	●	6.1
SHx	●	●	Setpoint hysteresis (x may be 1-3)	Model specific	●	●	●	●	●	●	6.1
SPx	●	●	Setpoint (x may be 1-3)	Model specific	●	●	●	●	●	●	6.1
SPD	●	●	Setpoint delay	ON,OFF	●	●	●	●	●	●	6.2
SSx	●		Setpoint status (x may be 1-3)	-	●	●	●	●	●	●	13
Differential piezo-specific commands											
ACP	●	●	Differential piezo auto calibration point	0.14 - 33			●			●	8.6.4
ATD	●	●	Virtual absolute piezo calibration	534 - 1066			●			●	8.6.4
ATS	●	●	Differential piezo atmospheric span calibration	14 - 1066			●			●	8.6.5

5 Pressure output

The THERMOVAC and PENNINGVAC transmitters can provide pressure measurement output as an analog voltage or RS232 digital value. The digital value is 3 digits scientific notation for PR1, PR2, PR3, PR5 reading and 4 digits for PR4 reading. Sensors include MEMS Pirani (MP), Piezo absolute (Piezo abs.), Piezo differential (Piezo diff.) and Cold Cathode (CC).

Pressure request:

Query:	@253PR1?;FF
Query reply:	@253ACK1.23E-4;FF

For transmitters with only one sensor, the analog output is per default based on the PR1 reading. For transmitters with more than one sensor, the analog output is per default based on the combined PR3 reading.

Pressure outputs	PR1	PR2	PR3	PR4 (4 digits)	PR5
TTR 911 N S	MP	-	-	MEMS Pirani	-
TTR 101 N S	MP	Piezo abs.	MP/Piezo abs.	MP/Piezo abs.	PR2 – PR1
TTR 200 N S	MP	Piezo diff.	MP/Piezo abs.*	MP/Piezo abs.*	-
PTR 90 N S	MP	CC	MP/CC	MP/CC	CC
PTR 200 N S	MP	Piezo diff.	MP/CC/Piezo abs.*	MP/CC/Piezo abs.*	CC
PTR 225 N S	CC	CC	CC	CC	CC

For transmitters with more than one sensor, the combined readings PR3 and PR4 combine the readings from the different sensors into one smooth pressure reading with accurate measuring performance throughout the entire pressure range.

* The combined readings, PR3 and PR4, provide a normalized absolute pressure measurement based on the Piezo differential sensor. When the MEMS Pirani is powered on for the first time, the combined output will read 1013 mbar (normal sea level pressure) at Zero differential pressure regardless of the actual absolute ambient barometric pressure. The ambient atmospheric pressure varies with weather and elevation of the location where the MEMS Pirani is used. When the MEMS Pirani is pumped down below 1.6 mbar the MEMS Pirani can determine the ambient pressure by reading and normalizing the differential Piezo output with reverse sign. The MEMS Pirani will automatically calibrate the Piezo absolute reading when the MEMS Pirani is pumped below 1.6 mbar. If the calibration deviates more than +/- 13 mbar from the current calibration value the calibration is stored in the non-volatile memory. When the MEMS Pirani is vented back to ambient pressure the combined outputs, PR3 and PR4, and the analog output will read the correct ambient pressure.

Caution

When designing pressure data collecting software and controlling loop make sure that the software does not interpret a communication error as a valid pressure value.

6 Setpoint relays

6.1 Setpoint relay setup

The correct procedure for setting up set point parameters is (this example is for setpoint 1; configuring setpoint 2 and 3 is done in the same way):

1. Enter set point value 5.00E-3 mbar
   Command: @253SP1!5.00E-3;FF
   Command reply: @253ACK5.00E-3;FF

2. Select set point direction (ABOVE/BELOW)
   Command: @253SD1!BELOW;FF
   Command reply: @253ACKBELOW;FF

3. Enter set point hysteresis value, if other than default +/- 10% of set point value is required.
   Command: @253SH1!1.00E-2;FF
   Command reply: @253ACK1.00E-2;FF

4. Enable set point
   Command: @253EN1!ON;FF
   Command values: (PIR,PZ,DIFF,CC,CMB,ON,OFF)*
   Command reply: @253ACKON;FF**

*command values are model dependent. Refer to table below.
** Specifically for TTR 200 N, the EN1!ABS command will give the reply ACKON and not ACKABS as expected.

Transmitter model	Transmitter P/N	"EN1!" command values
TTR 911 N S	89660V02	ON,OFF
TTR 101 N S	230366V02	ON,OFF
TTR 200 N S	230365V02	OFF, ABS, PZ
PTR 225 N S	89642V02	ON, OFF
PTR 90 N S	230088V02	OFF, CMB, PIR, CC
PTR 200 N S	230087V02	OFF, CMB, PIR, PZ, CC

Abbreviations used in the table above:
ABS: absolute (setpoint is based on the combined absolute reading).
PZ: differential piezo (setpoint is based on the differential piezo reading).
CMB: combined reading (setpoint is based on the combined reading).
PIR: MEMS Pirani (setpoint is based on the MEMS Pirani reading).
CC: cold cathode (setpoint is based on the cold cathode reading).

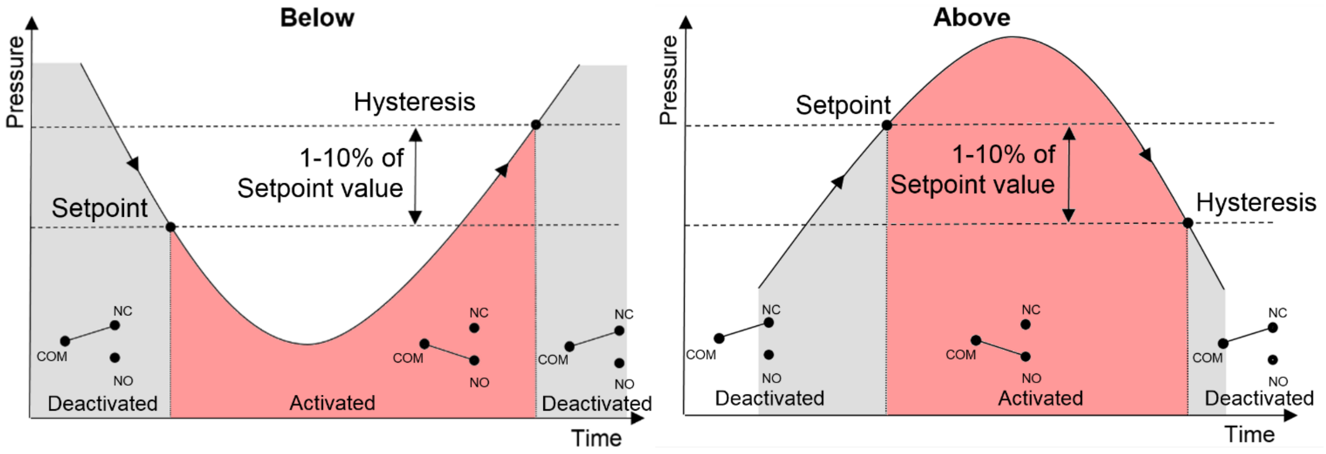
Setpoint value
The setpoint value is the pressure either below or above which the setpoint relay will be energized.

Setpoint hysteresis value
The hysteresis value is the pressure value at which the setpoint relay will be de-energized.

Setpoint direction
The setpoint direction determines whether the relay is energized above or below the set point value.

Enable setpoint
The enable setpoint command enables, disables or enable the setpoint relay.

The THERMOVAC and PENNINGVAC transmitters have an auto hysteresis setting of 10% of the set point value that overwrites the current hysteresis value whenever the setpoint value or setpoint direction is changed. If another hysteresis value than the 10% is required, first set the setpoint value and setpoint direction before setting the hysteresis value.



The valid ranges for the setpoints and the hysteresis values depend on the transmitter model. An overview of valid ranges is shown in the table below.

Transmitter model	Transmitter P/N	Setpoint/hysteresis range
TTR 911 N S	89660V02	2×10^{-4} to 1000 mbar
TTR 101 N S	230366V02	2×10^{-4} to 1300 mbar
TTR 200 N S	230365V02	2×10^{-4} to 1300 mbar
PTR 225 N S	89642V02	1×10^{-8} to 5×10^{-3} mbar
PTR 90 N S	230088V02	1×10^{-8} to 1000 mbar
PTR 200 N S	230087V02	1×10^{-8} to 1300 mbar

6.2 Setpoint safety delay

The setpoint safety delay function requires five continuous measurements that exceed the setpoint value before the relay is tripped. This feature prevents false triggering of the setpoint relay due to noise. If fast setpoint response is required, the setpoint safety delay can be disabled.

Setpoint safety delay

Command:	@253SPD!ON;FF
Command values:	ON, OFF
Command reply:	@253ACKON;FF
Query:	@253SPD?;FF
Query reply:	@253ACKON;FF
Factory default:	ON

7 Cold Cathode setup

7.1 Cold Cathode ignition startup

When the Cold Cathode high voltage is enabled, an ignition delay may occur. The ignition waiting time is from less than a second at high pressures to minutes at low pressures. The ignition time is a function of gas density, cleanness of the gauge and presence of any other ion sources in the system.

When the Cold Cathode is enabled, but ionization has not started, the LED ring will flash green. The LED ring will be illuminated continuously green when valid measurements are present. If the ignition has not started after 5 min, from enabling the Cold Cathode, the LED ring will turn red.

Pressure	Typical ignition time
1.00E-4 mbar	≈1 Second
1.00E-6 mbar	≈10 Seconds
≤5.00E-7 mbar	>10 Seconds

For transmitters with combined readings:
The combined analog output and the PR3 and PR4 digital readings provides the MEMS Pirani reading until ignition has occurred and valid Cold Cathode measurements are present.

7.2 Resolution

The digital pressure output can provide 3 digit or 4 digit values. However, the resolution is limited in certain parts of the measuring range.

MEMS Pirani:		
1.00E-5 to 1.00E-4 mbar	1 digit resolution	1.000E-5
1.00E-4 to 1.00E-3 mbar	2 digits resolution	1.200E-4
1.00E-3 to 900 mbar	3 or 4 digits resolution	1.234E-3
Piezo:		
-8.00E+2 to +8.00E+2 mbar	2 digit resolution	-1.23E+2
Cold Cathode:		
1.00E-7 to 1.00E-8 mbar	2 digits resolution	1.50E-8
5.00E-3 to 1.00E-7 mbar	3 digits resolution	1.230E-4

7.3 Measuring noise

External sources can interfere with the sensor signal and cause noise in the signal. The low measuring range is most sensitive to measuring noise due to low signal levels.

7.4 Magnetic interference

External magnetic sources can interfere with the Cold Cathode sensor and cause measurement deviation from actual pressure. Avoid having magnetic material located close to the transmitter.

7.5 Cold Cathode pressure dose

The Cold Cathode pressure dose continuously monitors the Cold Cathode time on as function of the pressure. If the cold cathode is on for 100 hours at 1E-4 mbar the pressure dose is 100 hours×1E-4 mbar = 1E-2 mbar hours. The pressure dose readout can be used to determine the time interval between Cold Cathode maintenance and service.

Pressure dose request:

Query:	@253TIM3?;FF
Query reply:	@253ACK1.23E-2;FF

Reset of pressure dose:

Command:	@253TIM3!;FF
Command values:	-

The pressure dose reading can be user reset after the MEMS Pirani has been cleaned or the anode assembly has been replaced.

Caution

The pressure dose reading is only a rough indication of the cold cathode status. When the cold cathode is contaminated the sensitivity of the gauge is decreased and it will provide a lower reading than actual pressure. Therefore the calculated pressure dose can be lower than the actual pressure dose.

7.6 Cold Cathode pressure dose setpoint

The Cold Cathode pressure dose setpoint provides an indication when a defined pressure dose is exceeded. The transmitter status query will provide “R” when pressure dose is exceeded.

Pressure dose setpoint command:

Command:	@253PD!1.00E-2;FF
Command values:	1.00E-6 to 100
Command reply:	@253ACK1.00E-2;FF
Query:	@253PD?;FF
Query reply:	@253ACK1.00E-2;FF
Factory default:	1.33E+00 mbar
Value out of range:	@253NAK172;FF

7.7 Cold Cathode protect setpoint

For transmitters with only a Cold Cathode sensor:
The Cold Cathode protect setpoint automatically turns off the Cold Cathode high voltage if the cold cathode measurement exceeds 6.67E-3 mbar for 120 seconds. The protect setpoint can be turned off (disabled) or time set between 0 and 999 seconds.

Command:	@253PRO!ON;FF
Command values:	ON (120), OFF, 0 to 999 seconds
Command reply:	@253ACK120;FF
Query:	@253PRO?;FF
Query reply:	@253ACK120;FF
Factory default:	OFF

Caution

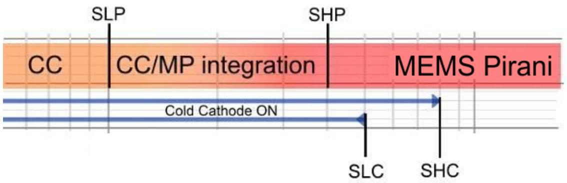
If FP is set to “ALWAYSON” the protect setpoint is automatically disabled.

7.8 Cold Cathode and MEMS Pirani integration

For transmitters with a Cold Cathode sensor in combination with a MEMS Pirani sensor:
The transmitters can be configured to the process and application by individually programming of the Cold Cathode turn on and off pressure and pressure settings for MEMS Pirani integration.

7.8.1 Cold cathode auto turn on and off

The SLC command sets the turn on pressure and SHC command sets the turn off pressure.



Caution

If the Cold Cathode control setpoint is disabled, the sensor control must be executed manually with the FP command. Operation of the cold cathode at higher pressure than 1.3x10^{-3} mbar can cause loss of measurement performance. The cold cathode will always turn off automatically at pressure higher than 6.7x10^{-3} mbar. If the SLC and SHC value are too close the Cold Cathode can turn off immediately after turning on.

7.8.2 Cold cathode turn on pressure (Only if ENC is ON)

Command:	@253SLC!1.33E-4;FF
Command values:	1.33E-4 to 6.67E-3
Command reply:	@253ACK1.33E-4;FF
Query:	@253SLC?;FF
Query reply:	@253ACK6.67E-4;FF
Factory default:	6.67E-4 mbar
Value out of range:	@253NAK172;FF

7.8.3 Cold cathode turn off pressure (Only if ENC is ON)

Command:	@253SHC!10.67E-4;FF
Command values:	>SLC (turn on pressure) or 1.33E-4 to 6.67E-3
Command reply:	@253ACK10.67E-4;FF
Query:	@253SHP?;FF
Query reply:	@253ACK10.67E-4;FF
Factory default:	10.67E-4 mbar
Value out of range:	@253NAK172;FF

7.8.4 Cold cathode / MEMS Pirani smoothing

The combined output (PR3) switches automatically between the MEMS Pirani and Cold Cathode sensor. The high and low switch value can be set and should correspond to the cold cathode turn on and off pressure.

7.8.5 Sensor smoothing low value

Command:	@253SLP!1.33E-4;FF
Command values:	1.33E-4 to SHP (turn off pressure)
Command reply:	@253ACK1.33E-4;FF
Query:	@253SLP?;FF
Query reply:	@253ACK1.33E-4;FF
Factory default:	1.33E-4 mbar
Value out of range:	@253NAK172;FF

When setting the turn on value, the turn off value is automatically set to 30% higher than the low value.

7.8.6 Sensor smoothing high value

Command:	@253SHP!10.67E-4;FF
Command values:	1.33E-4 to 6.67E-3
Command reply:	@253ACK10.67E-4;FF
Query:	@253SHP?;FF
Query reply:	@253ACK5.33E-4;FF
Factory default:	5.33E-4 mbar
Value out of range:	@253NAK172;FF

7.8.7 Cold Cathode control setpoint

The cold cathode control setpoint automatically turn on the Cold Cathode high voltage when the MEMS Pirani pressure is lower than the SLC value.

Command:	@253ENC!ON;FF
Command values:	ON, OFF
Command reply:	@253ACKON;FF
Query:	@253ENC?;FF
Query reply:	@253ACKON;FF
Factory default:	ON

7.8.8 Cold Cathode protect setpoint

The Cold Cathode protect setpoint automatically turns off the Cold Cathode high voltage if the cold cathode measurement exceeds 6.67E-3 mbar for 120 seconds. The protect setpoint can be turned off (disabled) or time set between 0 and 999 seconds.

Command:	@253PRO!ON;FF
Command values:	ON (120), OFF, 0 to 999 seconds
Command reply:	@253ACK120;FF
Query:	@253PRO?;FF
Query reply:	@253ACK120;FF
Factory default:	OFF

7.8.9 Cold Cathode power

If the Cold Cathode control setpoint is disabled (OFF) then the Cold Cathode high voltage can be manually controlled by the FP command.

Command:	@253FP!ON;FF
Command values:	ON, OFF
Command reply:	@253ACKON;FF
Query:	@253FP?;FF
Query reply:	@253ACKOFF;FF
Factory default:	OFF
ENC is ON:	@253NAK195;FF

If Cold Cathode control setpoint (ENC) is on, the Cold Cathode power cannot be controlled manually.

8 Calibration and adjustment

The THERMOVAC and PENNINGVAC transmitters are factory calibrated when delivered and in most applications further calibration is not required. If the sensor element has been contaminated or damaged by process gases, adjustment of zero and full scale can be executed to compensate for measurement errors.

> ⚠ **Caution**
>
> The THERMOVAC and PENNINGVAC transmitters with a MEMS Pirani sensor are per factory default calibrated for reading in Nitrogen gas.

8.1 Accuracy and repeatability

The THERMOVAC and PENNINGVAC transmitter measuremnet accuracy is specified as transmitter reading ± a percentage of the actual pressure. The basic measuring accuracy is factory calibrated and cannot be user adjusted. The repeatability specification is the transmitter's ability to repeat the same measurement value after multiple pressure cycles.

8.2 Pressure unit calibration

The transmitter can provide digital and analog output in mbar, Torr and Pascal pressure units.
When changing pressure unit all parameters such as setpoint settings are automatically converted to the new unit, so it will represent the same pressure level. All pressure parameters such as setpoint settings and calibration values must be entered in the actual transmitter unit setting.

Change of pressure unit calibration setup:

Command:	@253U!PASCAL;FF
Command values:	MBAR, TORR, PASCAL
Command reply:	@253ACKPASCAL;FF
Query:	@253U?;FF
Query reply:	@253ACKMBAR;FF
Factory default:	MBAR

8.3 Gas calibration

The THERMOVAC and PENNINGVAC transmitters with a MEMS Pirani sensor are based on measurement of thermal conductivity and consequently its reading depends on the gas type and concentration. The factory default setting is Nitrogen calibration. However, the transmitter has MEMS Pirani calibration curves for several common gases.

Change of gas calibration setup:

Command:	@253GT!ARGON;FF
Command values:	NITROGEN, AIR, ARGON, HELIUM, HYDROGEN, H2O, NEON, CO2, XENON
Command reply:	@253ACKARGON;FF
Query:	@253GT?;FF
Query reply:	@253ACKARGON;FF
Factory default:	NITROGEN

The cold cathode gas Nitrogen calibration does not change with the GT command.

8.4 TTR 911 N S

8.4.1 Zero Adjustment by serial interface

The zero adjustment function changes the measurement offset at low pressure. Temporally or permanent shift in zero offset can be caused by contamination, corrosion, electrical noise interference and temperature.

If the MEMS Pirani is reading 8.00E-5 mbar at an actual pressure of 1.00E-5 mbar, the offset error is +7.00E-5 or 700% error of actual pressure. At two decades higher pressure of 1.00E-3 mbar the offset error is a factor 100 lower when measured of the actual value, so the 7.00E-5 mbar offset will cause a 7% error at 1.00E-3 mbar.

Attention

To obtain best measuring performance, it is recommended that the transmitter is evacuated to a pressure below 1×10^{-5} mbar before executing zero adjustment of the MEMS Pirani sensor.
Zero adjustment of the MEMS Pirani sensor can be executed at pressures higher than 1×10^{-5} mbar, but this can cause inaccurate readings in the lower part of the measuring range.
If the pressure measured by the transmitter is higher than approximately $1x10^{-2}$ mbar, then the zero adjustment cannot be executed. If the zero adjustment failed, the LED-ring will flash red three times.

Executing zero adjustment. (Evacuate the MEMS Pirani to a pressure below 1×10^{-5} mbar)

Command:	@253VAC!5.00E-5;FF
Command values:	None, < 6.66E-3
Command reply:	@253ACK;FF
Query:	@253VAC?;FF
Query reply:	@253ACK5E-5;FF
Reset to default:	@253FD!VAC;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

After execution of zero adjustment the PR1 reading will be 5×10^{-5} mbar. If the pressure measured by the MEMS Pirani is higher than approximately 1×10^{-2} mbar then the zero adjustment cannot be executed. This indicates that the MEMS Pirani is contaminated and should be serviced.
The query feature reads the delta value between the user offset value and factory default value. This can be used to monitor the positive and negative offset trend regardless of how many times the zero adjustment is executed.

Attention

Zero adjustment only changes the low measuring range and will have no influence on measuring errors in the range from 1×10^{-2} mbar and above.
Full scale adjustment only changes the high measuring range and will have no influence on measuring errors in the range below 10 mbar.

8.4.2 Atmospheric adjustment

The atmospheric adjustment allows the user to adjust the MEMS Pirani full scale reading. Vent the MEMS Pirani to atmospheric pressure using the gas that corresponds to the gas calibration setup. Atmospheric adjustment can only be executed with air or Nitrogen.

Executing atmospheric adjustment (vent MEMS Pirani to Nitrogen or air pressure of 600 to 1000 mbar).

Command:	@253ATM!1.00E+3;FF
Command values:	6.00E+2 to 1.00E+3
Command reply:	@253ACK;FF
Query:	@253ATM?;FF
Query reply:	@253ACK1.00E+2;FF
Reset to default:	@FD!ATM;FF
Factory default:	*Factory adjustment value*

The query feature reads the delta value between the user atmospheric adjustment value and the factory default value.

8.5 TTR 101 N S

8.5.1 MEMS Pirani Zero Adjustment by serial interface

The zero adjustment function changes the measurement offset at low pressure. Temporally or permanent shift in zero offset can be caused by contamination, corrosion, electrical noise interference and temperature.

If the MEMS Pirani is reading 8.00E-5 mbar at an actual pressure of 1.00E-5 mbar, the offset error is +7.00E-5 or 700% error of actual pressure. At two decades higher pressure of 1.00E-3 mbar the offset error is a factor 100 lower when measured of the actual value, so the 7.00E-5 mbar offset will cause a 7% error at 1.00E-3 mbar.

Attention

To obtain best measuring performance, it is recommended that the transmitter is evacuated to a pressure below 1×10^{-5} mbar before executing zero adjustment of the MEMS Pirani sensor.
Zero adjustment of the MEMS Pirani sensor can be executed at pressures higher than 1×10^{-5} mbar, but this can cause inaccurate readings in the lower part of the measuring range.
If the pressure measured by the transmitter is higher than approximately $1x10^{-2}$ mbar, then the zero adjustment cannot be executed. If the zero adjustment failed, the LED-ring will flash red three times.

Executing zero adjustment. (Evacuate the MEMS Pirani to a pressure below 1×10^{-5} mbar)

Command:	@253VAC!5.00E-5;FF
Command values:	None, < 6.66E-3
Command reply:	@253ACK;FF
Query:	@253VAC?;FF
Query reply:	@253ACK5E-5;FF
Reset to default:	@253FD!VAC;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

After execution of zero adjustment the PR1 reading will be 5×10^{-5} mbar. If the pressure measured by the MEMS Pirani is higher than approximately 1×10^{-2} mbar then the zero adjustment cannot be executed. This indicates that the MEMS Pirani is contaminated and should be serviced.
The query feature reads the delta value between the user offset value and factory default value. This can be used to monitor the positive and negative offset trend regardless of how many times the zero adjustment is executed.

Attention

Zero adjustment only changes the low measuring range and will have no influence on measuring errors in the range from 1×10^{-2} mbar and above.
Full scale adjustment only changes the high measuring range and will have no influence on measuring errors in the range below 10 mbar.

8.5.2 Piezo zero adjustment

The Piezo zero is automatically zero adjusted when the MEMS Pirani measurement is below 6.67×10^{-2} mbar and consequently under normal operation it's not necessary to perform user adjustments. The Piezo zero adjustment can only be executed when the MEMS Pirani pressure measurement is below 1.3×10^{-1} mbar.
The Piezo zero adjustment sets the Piezo zero reading.

Executing Piezo absolute output adjustment. (Evacuate the MEMS Pirani to a pressure below 6.67×10^{-2} mbar)

Command:	@253ZER!;FF
Command values:	None
Command reply:	@253ACK;FF
Reset to default:	@253FD!ZER;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

8.5.3 MEMS Pirani Atmospheric adjustment

The atmospheric adjustment allows the user to adjust the MEMS Pirani full scale reading. Vent the MEMS Pirani to atmospheric pressure using the gas that corresponds to the gas calibration setup. Atmospheric adjustment can only be executed with air or Nitrogen.
Executing atmospheric adjustment. (Vent MEMS Pirani to Nitrogen or air pressure of 600 to 1000 mbar)

Command:	@253ATM!1.00E+3;FF
Command values:	6.00E+2 to 1.00E+3
Command reply:	@253ACK;FF
Query:	@253ATM?;FF
Query reply:	@253ACK1.00E+2;FF
Reset to default:	@FD!ATM;FF
Factory default:	*Factory adjustment value*

The query feature reads the delta value between the user atmospheric adjustment value and the factory default value.

8.5.4 Piezo Atmospheric adjustment

The Piezo atmospheric adjustment allows the user to adjust the atmospheric reading for the Piezo measurement.

Executing Piezo atmospheric adjustment. (Place the MEMS Pirani in atmospheric pressure)

Command:	@253SPN!1.00E+3;FF
Command values:	Atmospheric pressure value
Command reply:	@253ACK;FF
Query:	@253SPN?;FF
Query reply:	@253ACK1.00E+3;FF
Reset to default:	@253FD!SPN;FF
Factory default:	*Factory adjustment value*
Sensor value too high:	@253NAK8;FF

8.6 TTR 200 N S

8.6.1 MEMS Pirani Zero Adjustment by serial interface

The zero adjustment function changes the measurement offset at low pressure. Temporally or permanent shift in zero offset can be caused by contamination, corrosion, electrical noise interference and temperature.

If the MEMS Pirani is reading 8.00E-5 mbar at an actual pressure of 1.00E-5 mbar, the offset error is +7.00E-5 or 700% error of actual pressure. At two decades higher pressure of 1.00E-3 mbar the offset error is a factor 100 lower when measured of the actual value, so the 7.00E-5 mbar offset will cause a 7% error at 1.00E-3 mbar.

Attention

To obtain best measuring performance, it is recommended that the transmitter is evacuated to a pressure below 1×10^{-5} mbar before executing zero adjustment of the MEMS Pirani sensor.
Zero adjustment of the MEMS Pirani sensor can be executed at pressures higher than 1×10^{-5} mbar, but this can cause inaccurate readings in the lower part of the measuring range.
If the pressure measured by the transmitter is higher than approximately $1x10^{-2}$ mbar, then the zero adjustment cannot be executed. If the zero adjustment failed, the LED-ring will flash red three times.

Executing zero adjustment. (Evacuate the MEMS Pirani to a pressure below 1×10^{-5} mbar)

Command:	@253VAC!5.00E-5;FF
Command values:	None, < 6.66E-3
Command reply:	@253ACK;FF
Query:	@253VAC?;FF
Query reply:	@253ACK5E-5;FF
Reset to default:	@253FD!VAC;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

After execution of zero adjustment the PR1 reading will be 5×10^{-5} mbar. If the pressure measured by the MEMS Pirani is higher than approximately 1×10^{-2} mbar then the zero adjustment cannot be executed. This indicates that the MEMS Pirani is contaminated and should be serviced.
The query feature reads the delta value between the user offset value and factory default value. This can be used to monitor the positive and negative offset trend regardless of how many times the zero adjustment is executed.

Attention

Zero adjustment only changes the low measuring range and will have no influence on measuring errors in the range from 1×10^{-2} mbar and above.
Full scale adjustment only changes the high measuring range and will have no influence on measuring errors in the range below 10 mbar.

8.6.2 MEMS Pirani Atmospheric adjustment

The atmospheric adjustment allows the user to adjust the MEMS Pirani full scale reading. Vent the MEMS Pirani to atmospheric pressure using the gas that corresponds to the gas calibration setup. Atmospheric adjustment can only be executed with air or Nitrogen.

Executing atmospheric adjustment. (Vent MEMS Pirani to Nitrogen or air pressure of 600 to 1000 mbar)

Command:	@253ATM!1.00E+3;FF
Command values:	6.00E+2 to 1.00E+3
Command reply:	@253ACK;FF
Query:	@253ATM?;FF
Query reply:	@253ACK1.00E+2;FF
Reset to default:	@FD!ATM;FF
Factory default:	*Factory adjustment value*

The query feature reads the delta value between the user atmospheric adjustment value and the factory default value.

8.6.3 Piezo Atmospheric zero adjustment

The Piezo atmospheric adjustment allows the user to adjust zero offset error for the differential measurement.

Executing Piezo zero adjustment. (Place the MEMS Pirani in atmospheric pressure)

Command:	@253ATZ!;FF
Command values:	None
Command reply:	@253ACK;FF
Query:	@253ATZ?;FF
Query reply:	@253ACK5E-1;FF
Reset to default:	@253FD!ATZ;FF
Factory default:	*Factory adjustment value*
Sensor value too high:	@253NAK8;FF

After execution of Piezo atmospheric zero adjustment the PR2 reading will be $\pm 1.3\times 10^{-1}$ mbar.

8.6.4 Piezo absolute Atmospheric output adjustment

The Piezo atmospheric adjustment allows the user to adjust the absolute Piezo reading at zero differential pressure. The Piezo absolute output adjustment is automatically adjusted whenever the pressure measured by the MEMS Pirani is lower than 1.6 mbar (this value can be changed by using the ACP command). If the value deviates more than ±13 mbar of the current value ATD value the ATD value will be overwritten in the non-volatile memory.

Executing Piezo absolute output adjustment.

Command:	@253ATD!;FF
Command values:	5.34E+2 to 1.07E+3
Command reply:	@253ACK;FF
Reset to default:	@253FD!ATD;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

After execution of Piezo atmospheric zero adjustment, the PR3 reading will read the entered value at zero differential pressure.

8.6.5 Piezo differential full scale adjustment

The ATS command sets the full scale reading for the differential Piezo. Enter the applied pressure in the range from 14 to 1066 mbar.

Executing Piezo differential full scale adjustment.

Command:	@253ATS!1.00E+2;FF
Command values:	1.40E+1 to 1.07E+3
Command reply:	@253ACK;FF
Reset to default:	@253FD!ATS;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

8.7 PTR 90 N S

8.7.1 MEMS Pirani Auto Zero limit Adjustment (MZL)

The MEMS Pirani will be zero adjusted whenever the pressure measured by the Cold Cathode is lower than 1E-5 mbar (MZL). For applications that do not go below 1E-5 mbar the MEMS Pirani auto zero limit can be set to higher pressure.

Change of pressure auto zero limit:

Command:	@253MZL!1.00E-4;FF
Command values:	1.33E-6 to 6.67E-4
Command reply:	@253ACK1.00E-4;FF
Query:	@253MZL?;FF
Query reply:	@253ACK1.33E-4;FF
Reset to default:	@253FD!MZL;FF
Factory default:	1.33E-4 mbar
Value out of range:	@253NAK172;FF

8.7.2 Zero Adjustment by serial interface

The zero adjustment function changes the measurement offset at low pressure. Temporally or permanent shift in zero offset can be caused by contamination, corrosion, electrical noise interference and temperature.

If the MEMS Pirani is reading 8.00E-5 mbar at an actual pressure of 1.00E-5 mbar, the offset error is +7.00E-5 or 700% error of actual pressure. At two decades higher pressure of 1.00E-3 mbar the offset error is a factor 100 lower when measured of the actual value, so the 7.00E-5 mbar offset will cause a 7% error at 1.00E-3 mbar.

Attention

To obtain best measuring performance, it is recommended that the transmitter is evacuated to a pressure below 1×10^{-5} mbar before executing zero **ad**justment of the MEMS Pirani sensor.
Zero adjustment of the MEMS Pirani sensor can be executed at pressures higher than 1×10^{-5} mbar, but this can cause inaccurate readings in the lower part of the measuring range.
If the pressure measured by the transmitter is higher than approximately $1\text{x}10^{-2}$ mbar, then the zero adjustment cannot be executed. If the zero adjustment failed, the LED-ring will flash red three times.

Executing zero adjustment. (Evacuate the MEMS Pirani to a pressure below 1×10^{-5} mbar)

Command:	@253VAC!5.00E-5;FF
Command values:	None, < 6.66E-3
Command reply:	@253ACK;FF
Query:	@253VAC?;FF
Query reply:	@253ACK5E-5;FF
Reset to default:	@253FD!VAC;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

After execution of zero adjustment the PR1 reading will be 5×10^{-5} mbar. If the pressure measured by the MEMS Pirani is higher than approximately 1×10^{-2} mbar then the zero adjustment cannot be executed. This indicates that the MEMS Pirani is contaminated and should be serviced.
The query feature reads the delta value between the user offset value and factory default value. This can be used to monitor the positive and negative offset trend regardless of how many times the zero adjustment is executed.

Attention

Zero adjustment only changes the low measuring range and will have no influence on measuring errors in the range from 1×10^{-2} mbar and above.
Full scale adjustment only changes the high measuring range and will have no influence on measuring errors in the range below 10 mbar.

8.7.3 Atmospheric adjustment

The atmospheric adjustment allows the user to adjust the MEMS Pirani full scale reading. Vent the MEMS Pirani to atmospheric pressure using the gas that corresponds to the gas calibration setup. Atmospheric adjustment can only be executed with air or Nitrogen.

Executing atmospheric adjustment. (Vent MEMS Pirani to Nitrogen or air pressure of 600 to 1000 mbar)

Command:	@253ATM!1.00E+3;FF
Command values:	6.00E+2 to 1.00E+3
Command reply:	@253ACK;FF
Query:	@253ATM?;FF
Query reply:	@253ACK1.00E+2;FF
Reset to default:	@FD!ATM;FF
Factory default:	*Factory adjustment value*

The query feature reads the delta value between the user atmospheric adjustment value and the factory default value.

8.7.4 Cold cathode zero adjustment

The Cold Cathode zero adjustment allows the user to adjust the cold cathode zero reading.

Executing zero adjustment
Evacuate the MEMS Pirani to a base pressure below 1×10^{-6} mbar or enter the zero pressure by use of a calibrated reference gauge.

Attention

To obtain best measuring performance, it is recommended that the transmitter is evacuated to a pressure below 1×10^{-8} mbar before executing zero adjustment. Zero adjustment of the Cold Cathode sensor can be executed at pressures higher than 1×10^{-8} mbar, but this can cause inaccurate reading below the zero adjustment value.
If the pressure measured by the transmitter is higher than approximately 1.3×10^{-6} mbar, then the zero adjustment cannot be executed. If the zero adjustment failed, the LED-ring will flash red three times.

Command:	@253VAC3!2.00E-8;FF
Command values:	1.33E-8 to 1.33E-6 mbar
Command reply:	@253ACK;FF
Query:	@253VAC3?;FF
Query reply:	@253ACK0.00+00;FF
Reset to default:	@253FD!VAC3;FF
Factory default:	*Factory adjustment value*
Value out of range:	@253NAK172;FF

8.7.5 Cold cathode full scale adjustment

The Cold Cathode full scale adjustment allows the user to adjust the cold cathode reading at high pressure.

Command:	@253CFS!4.00E-3;FF
Command values:	1.33E-4 to 6.67E-3 mbar
Command reply:	@253ACK;FF
Query:	@253CFS?;FF
Query reply:	@253ACK5.00E-3;FF
Reset to default:	@253FD!CFS;FF
Factory default:	*Factory adjustment value*
Value out of range:	@253NAK172;FF

8.8 PTR 200 N S

8.8.1 MEMS Pirani Auto Zero limit Adjustment (MZL)

The MEMS Pirani will be zero adjusted whenever the pressure measured by the Cold Cathode is lower than 1E-5 mbar (MZL). For applications that do not go below 1E-5 mbar the MEMS Pirani auto zero limit can be set to higher pressure.

Change of pressure auto zero limit:

Command:	@253MZL!1.00E-4;FF
Command values:	1.33E-6 to 6.67E-4
Command reply:	@253ACK1.00E-4;FF
Query:	@253MZL?;FF
Query reply:	@253ACK1.33E-4;FF
Reset to default:	@253FD!MZL;FF
Factory default:	1.33E-4 mbar
Value out of range:	@253NAK172;FF

8.8.2 MEMS Pirani Zero Adjustment by serial interface

The zero adjustment function changes the measurement offset at low pressure. Temporally or permanent shift in zero offset can be caused by contamination, corrosion, electrical noise interference and temperature.

If the MEMS Pirani is reading 8.00E-5 mbar at an actual pressure of 1.00E-5 mbar, the offset error is +7.00E-5 or 700% error of actual pressure. At two decades higher pressure of 1.00E-3 mbar the offset error is a factor 100 lower when measured of the actual value, so the 7.00E-5 mbar offset will cause a 7% error at 1.00E-3 mbar.

Attention

To obtain best measuring performance, it is recommended that the transmitter is evacuated to a pressure below 1×10^{-5} mbar before executing zero adjustment of the MEMS Pirani sensor.
Zero adjustment of the MEMS Pirani sensor can be executed at pressures higher than 1×10^{-5} mbar, but this can cause inaccurate readings in the lower part of the measuring range.
If the pressure measured by the transmitter is higher than approximately $1\text{x}10^{-2}$ mbar, then the zero adjustment cannot be executed. If the zero adjustment failed, the LED-ring will flash red three times.

Executing zero adjustment. (Evacuate the MEMS Pirani to a pressure below 1×10^{-5} mbar)

Command:	@253VAC!5.00E-5;FF
Command values:	None, < 6.66E-3
Command reply:	@253ACK;FF
Query:	@253VAC?;FF
Query reply:	@253ACK5E-5;FF
Reset to default:	@253FD!VAC;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

After execution of zero adjustment the PR1 reading will be 5×10^{-5} mbar. If the pressure measured by the MEMS Pirani is higher than approximately 1×10^{-2} mbar then the zero adjustment cannot be executed. This indicates that the MEMS Pirani is contaminated and should be serviced.
The query feature reads the delta value between the user offset value and factory default value. This can be used to monitor the positive and negative offset trend regardless of how many times the zero adjustment is executed.

Attention

Zero adjustment only changes the low measuring range and will have no influence on measuring errors in the range from 1×10^{-2} mbar and above.
Full scale adjustment only changes the high measuring range and will have no influence on measuring errors in the range below 10 mbar.

8.8.3 MEMS Pirani Atmospheric adjustment

The atmospheric adjustment allows the user to adjust the MEMS Pirani full scale reading. Vent the MEMS Pirani to atmospheric pressure using the gas that corresponds to the gas calibration setup. Atmospheric adjustment can only be executed with air or Nitrogen.

Executing atmospheric adjustment. (Vent MEMS Pirani to Nitrogen or air pressure of 600 to 1000 mbar)

Command:	@253ATM!1.00E+3;FF
Command values:	6.00E+2 to 1.00E+3
Command reply:	@253ACK;FF
Query:	@253ATM?;FF
Query reply:	@253ACK1600E+2;FF
Reset to default:	@FD!ATM;FF
Factory default:	*Factory adjustment value*

The query feature reads the delta value between the user atmospheric adjustment value and the factory default value.

8.8.4 Piezo Atmospheric zero adjustment

The Piezo atmospheric adjustment allows the user to adjust zero offset error for the differential measurement.

Executing Piezo zero adjustment. (Place the MEMS Pirani in atmospheric pressure)

Command:	@253ATZ!;FF
Command values:	None
Command reply:	@253ACK;FF
Query:	@253ATZ?;FF
Query reply:	@253ACK5E-1;FF
Reset to default:	@253FD!ATZ;FF
Factory default:	*Factory adjustment value*
Sensor value too high:	@253NAK8;FF

After execution of Piezo atmospheric zero adjustment the PR2 reading will be $\pm 1.3\times10^{-1}$ mbar.

8.8.5 Piezo absolute Atmospheric output adjustment

The Piezo atmospheric adjustment allows the user to adjust the absolute Piezo reading at zero differential pressure. The Piezo absolute output adjustment is automatically adjusted whenever the pressure measured by the MEMS Pirani is lower than 1.6 mbar (this value can be changed by using the ACP command). If the value deviates more than ±13 mbar of the current value ATD value the ATD value will be overwritten in the non-volatile memory.

Executing Piezo absolute output adjustment.

Command:	@253ATD!;FF
Command values:	5.34E+2 to 1.07E+3
Command reply:	@253ACK;FF
Reset to default:	@253FD!ATD;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

After execution of Piezo atmospheric zero adjustment, the PR3 reading will read the entered value at zero differential pressure.

8.8.6 Piezo differential full scale adjustment

The ATS command sets the full scale reading for the differential Piezo. Enter the applied pressure in the range from 14 to 1066 mbar.

Executing Piezo differential full scale adjustment.

Command:	@253ATS!1.00E+2;FF
Command values:	1.40E+1 to 1.07E+3
Command reply:	@253ACK;FF
Reset to default:	@253FD!ATS;FF
Factory default:	*Factory adjustment value*
Sensor value to high:	@253NAK8;FF

8.8.7 Cold cathode zero adjustment

The Cold Cathode zero adjustment allows the user to adjust the cold cathode zero reading.

Executing zero adjustment
Evacuate the MEMS Pirani to a base pressure below 1×10^{-6} mbar or enter the zero pressure by use of a calibrated reference gauge.
To obtain measuring performance the MEMS Pirani should be evacuated to pressure below 6.67×10^{-8} mbar.

Attention

To obtain best measuring performance, it is recommended that the transmitter is evacuated to a pressure below 1×10^{-8} mbar before executing zero adjustment. Zero adjustment of the MEMS Pirani sensor can be executed at pressures higher than 1×10^{-8} mbar, but this can cause inaccurate reading below the zero adjustment value.
If the pressure measured by the transmitter is higher than approximately $1.3\text{x}10^{-6}$ mbar, then the zero adjustment cannot be executed. If the zero adjustment failed, the LED-ring will flash red three times.

Command:	@253VAC3!2.00E-8;FF
Command values:	1.33E-8 to 1.33E-6 mbar
Command reply:	@253ACK;FF
Query:	@253VAC3?;FF
Query reply:	@253ACK0.00+00;FF
Reset to default:	@253FD!VAC3;FF
Factory default:	*Factory adjustment value*
Value out of range:	@253NAK172;FF

8.8.8 Cold cathode full scale adjustment

The Cold Cathode full scale adjustment allows the user to adjust the cold cathode reading at high pressure.

Command:	@253CFS!4.00E-3;FF
Command values:	1.33E-4 to 6.67E-3 mbar
Command reply:	@253ACK;FF
Query:	@253CFS?;FF
Query reply:	@253ACK5.00E-3;FF
Reset to default:	@253FD!CFS;FF
Factory default:	*Factory adjustment value*
Value out of range:	@253NAK172;FF

8.9 PTR 225 N S

8.9.1 Cold cathode zero adjustment

The Cold Cathode zero adjustment allows the user to adjust the cold cathode zero reading.

Executing zero adjustment
Evacuate the MEMS Pirani to a base pressure below 1×10^{-6} mbar or enter the zero pressure by use of a calibrated reference gauge.
To obtain measuring performance the MEMS Pirani should be evacuated to pressure below 6.67×10^{-8} mbar.

Attention

To obtain best measuring performance, it is recommended that the transmitter is evacuated to a pressure below 1×10^{-8} mbar before executing zero adjustment. Zero adjustment of the MEMS Pirani sensor can be executed at pressures higher than 1×10^{-8} mbar, but this can cause inaccurate reading below the zero adjustment value.
If the pressure measured by the transmitter is higher than approximately $1.3\text{x}10^{-6}$ mbar, then the zero adjustment cannot be executed. If the zero adjustment failed, the LED-ring will flash red three times.

Command:	@253VAC3!2.00E-8;FF
Command values:	1.33E-8 to 1.33E-6 mbar
Command reply:	@253ACK;FF
Query:	@253VAC3?;FF
Query reply:	@253ACK0.00+00;FF
Reset to default:	@253FD!VAC3;FF
Factory default:	*Factory adjustment value*
Value out of range:	@253NAK172;FF

8.9.2 Cold cathode full scale adjustment

The Cold Cathode full scale adjustment allows the user to adjust the cold cathode reading at high pressure.

Command:	@253CFS!4.00E-3;FF
Command values:	1.33E-4 to 6.67E-3 mbar
Command reply:	@253ACK;FF
Query:	@253CFS?;FF
Query reply:	@253ACK5.00E-3;FF
Reset to default:	@253FD!CFS;FF
Factory default:	*Factory adjustment value*
Value out of range:	@253NAK172;FF

9 Factory default

The transmitter is per factory default delivered with parameters and setup as listed below. Most of these parameters are common for all transmitters with RS232 but some are model specific (denoted by an asterisk). Please refer to the table at the bottom of the page for an overview of the model specific parameters.

Communication parameters:

Description	Command	Parameter	FD!	FD!ALL
Address:	AD!	253	-	×
Baud rate:	BR!	9600	-	×
Communication delay:	RSD!	ON	-	×

Transmitter parameters:

Description	Command	Parameter	FD!	FD!ALL
Test mode (LED flash):	TST!	OFF	×	×
User tag:	UT!	LEYBOLD	-	×
Setpoint 1 value*:	SP1!	1.33E0	-	×
Setpoint 1 hysteresis value*:	SH1!	1.46E0	-	×
Setpoint 1 direction:	SD1!	BELOW	-	×
Setpoint 1 enable*:	EN1!	OFF	-	×
Setpoint 2 value:	SP1!	1.33E0	-	×
Setpoint 2 hysteresis value:	SH1!	1.46E0	-	×
Setpoint 2 direction:	SD1!	BELOW	-	×
Setpoint 2 enable:	EN1!	OFF	-	×
Setpoint 3 value:	SP1!	1.33E0	-	×
Setpoint 3 hysteresis value:	SH1!	1.46E0	-	×
Setpoint 3 direction:	SD1!	BELOW	-	×
Setpoint 3 enable:	EN1!	OFF	-	×
Setpoint safety delay:	SPD!	ON	-	×
RS delay	RSD!	10 ms	-	×
Switch enable:	SW!	ON	-	×
Cold Cathode turn on setpoint	SLC!	6.65E-4	-	×
Cold Cathode turn off setpoint	SHC!	1.64E-3	-	×
Cold Cathode control setpoint	ENC!	ON	-	×
Cold Cathode protect setpoint	PRO!	OFF	-	×
MP/CC Smoothing low limit	SLP!	1.33E-4	-	×
MP/CC Smoothing high limit	SHP!	5.32E-4	-	×
MP Zero limit	MZL!	1.33E-4	×	×

Calibration setup:

Description	Command	Parameter	FD!	FD!ALL
Gas calibration:	GT!	NITROGEN	×	×
MP Vacuum adjustment:	VAC!	*Factory adjustment value*	×	×
MP Span atmospheric adjustment:	ATM!	*Factory adjustment value*	×	×
CC Vacuum adjustment:	VAC3!	*Factory adjustment value*	×	×
CC full scale adjustment:	CFS!	*Factory adjustment value*	×	×
PZ atmospheric zero adjust:	ATZ!	*Factory adjustment value*	×	×
PZ positive full scale adjustment:	ATS!	*Factory adjustment value*	×	×
PZ absolute calibration:	ATD!	1013 mbar	×	×
Pressure unit:	U!	mbar	-	×

Model specific parameters

Transmitter model	Transmitter P/N	SP1!	SH1!	EN1!	AO1!
TTR 911 N S	89660V02				34
TTR 101 N S	230366V02				34
TTR 200 N S	230365V02	-6	-3	PZ	34
PTR 225 N S	89642V02				349
PTR 90 N S	230088V02				35
PTR 200 N S	230087V02	-6	-3	PZ	35

Resetting to factory default

The factory default command resets all or certain parameters of the transmitter to factory default settings as listed above. One exception is the analog output, which will not be affected by an FD!ALL command. Please refer to the table above for the default analog output settings (using the AO1! command as described in chapter 14). If other digital communication setup than factory default values are used, then the communication will be lost after execution of factory default and the transceiver equipment should be set to transmitter values.

Command:	@253FD!ALL;FF
Command values:	*None*, ALL, UNLOCK, LOCK, VAC, VAC3, ATM, CFS, ATD, ATS, ATZ, MZL
Command reply:	@253ACKFD;FF

10 Lock function

To ensure that no unauthorized personal are able to change transmitter setup and parameters the MEMS Pirani lock function can prevent direct access to parameter changes. To enable changing the transmitter setup and parameters, the disable lock function command needs to be executed.

Enable lock function command:

Command:	@253FD!LOCK;FF
Command reply:	@253ACK;FF

Disable lock function command:

Command:	@253FD!UNLOCK;FF
Command reply:	@253ACK;FF

11 User switch enabling/disabling

The User Switch function can be disabled to prevent accidental execution of zero and atmospheric adjustments.

Command:	@253SW!OFF;FF
Command values:	ON,OFF
Command reply:	@253ACKOFF;FF
Query:	@253SW?;FF
Query reply:	@253ACKON;FF
Factory default:	ON

12 Transmitter test

The transmitter test command can be used to visually identify a transmitter. If the test mode is enabled the LED will flash with a 1 sec. cycle.

Command:	@253TST!ON;FF
Command values:	ON,OFF
Command reply:	@253ACKON;FF
Query:	@253TST?;FF
Query reply:	@253ACKON;FF
Factory default:	OFF

13 Status Query Commands

Query replies are examples that might be different from actual transmitter replies.

Device Type - DT
Specifies transmitter device type name:

Query:	@253DT?;FF
Query reply:	@253ACKTHERMOVAC;FF

Firmware Version - FV
Specifies transmitter firmware version:

Query:	@253FV?;FF
Query reply:	@253ACK1.00;FF

Hardware Version - HV
Specifies transmitter hardware version:

Query:	@253HV?;FF
Query reply:	@253ACK1;FF

Manufacturer - MF
Specifies transmitter manufacturer:

Query:	@253MF?;FF
Query reply:	@253ACKLEYBOLD;FF

Model - MD
Specifies transmitter model number:

Query:	@253MD?;FF
Query reply:	@253ACKTTR 911 N S;FF

Part Number - PN
Specifies transmitter part number:

Query:	@253PN?;FF
Query reply:	@253ACK89660V02;FF

Serial Number - SN
Specifies transmitter serial number:

Query:	@253SN?;FF
Query reply:	@253ACK1234567890;FF

Time ON - TIM
The TIM command returns the number of hours the transmitter has been on:

Query:	@253TIM?;FF
Query reply:	@253ACK123;FF

Time ON 2 (Cold Cathode sensor) – TIM2
The TIM2 command returns the number of hours the cold cathode sensor has been on:

Query:	@253TIM2?;FF
Query reply:	@253ACK123;FF

Time ON 3 (Cold Cathode pressure dose) – TIM3
The TIM3 command returns the cold cathode pressure dose:

Query:	@253TIM3?;FF
Query reply:	@253ACK1.00E-2;FF

Temperature - TEM
The TEM query returns the MEMS Pirani on chip sensor temperature ºC typical within ±3 ºC.

Query:	@253TEM?;FF
Query reply:	@253ACK2.50E+1;FF

Transmitter Status – T
The T command returns the Transmitter sensor status as O for OK, M for MEMS Pirani failure, C for Cold Cathode failure, R pressure dose setpoint exceeded or G for Cold Cathode ON.

Query:	@253T?;FF
Query reply:	@253ACKO;FF

Setpoint Status – SS
The SS query returns the Transmitter sensor Set point relay 1-3 status (SET=Relay energized / CLEAR=Relay deenergized).

Query:	@253SS?;FF
Query reply:	@253ACKSET;FF

Firmware Build Date – FVD
The FVD query returns the firmware build date.

Query:	@253FVD?;FF
Query reply:	@253ACK01/01/15;FF

Firmware Part Number Status – FVP
The FVP query returns the firmware part number.

Query:	@253FVP?;FF
Query reply:	@253ACK100017876;FF

Cold Cathode Filament Status – FS
The FS query returns the cold cathode filament status.

Query:	@253FS?;FF
Query reply:	@253ACKON;FF

14 Analog output setup

The THERMOVAC and PENNINGVAC Transmitters can emulate analog voltage outputs from other vacuum transmitters. The analog output can be assigned to the different digital pressure readings, PR1, PR2, PR3 and PR4. Thus it is possible to configure the analog output to be assigned to only one sensor, for example the differential piezo reading in a TTR 200 N transmitter (refer to chapter 5). This is set by the first digit. The second and third digit represents the analog output calibration. The analog output provides 16 bit resolution.

Attention

Due to curve form and limits, some of the alternative analog outputs will cause loss of measuring range and accuracy. For best performance use the standard Leybold analog output. Change of analog output setup does not interfere with the digital reading.

Change of analog output setup:

Command: @253AO1!15;FF
Command values: 10 to 319 (xy)

First digit (x) 1 = PR1, 2 = PR2, 3 = PR3, 4 = PR4

Second digit(s) (y)

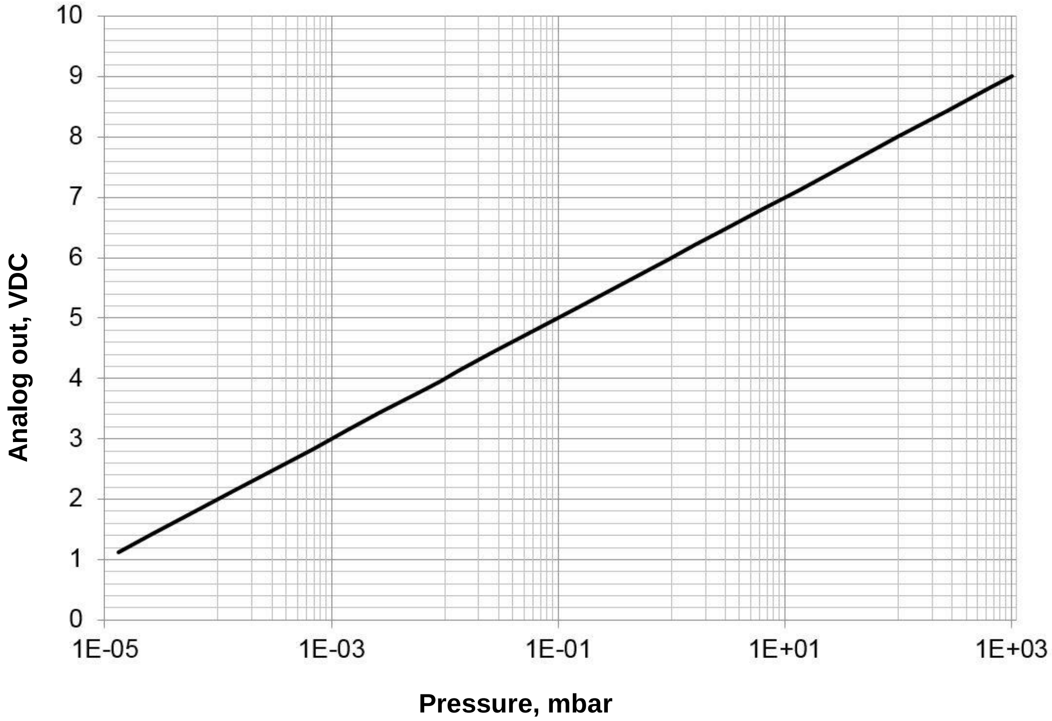
0	MKS 900 series emulation (transmitter dependent)
1	Edwards APG-L (1.99 -10 VDC) emulation
2	Edwards APG-100 emulation
3	Edwards WRG emulation
4	Leybold TTR 91N, TTR 911 N, TTR 101 N, TTR 200 N / Inficon PSG500
5	Leybold PTR 90 N, PTR 200 N / Inficon MPG400 / Inficon PKR251 / Pfeiffer PKR251
6	Inficon BPG400 / MKS 999 Quattro emulation
8	MKS Moducell 325 emulation
9	MKS Moducell 325 (amplified 3 times) emulation
10	MKS Baratron 0.1 Torr (0-10 VDC) emulation
11	MKS Baratron 1 Torr (0-10 VDC) emulation
12	MKS Baratron 10 Torr 0-10 VDC) emulation
13	MKS Baratron 100 Torr (0-10 VDC) emulation
14	MKS Baratron 1000 Torr (0-10 VDC) emulation
15	Piezo differential output
16	Edwards AIM-S /-SL emulation
17	Edwards AIM-X /-XL emulation
18	Pfeiffer IKR251 emulation
19	Pfeiffer TPR265, Pfeiffer TPR280, Inficon TPR280 emulation
20	OBE Special emulation
21	Edwards DV6M emulation
22	Edwards APG-M emulation
23	Brooks / Granville Phillips GP275 Emulation 9 VDC FS emulation
24	Thyracont MT241.1-5 emulation
25	Brooks / Granville Phillips GP275 Emulation 5.6 VDC FS emulation
26	Edwards APG100-LC emulation
27	Edwards APG100-M emulation
28	MKS 907 emulation
29	K6080 emulation
30	Inficon PEG100 emulation
31	Varian Eysys emulation
32	Alcatel TA111 emulation
33	MKS 685 emulation
49	Leybold PTR 225 N, PTR 237N

Command reply: @253ACK15;FF
Query: @253AO1?;FF
Query reply: @253ACK15;FF
Factory default: 30

Analog output calibration = 0 (MKS 900 series emulation, depends on transmitter model)
The MKS 900 series analog output emulation provides always 1 VDC/decade if selected on a THERMOVAC transmitter. If selected on a PENNINGVAC transmitter the analog output is 0.5 VDC/decade. If the transmitter pressure unit is changed from mbar to Pascal or Torr the analog output scaling will change as well.

THERMOVAC transmitter analog output equations:

$P_{Torr} = 10^{(V_{out} - 6)}$	$V_{out} = \log_{10}(P_{Torr}) + 6$
$P_{mbar} = 10^{(V_{out} - 6)}$	$V_{out} = \log_{10}(P_{mbar}) + 6$
$P_{Pascal} = 10^{(V_{out} - 4)}$	$V_{out} = \log_{10}(P_{Pascal}) + 4$



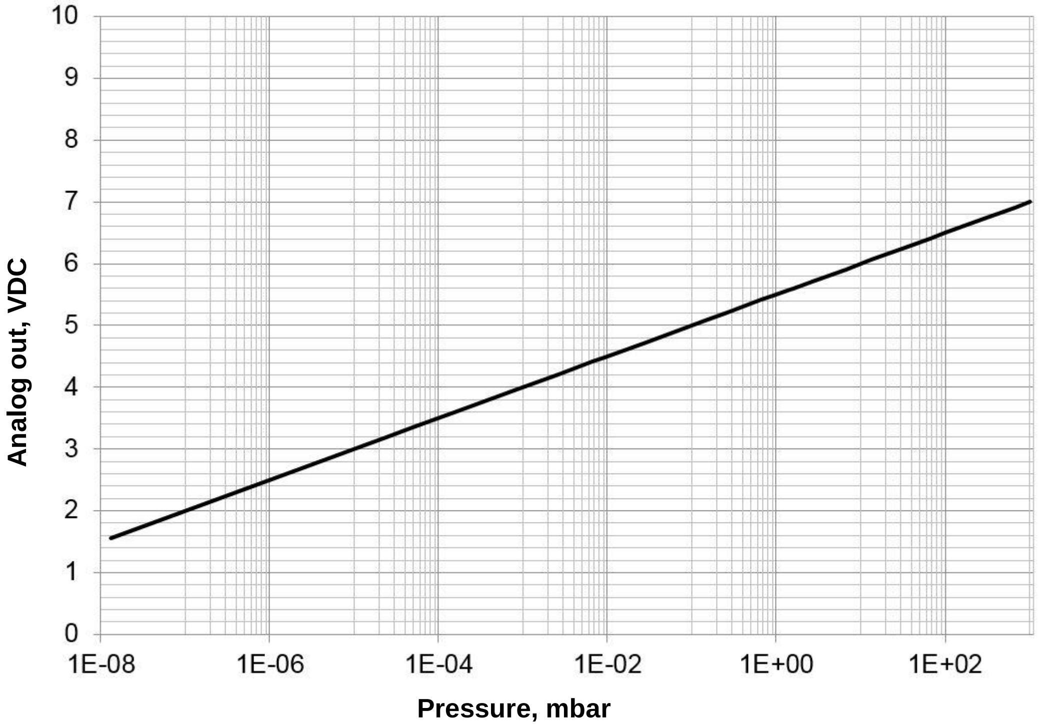
Torr/mbar	Vout	Torr/mbar	Vout	Torr/mbar	Vout	Torr/mbar	Vout
1.0E-5	1.000	1.0E-3	3.000	1.0E-1	5.000	10	7.000
2.0E-5	1.301	2.0E-3	3.301	2.0E-1	5.301	20	7.301
3.0E-5	1.477	3.0E-3	3.477	3.0E-1	5.477	30	7.477
4.0E-5	1.602	4.0E-3	3.602	4.0E-1	5.602	40	7.602
5.0E-5	1.699	5.0E-3	3.699	5.0E-1	5.699	50	7.699
6.0E-5	1.778	6.0E-3	3.778	6.0E-1	5.778	60	7.778
7.0E-5	1.845	7.0E-3	3.845	7.0E-1	5.845	70	7.845
8.0E-5	1.903	8.0E-3	3.903	8.0E-1	5.903	80	7.903
9.0E-5	1.954	9.0E-3	3.954	9.0E-1	5.954	90	7.954
1.0E-4	2.000	1.0E-2	4.000	1.0	6.000	100	8.000
2.0E-4	2.301	2.0E-2	4.301	2.0	6.301	200	8.301
3.0E-4	2.477	3.0E-2	4.477	3.0	6.477	300	8.477
4.0E-4	2.602	4.0E-2	4.602	4.0	6.602	400	8.602
5.0E-4	2.699	5.0E-2	4.699	5.0	6.699	500	8.699
6.0E-4	2.778	6.0E-2	4.778	6.0	6.778	600	8.778
7.0E-4	2.845	7.0E-2	4.845	7.0	6.845	700	8.845
8.0E-4	2.903	8.0E-2	4.903	8.0	6.903	760	8.881
9.0E-4	2.954	9.0E-2	4.954	9.0	6.954	800	8.903

PENNINGVAC transmitter analog output equations:

$P_{\text{Torr}} = 10^{(2 \cdot Vout - 11)}$ $\qquad V_{out} = \frac{log_{10}(P_{\text{Torr}})+11}{2}$

$P_{\text{mbar}} = 10^{(2 \cdot Vout - 11)}$ $\qquad V_{out} = \frac{log_{10}(P_{\text{mbarr}})+11}{2}$

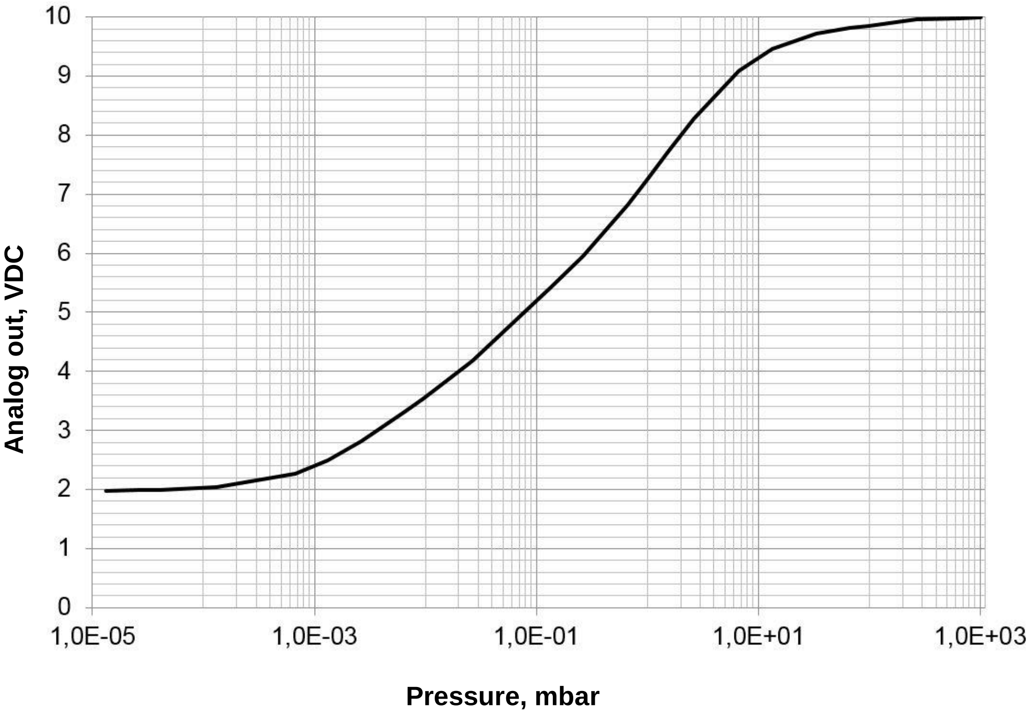
$P_{\text{Pascal}} = 10^{(2 \cdot Vout - 9)}$ $\qquad V_{out} = \frac{log_{10}(P_{\text{Pascal}})+9}{2}$



Torr/mbar	Vout	Torr/mbar	Vout	Torr/mbar	Vout	Torr/mbar	Vout
1.0E-8	1.5000	1.0E-5	3.0000	1.0E-2	4.5000	10	6.0000
2.0E-8	1.6505	2.0E-5	3.1505	2.0E-2	4.6505	20	6.1505
4.0E-8	1.8010	4.0E-5	3.3010	4.0E-2	4.8010	40	6.3010
6.0E-8	1.8891	6.0E-5	3.3891	6.0E-2	4.8891	60	6.3891
8.0E-8	1.9515	8.0E-5	3.4515	8.0E-2	4.9515	80	6.4515
1.0E-7	2.0000	1.0E-4	3.5000	1.0E-1	5.0000	100	6.5000
2.0E-7	2.1505	2.0E-4	3.6505	2.0E-1	5.1505	200	6.6505
4.0E-7	2.3010	4.0E-4	3.8010	4.0E-1	5.3010	400	6.8010
6.0E-7	2.3891	6.0E-4	3.8891	6.0E-1	5.3891	600	6.8891
8.0E-7	2.4515	8.0E-4	3.9515	8.0E-1	5.4515	760	6.9404
1.0E-6	2.5000	1.0E-3	4.0000	1.0	5.5000	800	6.9515
2.0E-6	2.6505	2.0E-3	4.1505	2.0	5.6505		
4.0E-6	2.8010	4.0E-3	4.3010	4.0	5.8010		
6.0E-6	2.8891	6.0E-3	4.3891	6.0	5.8891		
8.0E-6	2.9515	8.0E-3	4.4515	8.0	5.9515		

Analog output calibration = 1 (Edwards APG-L (1.99 -10 VDC) emulation)

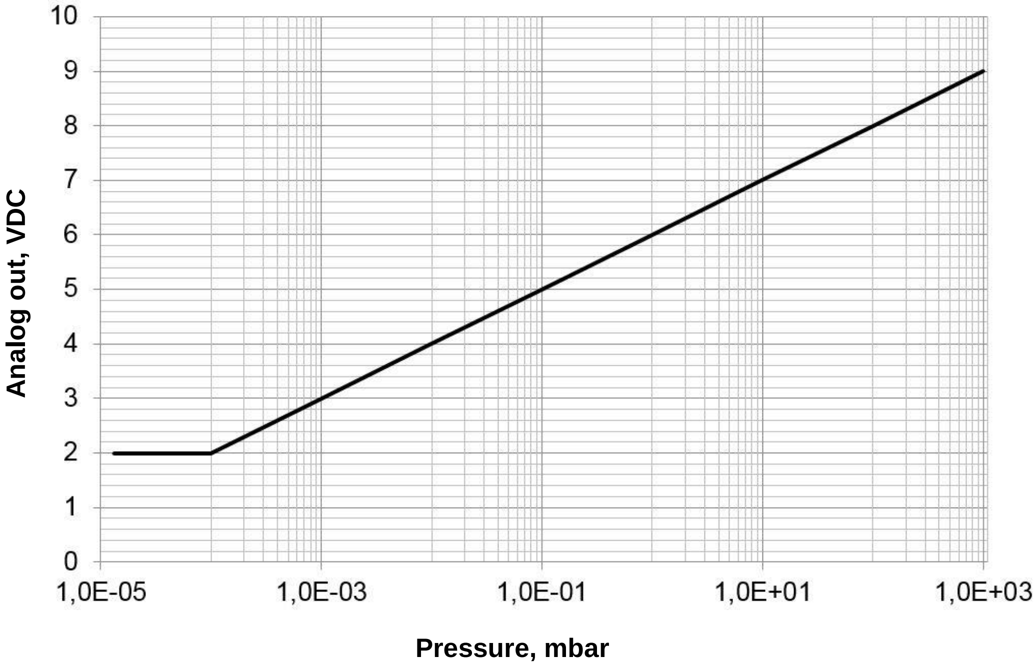
The APG-L emulation provides a strongly non-linear output with very poor resolution in the low range and virtually no signal from 100 Torr to atmosphere.



Torr	mbar	Pascal	Vout
1.90E-5	2.53E-5	2.53E-3	1.99
3.00E-5	4.00E-5	4.00E-3	2.00
1.00E-4	1.33E-4	1.33E-2	2.04
5.00E-4	6.66E-4	6.66E-2	2.27
1.00E-3	1.33E-3	1.33E-1	2.50
2.00E-3	2.66E-3	2.66E-1	2.82
5.00E-3	6.66E-3	6.66E-1	3.34
7.00E-3	9.32E-3	9.32E-1	3.53
1.00E-2	1.33E-2	1.33	3.74
2.00E-2	2.66E-2	26.6	4.18
1.00E-1	1.33E-1	13.3	5.42
2.00E-1	2.66E-1	26.6	5.96
5.00E-1	6.66E-1	66.6	6.83
7.00E-1	9.32E-1	93.2	7.19
1.00	1.33	133	7.57
1.20	1.60	160	7.77
2.00	2.66	2.66	8.28
5.00	6.66	666	9.08
10.0	13.3	1.330	9.46
25.0	33.3	3.330	9.72
50.0	66.6	6.660	9.81
75.0	99.9	9.990	9.84
200	266	26.600	9.96
500	666	66.600	9.98
760	1013	101.300	10.00

Analog output calibration = 2 (Edwards APG-100 emulation)
The APG-L emulation provides a log linear output of 1 VDC/mbar.

$P_{Torr} = 10^{(Vout - 6.125)}$ $V_{out} = \log_{10}(P_{Torr})+6.125$
$P_{mbar} = 10^{(Vout - 6)}$ $V_{out} = \log_{10}(P_{mbar})+6$
$P_{Pascal} = 10^{(Vout - 4)}$ $V_{out} = \log_{10}(P_{Pascal})+4$

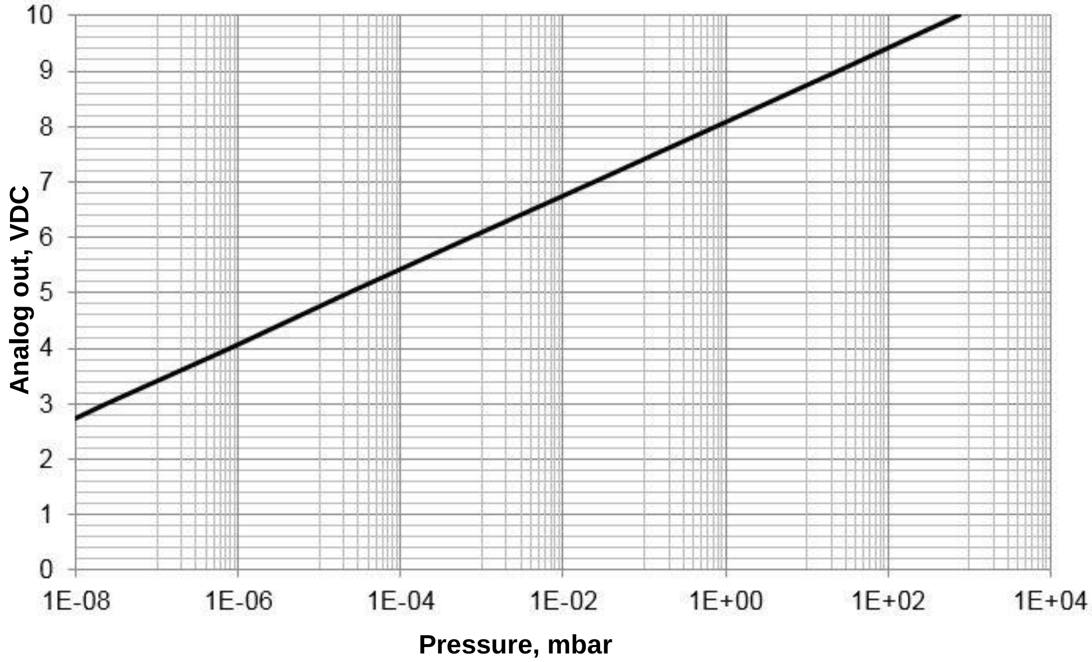


Torr	mbar	Pascal	Vout
7.50E-5	1.00E-4	1.00E-2	2.00
7.50E-4	1.00E-3	1.00E-1	3.00
7.50E-3	1.00E-2	1.00	4.00
7.50E-2	1.00E-1	10.0	5.00
7.50E-1	1.00	100	6.00
7.50	10.0	1.000	7.00
75.0	100	10.000	8.00
750	1.000	100.000	9.00

Analog output calibration = 3 (Edwards WRG emulation)

$P_{Torr} = 10^{(1.5\times Vout -12.125)}$
$P_{mbar} = 10^{(1.5\times Vout -12)}$
$P_{Pascal} = 10^{(1.5\times Vout -10)}$

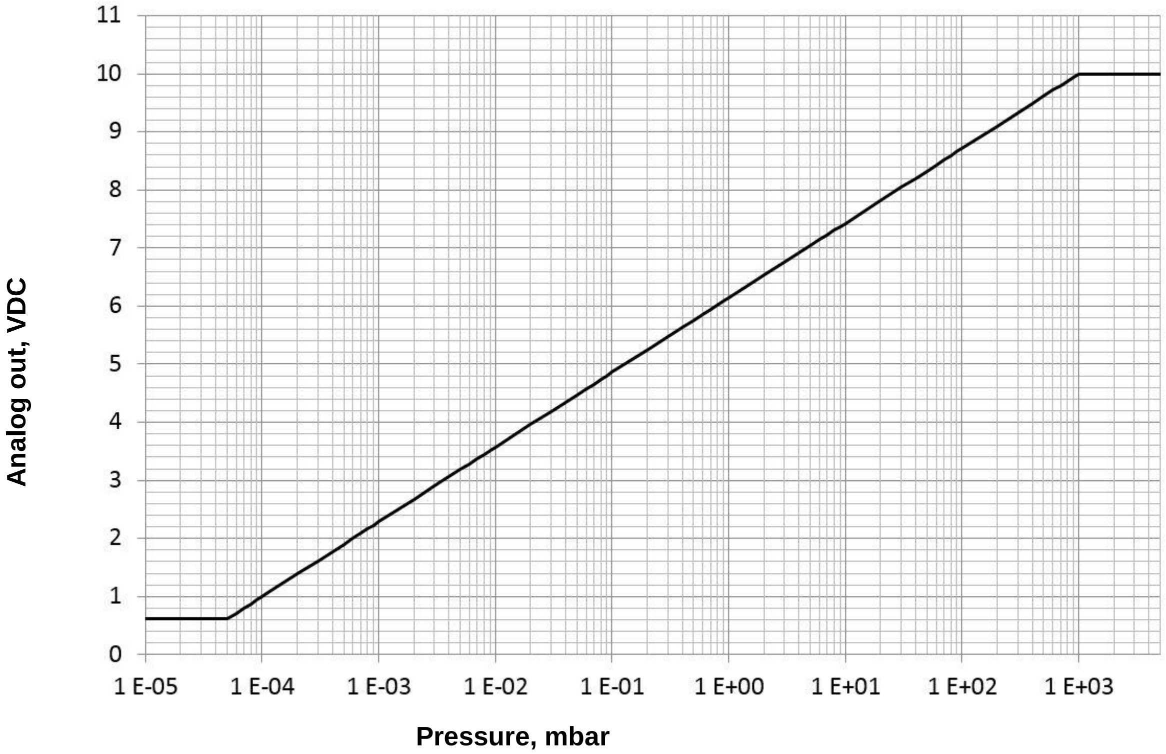
$V_{out} = (\log_{10} (P_{Torr})+12.125) / 1.5$
$V_{out} = (\log_{10} (P_{mbar})+12) / 1.5$
$V_{out} = (\log_{10} (P_{Pascal})+10) / 1.5$



Torr	mbar	Pascal	Vout
1.00E-8	1.33E-8	1.33E-6	2.75
2.37E-8	3.16E-8	3.16E-6	3.00
7.50E-7	1.00E-6	1.00E-4	4.00
2.37E-5	3.16E-5	3.16E-2	5.00
7.50E-4	1.00E-3	1.00E-1	6.00
2.37E-2	3.16E-2	3.16	7.00
7.50E-1	1.00	100	8.00
2.37	31.6	3.160	9.00
750.0	1.000	100.000	10.00

Analog output calibration = 4 (Leybold TTR 91N, TTR 911 N, TTR 101 N, TTR 200 N / Inficon PSG500)
The TTR 91N, TTR 911 N, TTR 101 N, TTR 200 N or Inficon PSG500 option provides a log linear output. The output does not provide a pressure dependent signal at pressures below 5E-5 mbar.

$P_{Torr} = 10^{((Vout -6.304)/1.286)}$ $V_{out} = \log_{10} (P_{Torr}) \times 1.286+6.304$
$P_{mbar} = 10^{((Vout -6.143)/1.286)}$ $V_{out} = \log_{10} (P_{mbar}) \times 1.286+6.143$
$P_{Pascal} = 10^{((Vout -3.572)/1.286)}$ $V_{out} = \log_{10} (P_{Pascal}) \times 1.286+3.572$



Torr	mbar	Pascal	Vout
1.00E-5	5.00E-05	1.33E-03	0.61
2.00E-04	2.67E-04	2.67E-02	1.547
5.00E-04	6.67E-04	6.67E-02	2.058
1.00E-03	1.33E-03	1.33E-01	2.446
1.00E-02	1.33E-02	1.33E+00	3.732
1.00E-01	1.33E-01	1.33E+01	5.018
1.00E+00	1.33E+00	1.33E+02	6.304
1.00E+01	1.33E+01	1.33E+03	7.59
1.00E+02	1.33E+02	1.33E+04	8.876
7.50E+02	1.00E+03	1.00E+05	10.008

Analog output calibration = 5 (Leybold PTR 90 N, PTR 200 N / Inficon MPG400 / Inficon PKR251 / Pfeiffer PKR251)

The PTR 90 N, PTR 200 N, Inficon MPG400, Inficon PKR251 or Pfeiffer PKR251 option provides a log linear output.

$P_{Torr} = 10^{((V_{out} - 6.875)/0.6)}$

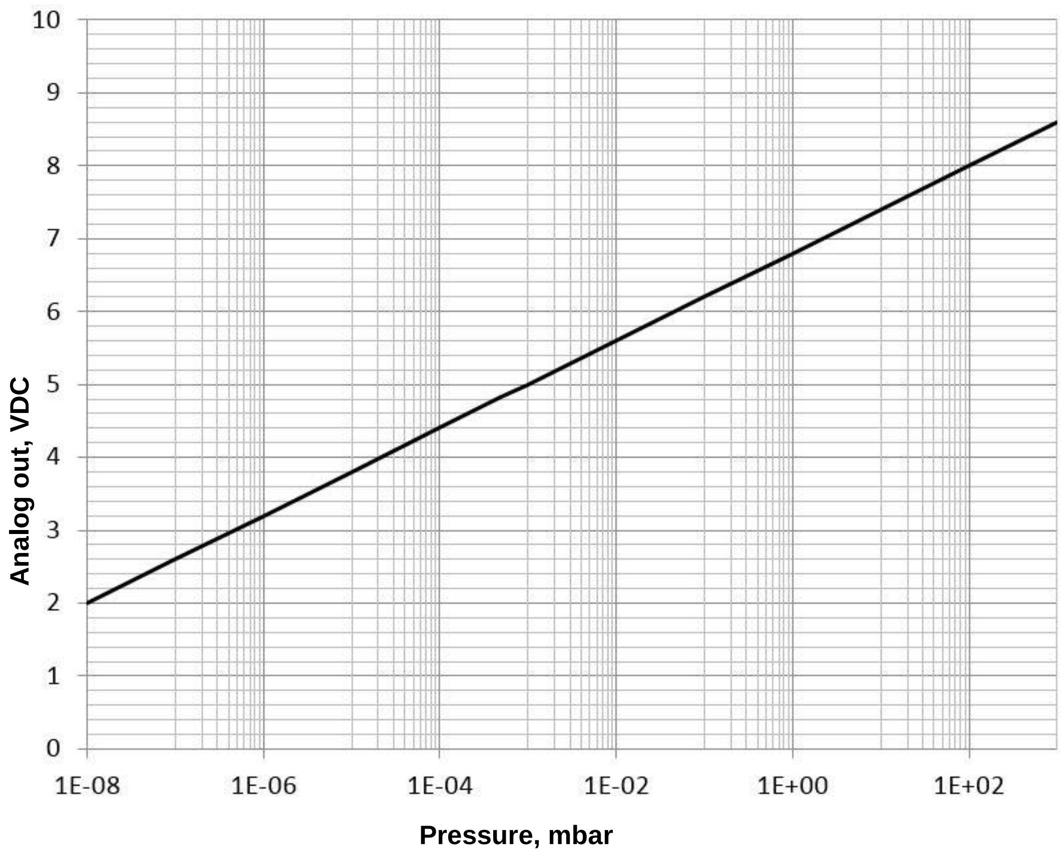
$P_{mbar} = 10^{((V_{out} - 6.8)/0.6)}$

$P_{Pascal} = 10^{((V_{out} - 5.6)/0.6)}$

$V_{out} = \log_{10}(P_{Torr}) \times 0.6 + 6.875$

$V_{out} = \log_{10}(P_{mbar}) \times 0.6 + 6.8$

$V_{out} = \log_{10}(P_{Pascal}) \times 0.6 + 5.6$



Torr	mbar	Pascal	Vout
1.00E-08	1.33E-08	1.33E-06	2.075
1.00E-07	1.33E-07	1.33E-05	2.675
1.00E-06	1.33E-06	1.33E-04	3.275
1.00E-05	1.33E-05	1.33E-03	3.875
1.00E-04	1.33E-04	1.33E-02	4.475
1.00E-03	1.33E-03	1.33E-01	5.075
1.00E-02	1.33E-02	1.33E+00	5.675
1.00E-01	1.33E-01	1.33E+01	6.275
1.00E+00	1.33E+00	1.33E+02	6.875
1.00E+01	1.33E+01	1.33E+03	7.475
1.00E+02	1.33E+02	1.33E+04	8.075
7.60E+02	1.01E+03	1.01E+05	8.603

Analog output calibration = 6 (Inficon BPG400 / MKS 999 Quattro emulation)

$P_{Torr} = 10^{((V_{out} - 7.75)/0.75)} - 0.125$

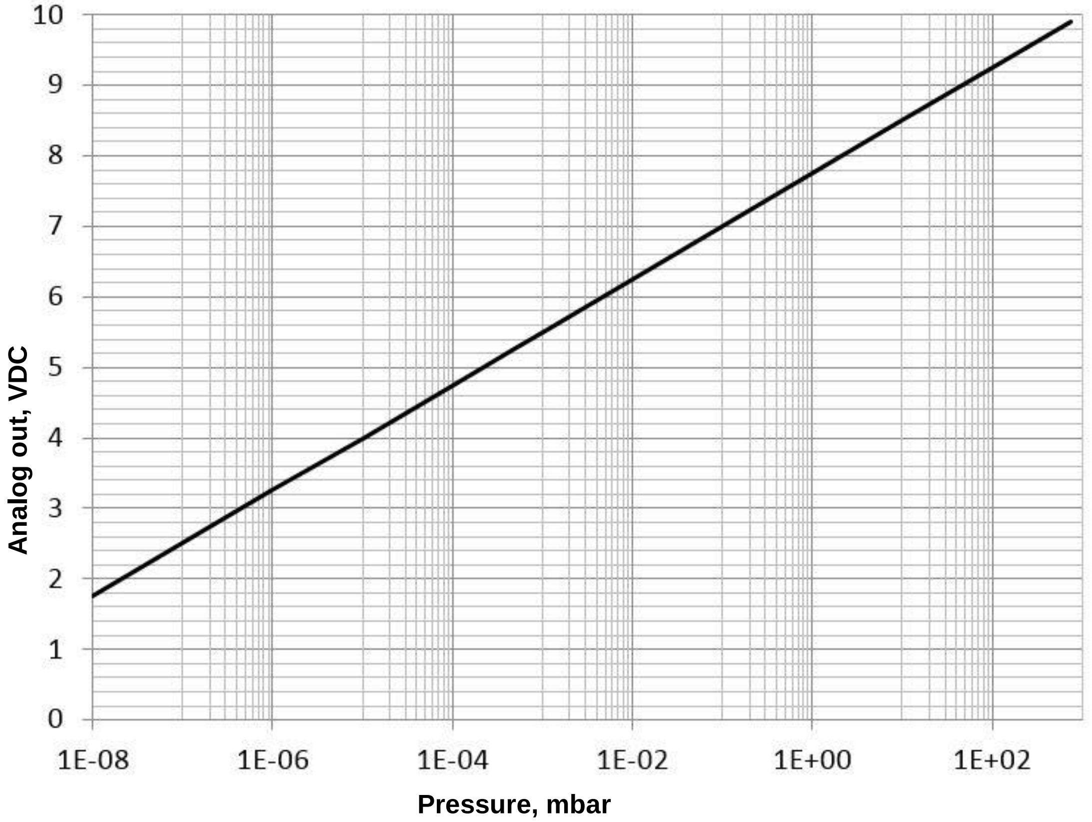
$P_{mbar} = 10^{((V_{out} - 7.75)/0.75)}$

$P_{Pascal} = 10^{(V_{out}/0.75)+2}$

$V_{out} = \log_{10}(P_{Torr} + 0.125) \times 0.75 + 7.75$

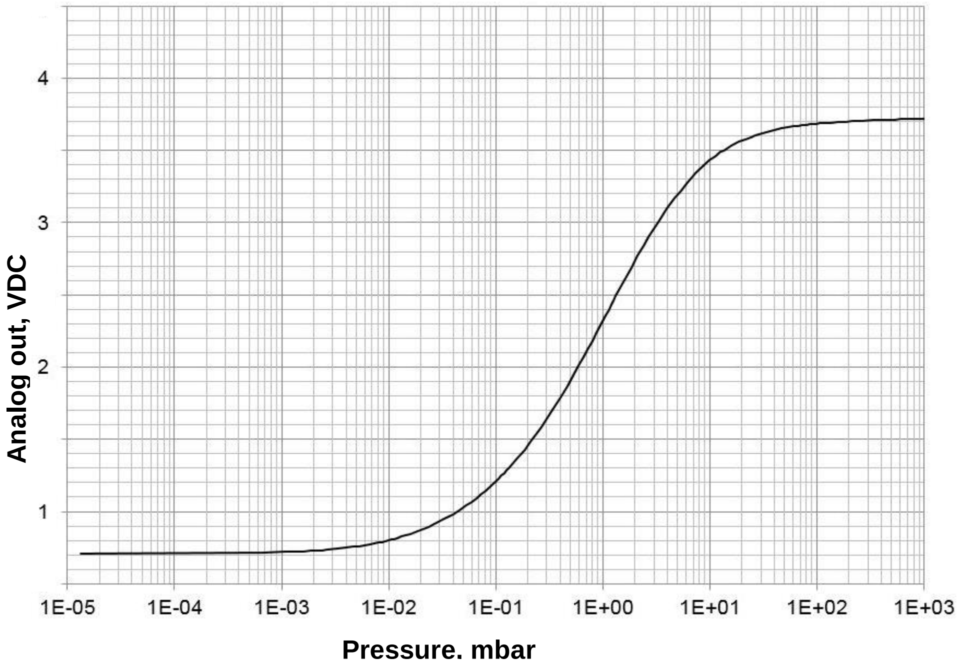
$V_{out} = \log_{10}(P_{mbar}) \times 0.75 + 7.75$

$V_{out} = \log_{10}(P_{Pascal} - 2) \times 0.75 + 7.75$



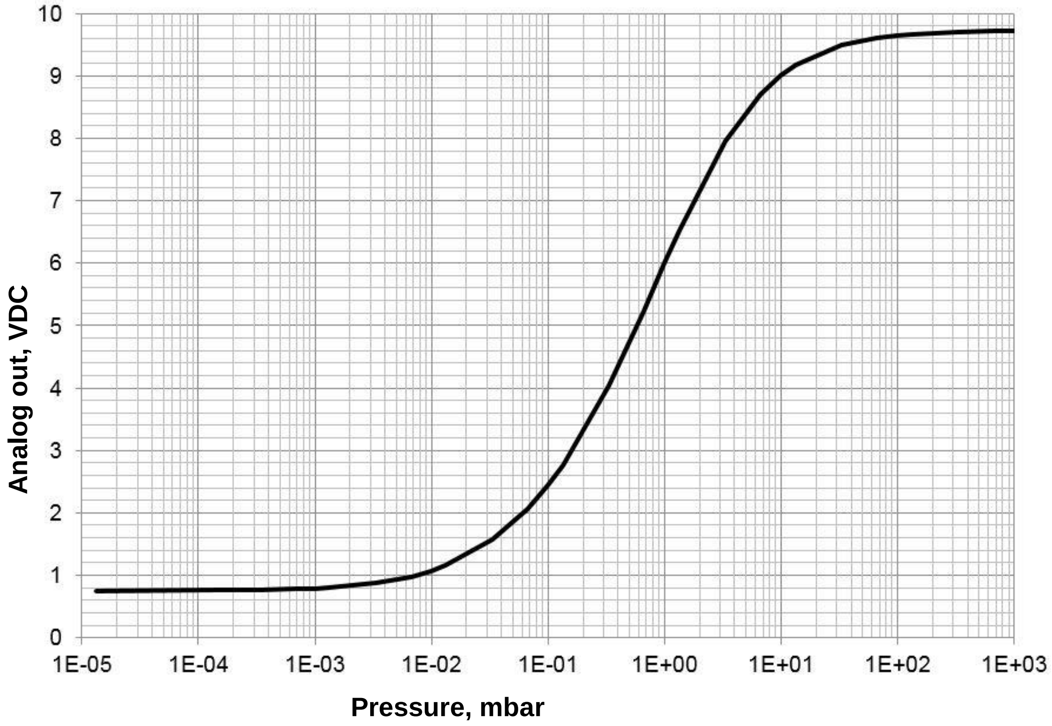
Torr	mbar	Pascal	Vout
1.00E-08	1.33E-08	1.33E-06	1.843
1.00E-07	1.33E-07	1.33E-05	2.593
1.00E-06	1.33E-06	1.33E-04	3.343
1.00E-05	1.33E-05	1.33E-03	4.093
1.00E-04	1.33E-04	1.33E-02	4.843
5.00E-04	6.67E-04	6.67E-02	5.367
1.00E-03	1.33E-03	1.33E-01	5.593
1.00E-02	1.33E-02	1.33E+00	6.343
1.00E-01	1.33E-01	1.33E+01	7.093
1.00E+00	1.33E+00	1.33E+02	7.843
1.00E+01	1.33E+01	1.33E+03	8.593
1.00E+02	1.33E+02	1.33E+04	9.343
7.60E+02	1.01E+03	1.01E+05	10.004

Analog out calibration = 8 (MKS Moducell 325 emulation)
The Moducell emulation provides a strongly non-linear output.



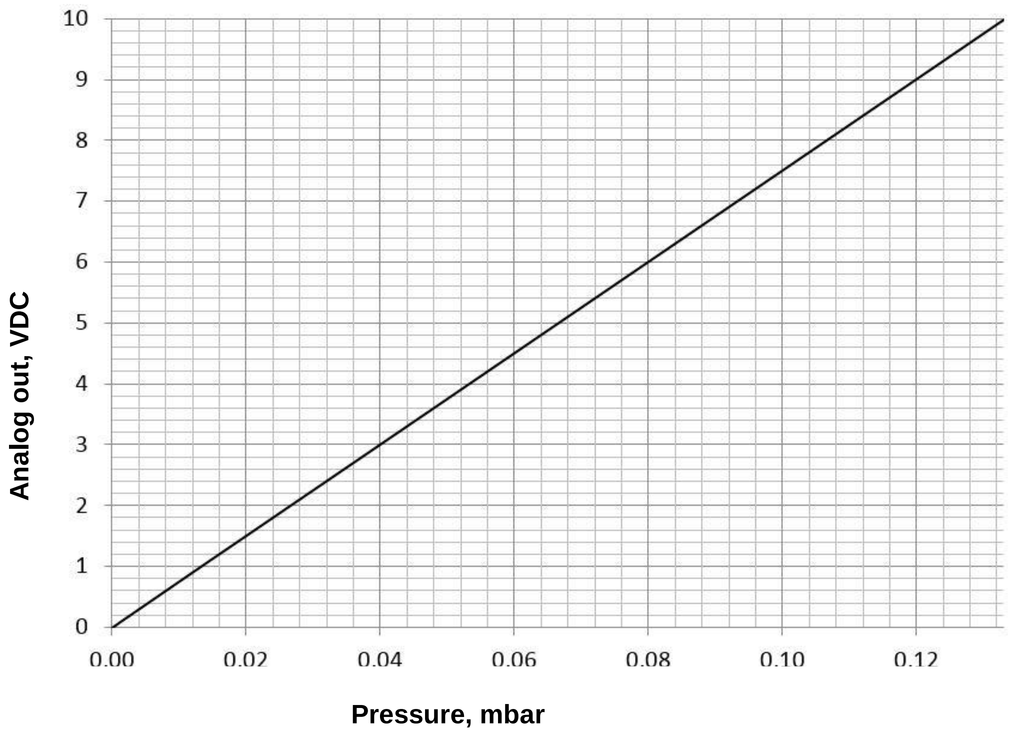
Torr	mbar	Pascal	Vout
1.00E-05	1.33E-05	1.33E-03	0.2509
1.00E-04	1.33E-04	1.33E-02	0.2524
2.50E-04	3.33E-04	3.33E-02	0.2550
5.00E-04	6.67E-04	6.67E-02	0.2592
7.50E-04	1.00E-03	1.00E-01	0.2633
1.00E-03	1.33E-03	1.33E-01	0.2674
2.50E-03	3.33E-03	3.33E-01	0.2905
5.00E-03	6.67E-03	6.67E-01	0.3251
7.50E-03	1.00E-02	1.00E+00	0.3561
1.00E-02	1.33E-02	1.33E+00	0.3845
2.50E-02	3.33E-02	3.33E+00	0.5215
5.00E-02	6.67E-02	6.67E+00	0.6868
7.50E-02	1.00E-01	1.00E+01	0.8144
1.00E-01	1.33E-01	1.33E+01	0.9205
2.50E-01	3.33E-01	3.33E+01	1.3489
5.00E-01	6.67E-01	6.67E+01	1.7504
7.50E-01	1.00E+00	1.00E+02	1.9986
1.00E+00	1.33E+00	1.33E+02	2.1720
2.50E+00	3.33E+00	3.33E+02	2.6512
5.00E+00	6.67E+00	6.67E+02	2.9012
7.50E+00	1.00E+01	1.00E+03	3.0022
1.00E+01	1.33E+01	1.33E+03	3.0569
2.50E+01	3.33E+01	3.33E+03	3.1639
5.00E+01	6.67E+01	6.67E+03	3.2023
7.50E+01	1.00E+02	1.00E+04	3.2154
1.00E+02	1.33E+02	1.33E+04	3.2221
2.50E+02	3.33E+02	3.33E+04	3.2342
5.00E+02	6.67E+02	6.67E+04	3.2382
6.00E+02	8.00E+02	8.00E+04	3.2389
7.00E+02	9.33E+02	9.33E+04	3.2394
7.60E+02	1.01E+03	1.01E+05	3.2396
8.00E+02	1.07E+03	1.07E+05	3.2398

Analog out calibration = 9 (MKS Moducell 325, amplified 3 times, emulation)
The Moducell x3 emulation is in curve form identical with the standard Moducell, however, to provide better signal resolution the signal is amplified by a factor three.



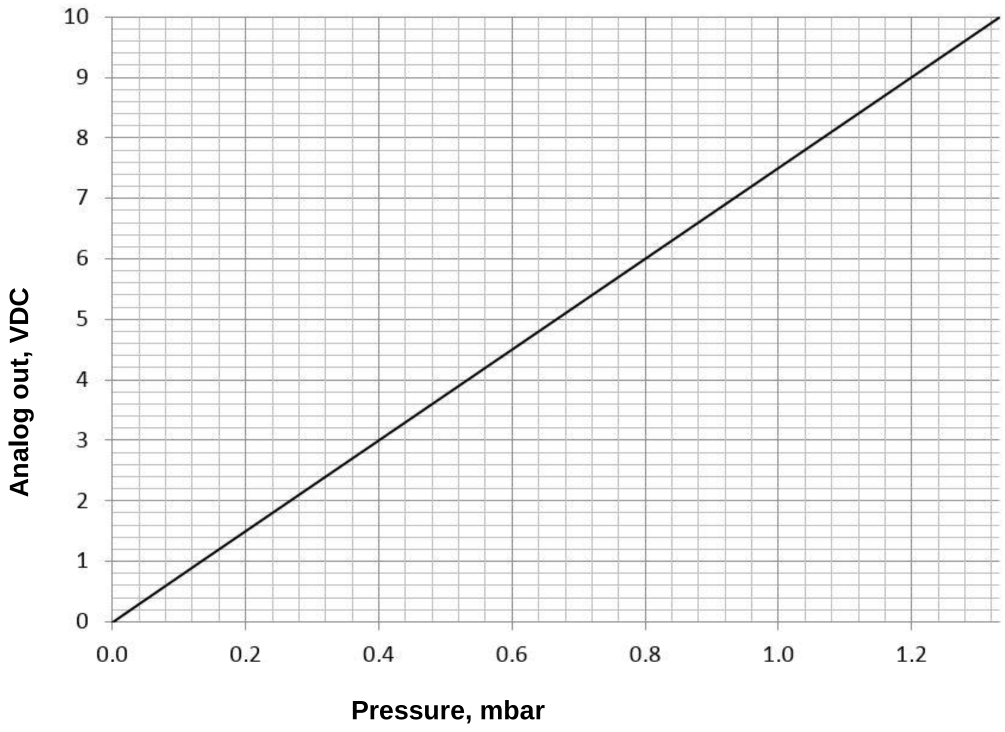
Torr	mbar	Pascal	Vout
1.00E-05	1.33E-05	1.33E-03	0.753
1.00E-04	1.33E-04	1.33E-02	0.757
2.50E-04	3.33E-04	3.33E-02	0.765
5.00E-04	6.67E-04	6.67E-02	0.778
7.50E-04	1.00E-03	1.00E-01	0.790
1.00E-03	1.33E-03	1.33E-01	0.802
2.50E-03	3.33E-03	3.33E-01	0.871
5.00E-03	6.67E-03	6.67E-01	0.975
7.50E-03	1.00E-02	1.00E+00	1.068
1.00E-02	1.33E-02	1.33E+00	1.154
2.50E-02	3.33E-02	3.33E+00	1.565
5.00E-02	6.67E-02	6.67E+00	2.060
7.50E-02	1.00E-01	1.00E+01	2.443
1.00E-01	1.33E-01	1.33E+01	2.762
2.50E-01	3.33E-01	3.33E+01	4.047
5.00E-01	6.67E-01	6.67E+01	5.251
7.50E-01	1.00E+00	1.00E+02	5.996
1.00E+00	1.33E+00	1.33E+02	6.516
2.50E+00	3.33E+00	3.33E+02	7.954
5.00E+00	6.67E+00	6.67E+02	8.704
7.50E+00	1.00E+01	1.00E+03	9.007
1.00E+01	1.33E+01	1.33E+03	9.171
2.50E+01	3.33E+01	3.33E+03	9.492
5.00E+01	6.67E+01	6.67E+03	9.607
7.50E+01	1.00E+02	1.00E+04	9.646
1.00E+02	1.33E+02	1.33E+04	9.666
2.50E+02	3.33E+02	3.33E+04	9.702
5.00E+02	6.67E+02	6.67E+04	9.715
6.00E+02	8.00E+02	8.00E+04	9.717
7.00E+02	9.33E+02	9.33E+04	9.718
7.60E+02	1.01E+03	1.01E+05	9.719
8.00E+02	1.07E+03	1.07E+05	9.719

Analog out calibration = 10 (MKS Baratron 0.1 Torr (0-10 VDC) emulation)
The 0.1 Torr Baratron emulation provides a signal directly proportional with pressure with a full scale reading of 10 VDC at 0.133 mbar.



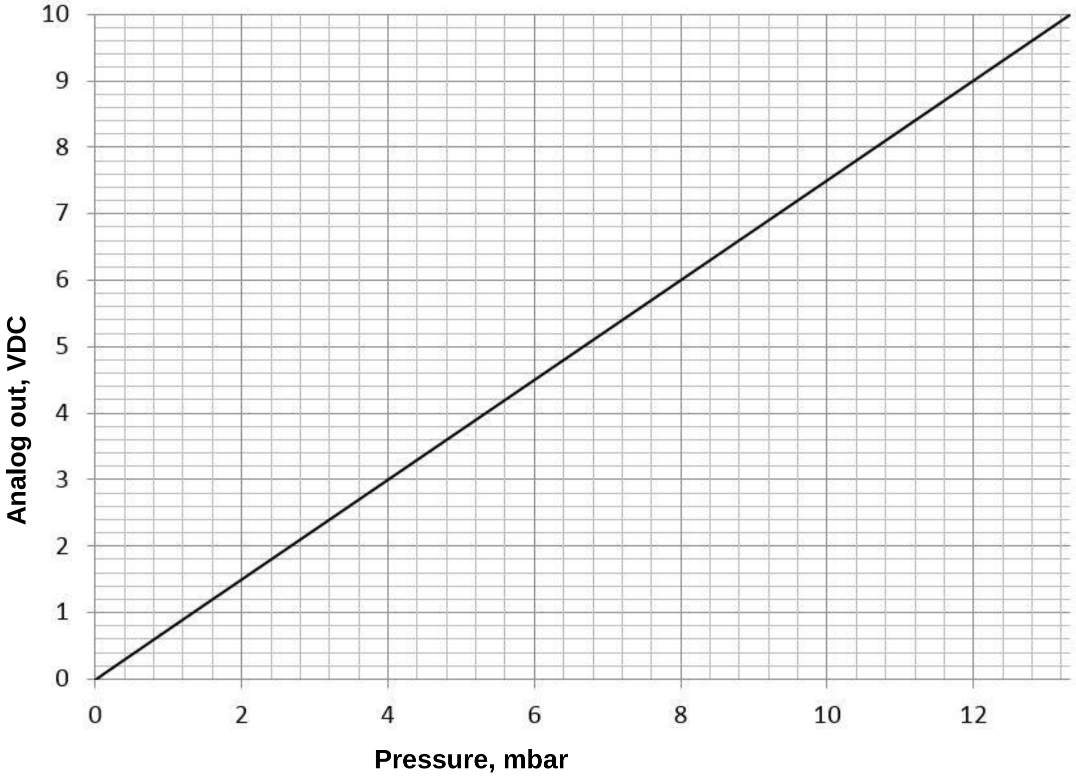
Torr	mbar	Pascal	Vout
1.00E-3	1.33E-3	1.33E-1	0.100
5.00E-3	6.66E-3	6.66E-1	0.500
1.00E-2	1.33E-2	1.33E0	1.000
5.00E-2	6.66E-2	6.66E0	5.000
1.00E-1	1.33E-1	1.33E+1	10.000

Analog out calibration = 11 (MKS Baratron 1 Torr (0-10 VDC) emulation)
The 1 Torr Baratron emulation provides a signal directly proportional with pressure with a full scale reading of 10 VDC at 1.33 mbar.



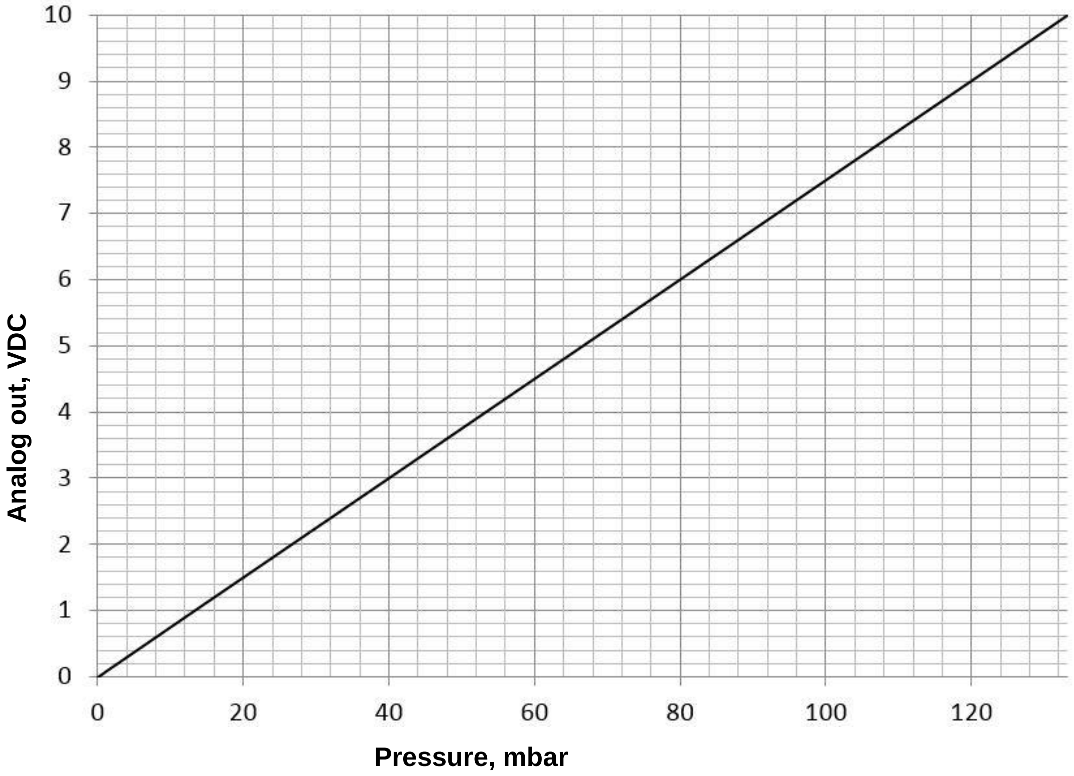
Torr	mbar	Pascal	Vout
1.00E-2	1.33E-2	1.33E0	0.100
5.00E-2	6.66E-2	6.66E0	0.500
1.00E-1	1.33E-1	1.33E+1	1.000
5.00E-1	6.66E-1	6.66E+1	5.000
1.00E0	1.33E0	1.33E+2	10.000

Analog out calibration = 12 (MKS Baratron 10 Torr (0-10 VDC) emulation)
The 10 Torr Baratron emulation provides a signal directly proportional with pressure with a full scale reading of 10 VDC at 13.3 mbar.



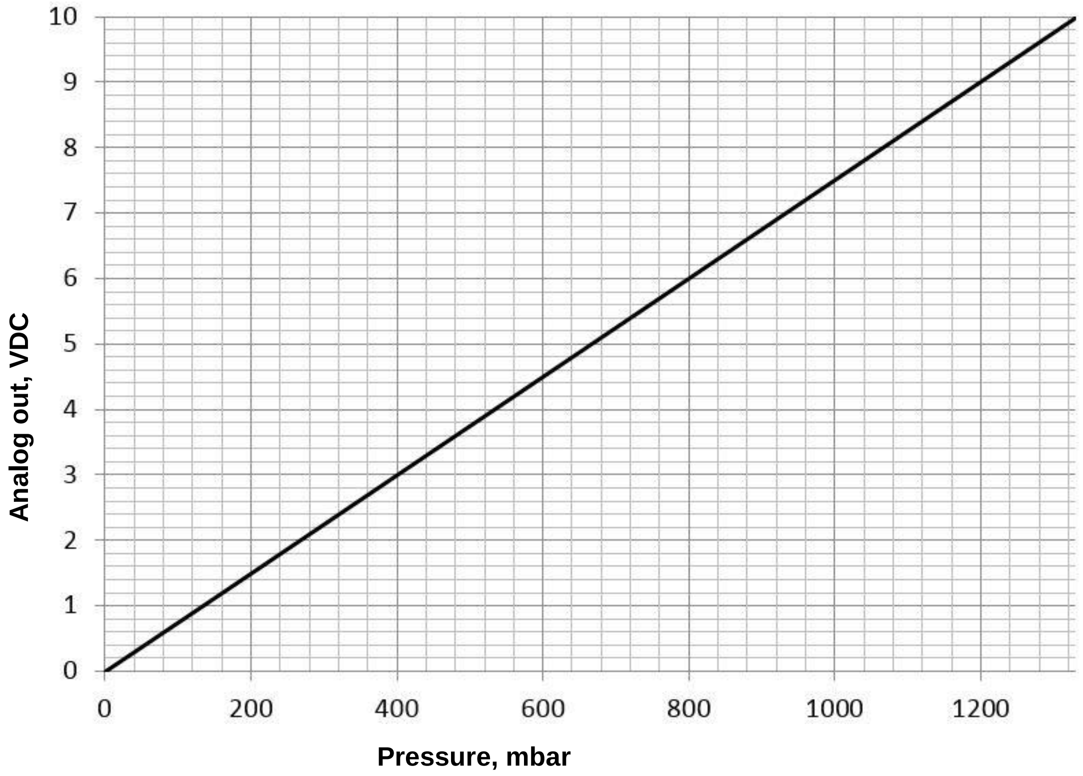
Torr	mbar	Pascal	Vout
1.00E-1	1.33E-1	1.33E+1	0.100
5.00E-1	6.66E-1	6.66E+1	0.500
1.00E0	1.33E0	1.33E+2	1.000
5.00E0	6.66E0	6.66E+2	5.000
1.00E+1	1.33E+1	1.33E+3	10.000

Analog out calibration = 13 (MKS Baratron 100 Torr (0-10 VDC) emulation)
The 100 Torr Baratron emulation provides a signal directly proportional with pressure with a full scale reading of 10 VDC at 100 Torr.



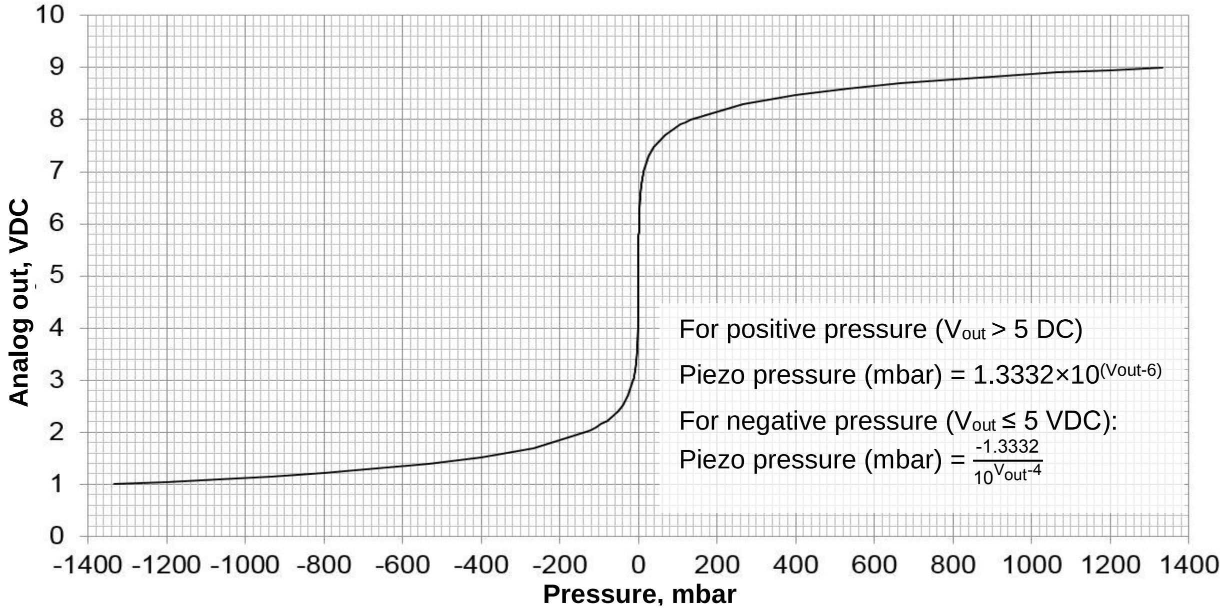
Torr	mbar	Pascal	Vout
1.0	1.33	1.333E+2	0.100
5.0	6.66	6.66E+2	0.500
10.0	13.3	1.333E+3	1.000
50.0	66.66	6.66E+3	5.000
100.0	133.3	1.333E+4	10.000

Analog out calibration = 14 (MKS Baratron 1000 Torr (0-10 VDC) emulation)
The 1000 Torr Baratron emulation provides a signal directly proportional with pressure with a full scale reading of 10 VDC at 1333.2 mbar.



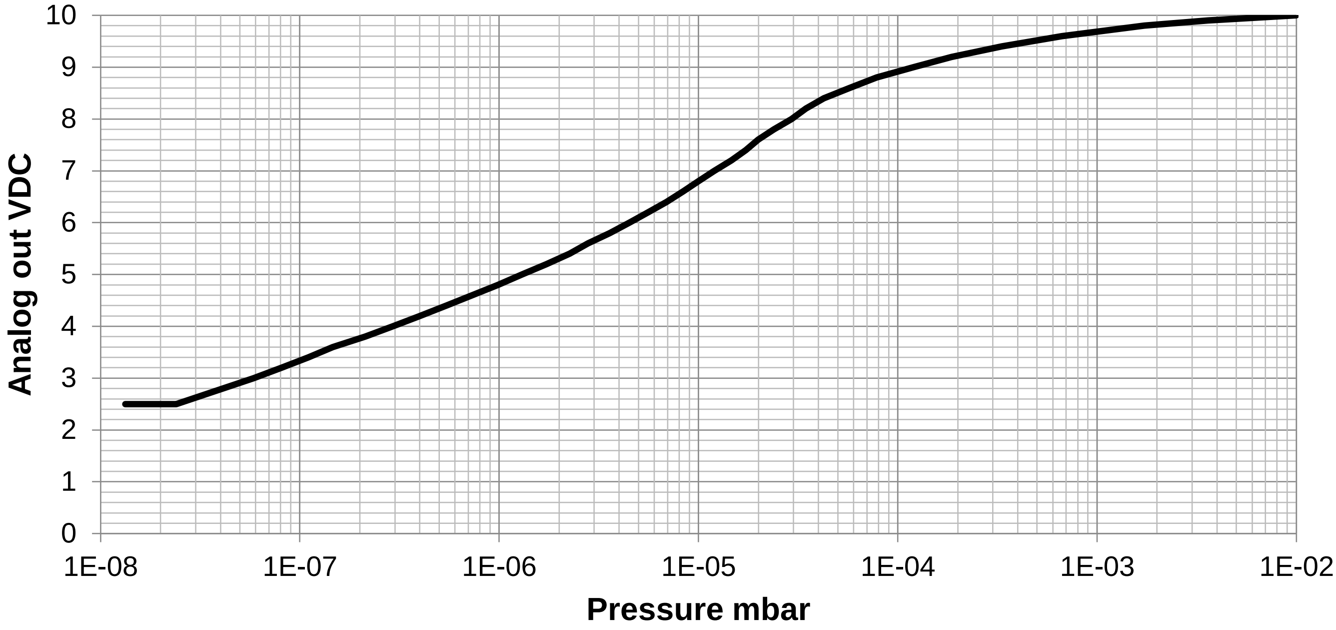
Torr	mbar	Pascal	Vout
10.0	13.3	1.333E+3	0.100
50.0	66.66	6.66E+3	0.500
100.0	133.3	1.333E+4	1.000
500.0	666.6	6.666E+4	5.000
1,000	1333.2	1.3332E+5	10.000

Analog out calibration = 15 (Piezo analog output)
This curve is suited for the differential piezo readout (“PR2” for TTR 200 N and PTR 200 N). In that case, use the command “@253AO1!215;FF”.



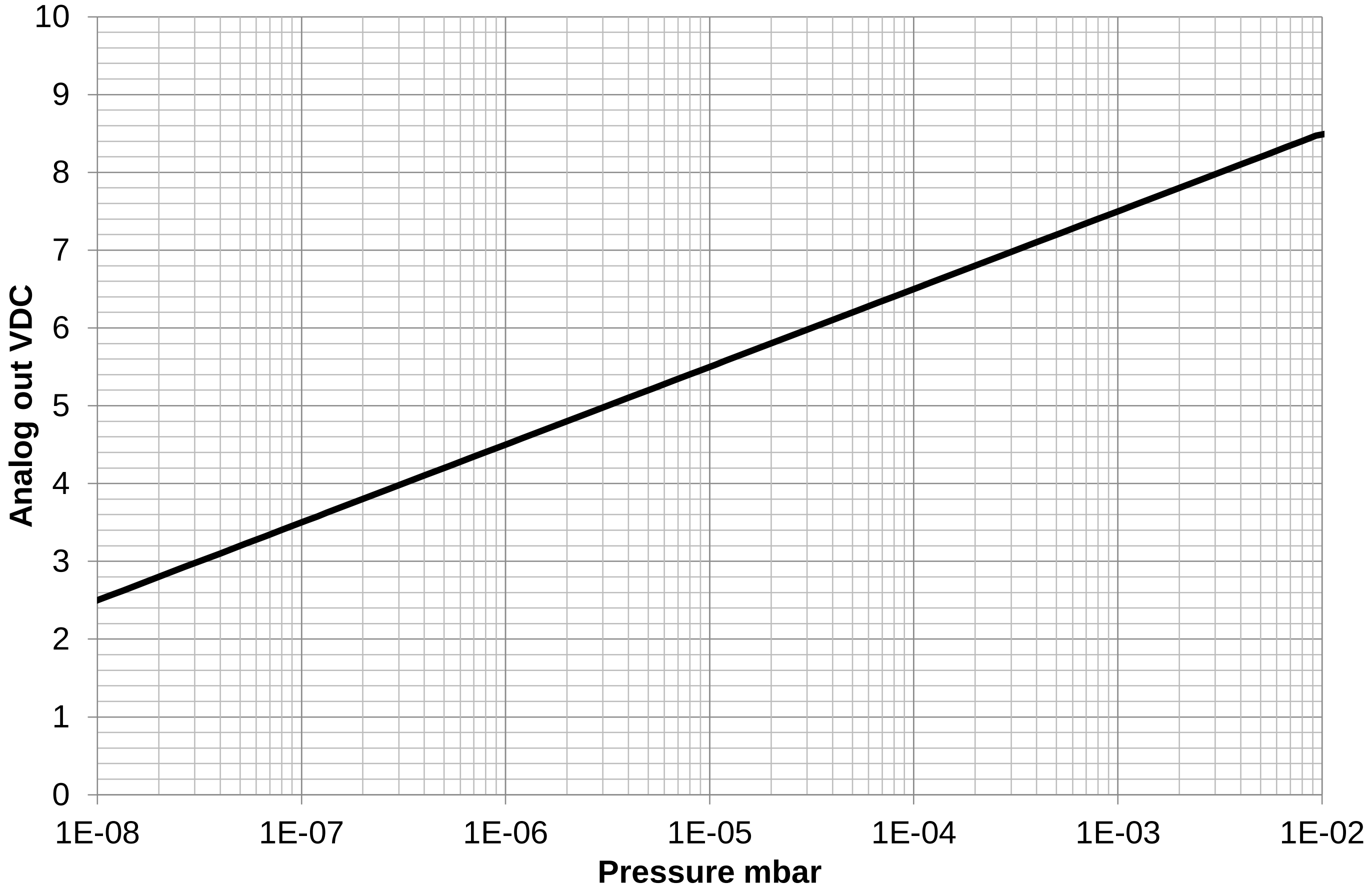
Torr	mbar	Pascal	Vout	Torr	mbar	Pascal	Vout
-8.00E+2	-1.07E+3	-1.07E+5	1.10	2.00E-1	2.67E-1	2.67E+1	5.30
-7.00E+2	-9.33E+2	-9.33E+4	1.15	3.00E-1	4.00E-1	4.00E+1	5.48
-6.00E+2	-8.00E+2	-8.00E+4	1.22	4.00E-1	5.33E-1	5.33E+1	5.60
-5.00E+2	-6.67E+2	-6.67E+4	1.30	5.00E-1	6.67E-1	6.67E+1	5.70
-4.00E+2	-5.33E+2	-5.33E+4	1.40	6.00E-1	8.00E-1	8.00E+1	5.78
-3.00E+2	-4.00E+2	-4.00E+4	1.52	7.00E-1	9.33E-1	9.33E+1	5.85
-2.00E+2	-2.67E+2	-2.67E+4	1.70	8.00E-1	1.07E+0	1.07E+2	5.90
-1.00E+2	-1.33E+2	-1.33E+4	2.00	9.00E-1	1.20E+0	1.20E+2	5.95
-9.00E+1	-1.20E+2	-1.20E+4	2.05	1.00E+0	1.33E+0	1.33E+2	6.00
-8.00E+1	-1.07E+2	-1.07E+4	2.10	2.00E+0	2.67E+0	2.67E+2	6.30
-7.00E+1	-9.33E+1	-9.33E+3	2.15	3.00E+0	4.00E+0	4.00E+2	6.48
-6.00E+1	-8.00E+1	-8.00E+3	2.22	4.00E+0	5.33E+0	5.33E+2	6.60
-5.00E+1	-6.67E+1	-6.67E+3	2.30	5.00E+0	6.67E+0	6.67E+2	6.70
-4.00E+1	-5.33E+1	-5.33E+3	2.40	6.00E+0	8.00E+0	8.00E+2	6.78
-3.00E+1	-4.00E+1	-4.00E+3	2.52	7.00E+0	9.33E+0	9.33E+2	6.85
-2.00E+1	-2.67E+1	-2.67E+3	2.70	8.00E+0	1.07E+1	1.07E+3	6.90
-1.00E+1	-1.33E+1	-1.33E+3	3.00	9.00E+0	1.20E+1	1.20E+3	6.95
-9.00E+0	-1.20E+1	-1.20E+3	3.05	1.00E+1	1.33E+1	1.33E+3	7.00
-8.00E+0	-1.07E+1	-1.07E+3	3.10	2.00E+1	2.67E+1	2.67E+3	7.30
-7.00E+0	-9.33E+0	-9.33E+2	3.15	3.00E+1	4.00E+1	4.00E+3	7.48
-6.00E+0	-8.00E+0	-8.00E+2	3.22	4.00E+1	5.33E+1	5.33E+3	7.60
-5.00E+0	-6.67E+0	-6.67E+2	3.30	5.00E+1	6.67E+1	6.67E+3	7.70
-4.00E+0	-5.33E+0	-5.33E+2	3.40	6.00E+1	8.00E+1	8.00E+3	7.78
-3.00E+0	-4.00E+0	-4.00E+2	3.52	7.00E+1	9.33E+1	9.33E+3	7.85
-2.00E+0	-2.67E+0	-2.67E+2	3.70	8.00E+1	1.07E+2	1.07E+4	7.90
-1.00E+0	-1.33E+0	-1.33E+2	4.00	9.00E+1	1.20E+2	1.20E+4	7.95
-9.00E-1	-1.20E+0	-1.20E+2	4.05	1.00E+2	1.33E+2	1.33E+4	8.00
-8.00E-1	-1.07E+0	-1.07E+2	4.10	2.00E+2	2.67E+2	2.67E+4	8.30
-7.00E-1	-9.33E-1	-9.33E+1	4.15	3.00E+2	4.00E+2	4.00E+4	8.48
-6.00E-1	-8.00E-1	-8.00E+1	4.22	4.00E+2	5.33E+2	5.33E+4	8.60
-5.00E-1	-6.67E-1	-6.67E+1	4.30	5.00E+2	6.67E+2	6.67E+4	8.70
-4.00E-1	-5.33E-1	-5.33E+1	4.40	6.00E+2	8.00E+2	8.00E+4	8.78
-3.00E-1	-4.00E-1	-4.00E+1	4.52	7.00E+2	9.33E+2	9.33E+4	8.85
-2.00E-1	-2.67E-1	-2.67E+1	4.70	8.00E+2	1.07E+3	1.07E+5	8.90
-1.00E-1	-1.33E-1	-1.33E+1	5.00	9.00E+2	1.20E+3	1.20E+5	8.95
1.00E-1	1.33E-1	1.33E+1	5.00	1.00E+3	1.33E+3	1.33E+5	9.00

Analog out calibration = 16 (Edwards AIM-S /-SL emulation)
The Edwards AIM-S / SL emulation provides a strongly non-linear output.



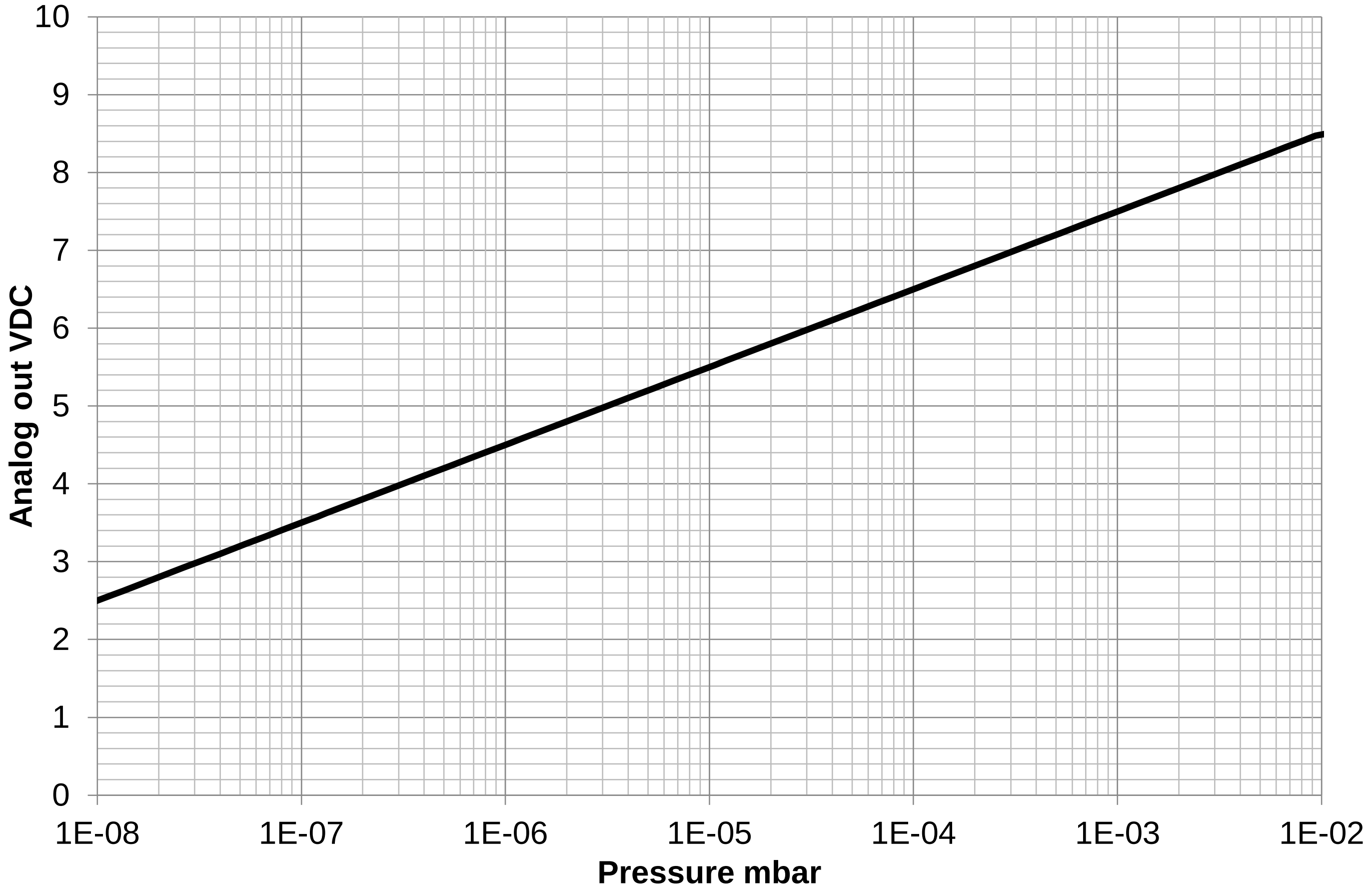
Torr	mbar	Pascal	Vout
1.00E-8	1.33E-8	1.33E-6	2.5
1.80E-8	2.40E-8	2.40E-6	2.5
4.40E-8	5.87E-8	5.87E-6	3
6.10E-8	8.13E-8	8.13E-6	3.2
8.30E-8	1.11E-7	1.11E-5	3.4
1.10E-7	1.47E-7	1.47E-5	3.6
2.20E-7	2.93E-7	2.93E-5	4
5.50E-7	7.33E-7	7.33E-5	4.6
7.40E-7	9.87E-7	9.87E-5	4.8
9.80E-7	1.31E-6	1.31E-4	5
1.30E-6	1.73E-6	1.73E-4	5.2
2.10E-6	2.80E-6	2.80E-4	5.6
3.40E-6	4.53E-6	4.53E-4	6
4.20E-6	5.60E-6	5.60E-4	6.2
5.20E-6	6.93E-6	6.93E-4	6.4
7.50E-6	1.00E-5	1.00E-3	6.8
9.00E-6	1.20E-5	1.20E-3	7
1.10E-5	1.47E-5	1.47E-3	7.2
2.20E-5	2.93E-5	2.93E-3	8
3.20E-5	4.27E-5	4.27E-3	8.4
4.30E-5	5.73E-5	5.73E-3	8.6
5.90E-5	7.87E-5	7.87E-3	8.8
9.00E-5	1.20E-4	1.20E-2	9
1.40E-4	1.87E-4	1.87E-2	9.2
2.5E-4	3.33E-4	3.33E-2	9.4
5.0E-4	6.67E-4	6.67E-2	9.6
1.3E-3	1.73E-3	1.73E-1	9.8
2.7E-3	3.60E-3	3.60E-1	9.9
7.5E-3	1.00E-2	1.00E+0	10

Analog out calibration = 17 (Edwards AIM-X /-XL emulation)
The Edwards AIM-X / XL emulation provides a log linear output.



Torr	mbar	Pascal	Vout
1.00E-8	1.33E-8	1.33E-6	3.286
5.00E-8	6.67E-8	6.67E-6	4.084
1.00E-7	1.33E-7	1.33E-5	4.428
5.00E-7	6.67E-7	6.67E-5	5.227
1.00E-6	1.33E-6	1.33E-4	5.571
5.00E-6	6.67E-6	6.67E-4	6.370
1.00E-5	1.33E-5	1.33E-3	6.714
5.00E-5	6.67E-5	6.67E-3	7.513
1.00E-4	1.33E-4	1.33E-2	7.857
5.00E-4	6.67E-4	6.67E-2	8.656
1.00E-3	1.33E-3	1.33E-1	9.000
5.00E-3	6.67E-3	6.67E-1	9.799

Analog out calibration = 18 (Pfeiffer IKR251 emulation)
The Pfeiffer IKR251 emulation provides a log linear output.

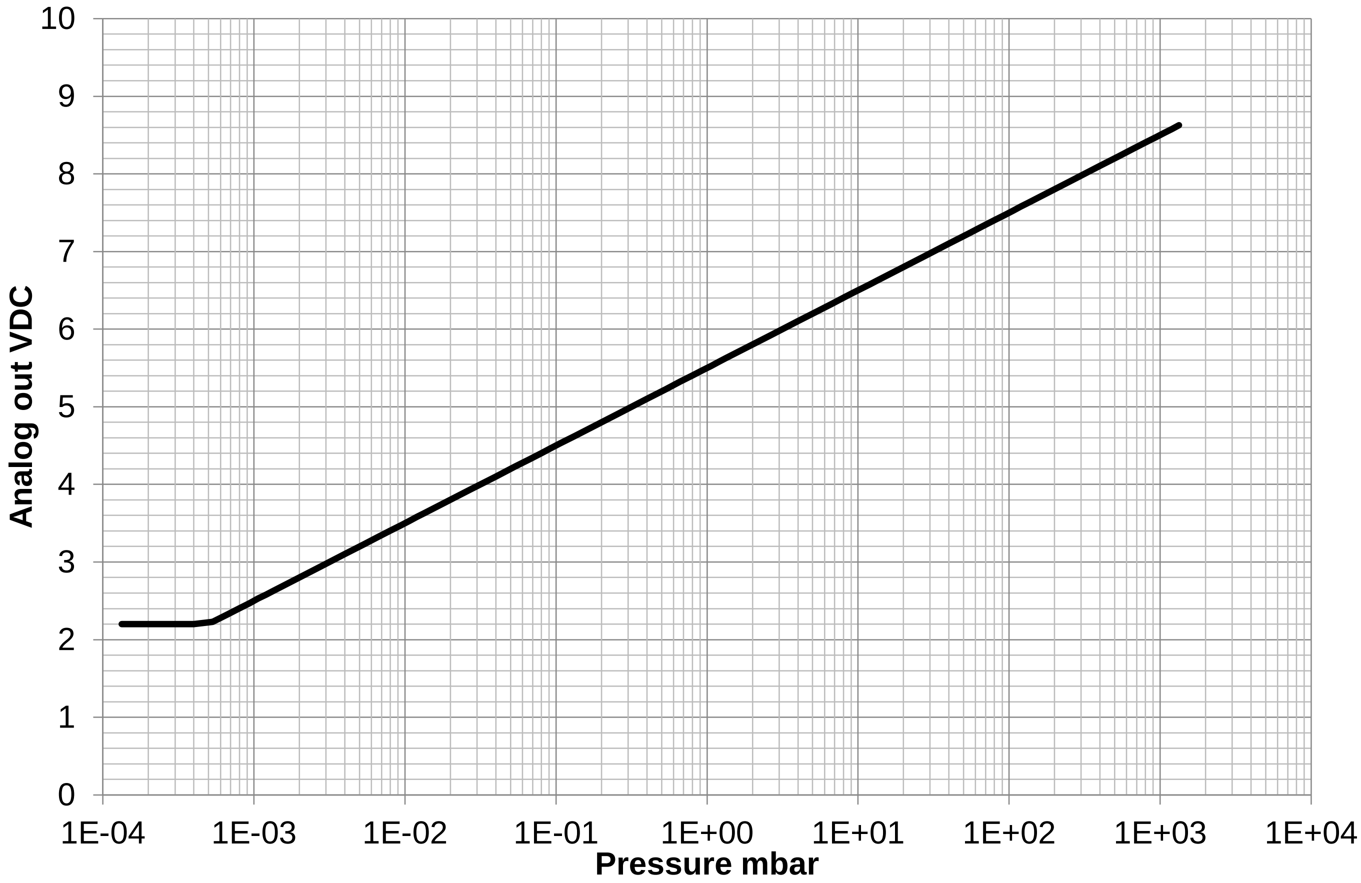


Torr	mbar	Pascal	Vout
5.00E-9	6.67E-9	6.67E-7	2.3240
1.00E-8	1.33E-8	1.33E-6	2.6250
5.00E-8	6.67E-8	6.67E-6	3.3240
1.00E-7	1.33E-7	1.33E-5	3.6250
5.00E-7	6.67E-7	6.67E-5	4.3240
1.00E-6	1.33E-6	1.33E-4	4.6250
5.00E-6	6.67E-6	6.67E-4	5.3240
1.00E-5	1.33E-5	1.33E-3	5.6250
5.00E-5	6.67E-5	6.67E-3	6.3240
1.00E-4	1.33E-4	1.33E-2	6.6250
5.00E-4	6.67E-4	6.67E-2	7.3240
1.00E-3	1.33E-3	1.33E-1	7.6250
5.00E-3	6.67E-3	6.67E-1	8.3240
9.00E-3	1.20E-2	1.20E+0	8.5000

$P = 10^{(V_{out} - c)}$
$V_{out} = c + \log_{10}(P)$

	c
mbar	10.5
Torr	10.625
Pascal	8.5

Analog out calibration = 19 (Pfeiffer TPR265, Pfeiffer TPR280, Inficon TPR280 emulation)
The Pfeiffer TPR265 emulation provides a log linear output.

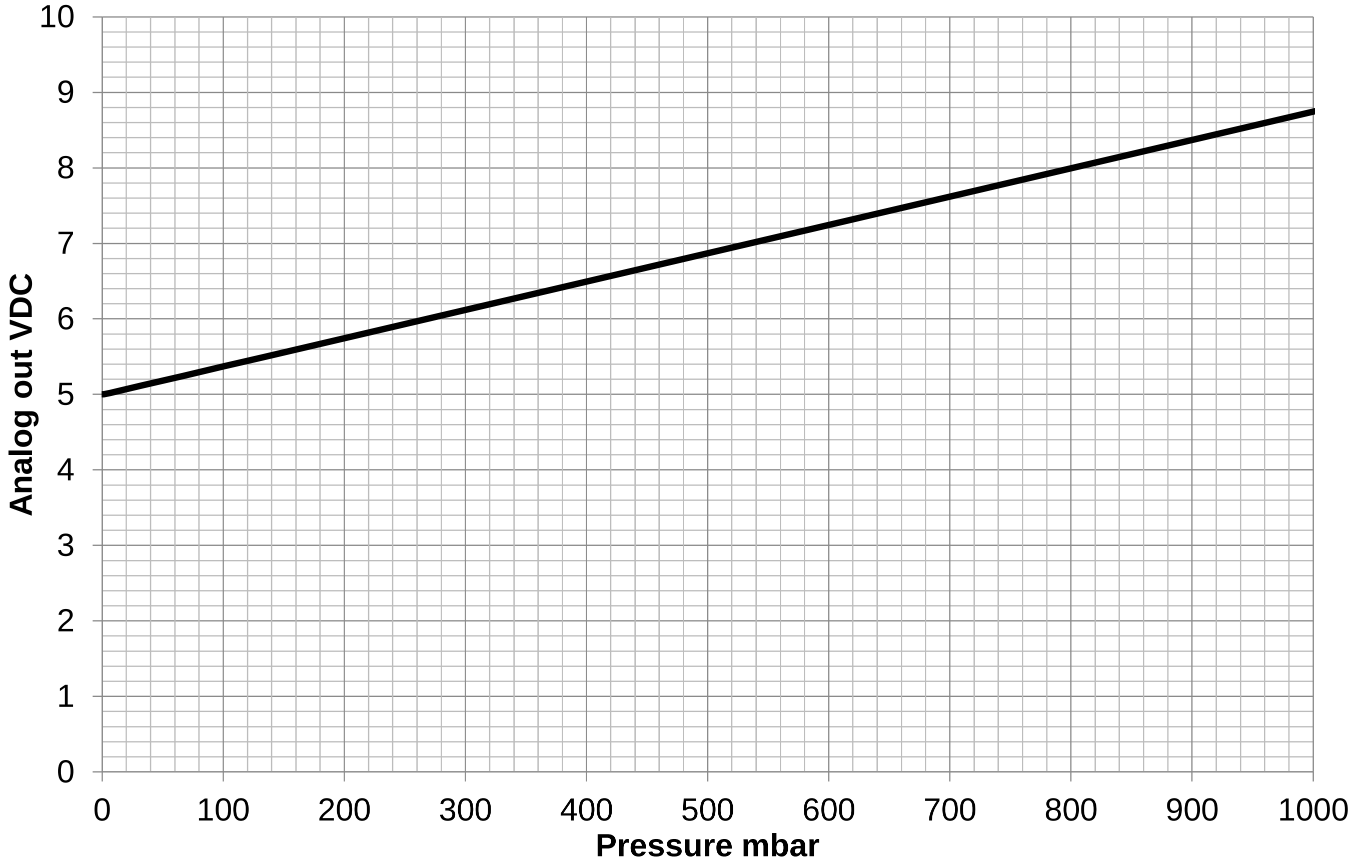


Torr	mbar	Pascal	Vout
1.00E-4	1.33E-4	1.33E-2	2.199
4.00E-4	5.33E-4	5.33E-2	2.227
5.00E-4	6.67E-4	6.67E-2	2.324
1.00E-3	1.33E3	1.33E-1	2.625
5.00E-3	6.67E-3	6.67E-1	3.324
1.00E-2	1.33E-2	1.33E+0	3.625
5.00E-2	6.67E2	6.67E+0	4.324
1.00E-1	1.33E-1	1.33E+1	4.625
5.00E-1	6.67E-1	6.67E+1	5.324
1.00E+0	1.33E+0	1.33E+2	5.625
5.00E+0	6.67E+0	6.67E+2	6.324
1.00E+1	1.33E+1	1.33E+3	6.625
5.00E+1	6.67E+1	6.67E+3	7.324
1.00E+2	1.33E+2	1.33E+4	7.625
5.00E+2	6.67E+2	6.67E+4	8.324
9.00E+2	1.20E+3	1.20E+5	8.579
1.00E+3	1.33E+3	1.33E+5	8.625

$P = 10^{(V_{out} - c)}$
$V_{out} = c + \log_{10}(P)$

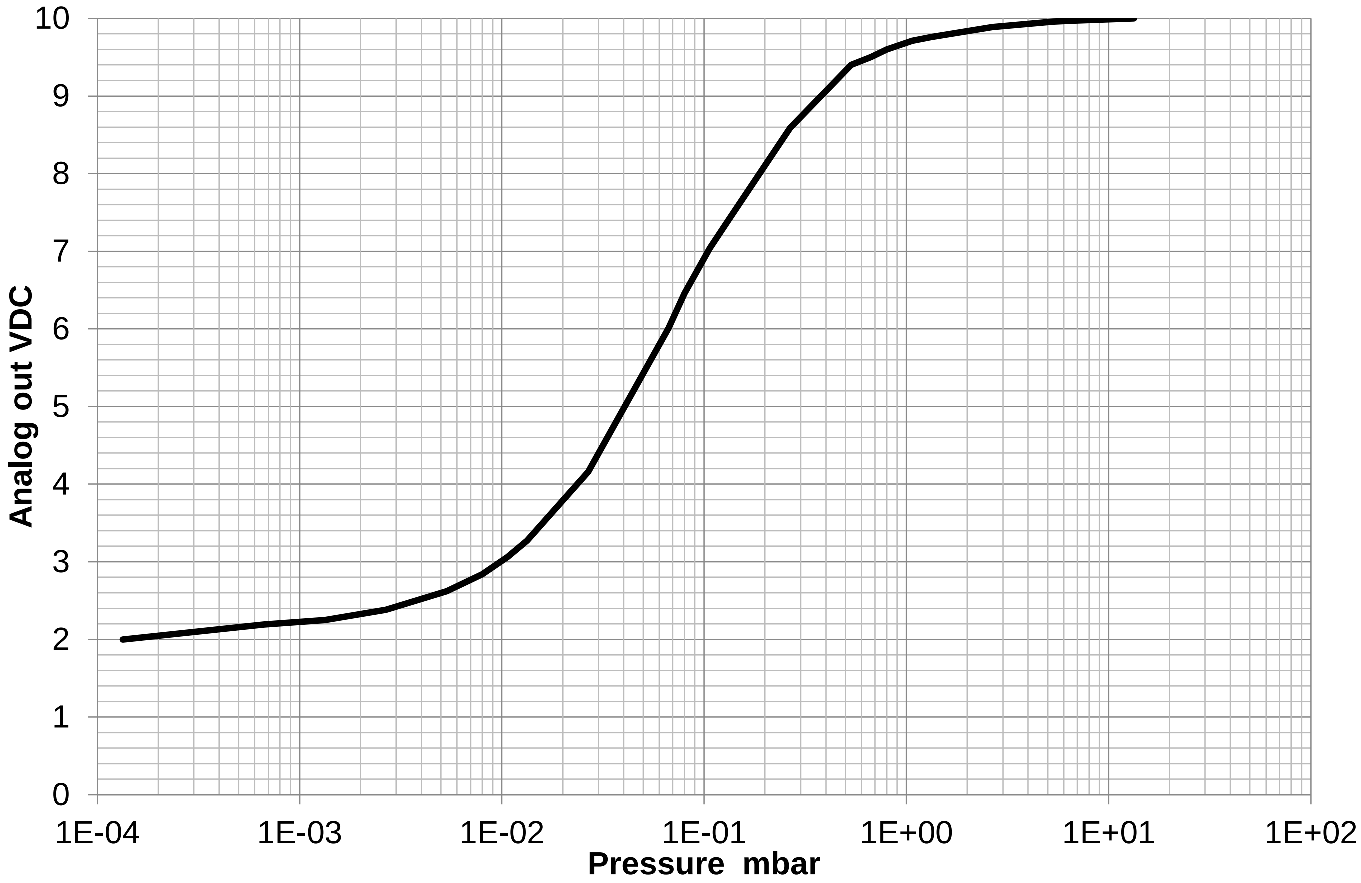
	c
mbar	5.5
Torr	5.625
Pascal	3.5

Analog out calibration = 20 (OBE Special emulation)
The OBE special emulation provides a linear output from 1 to 1000 Torr.



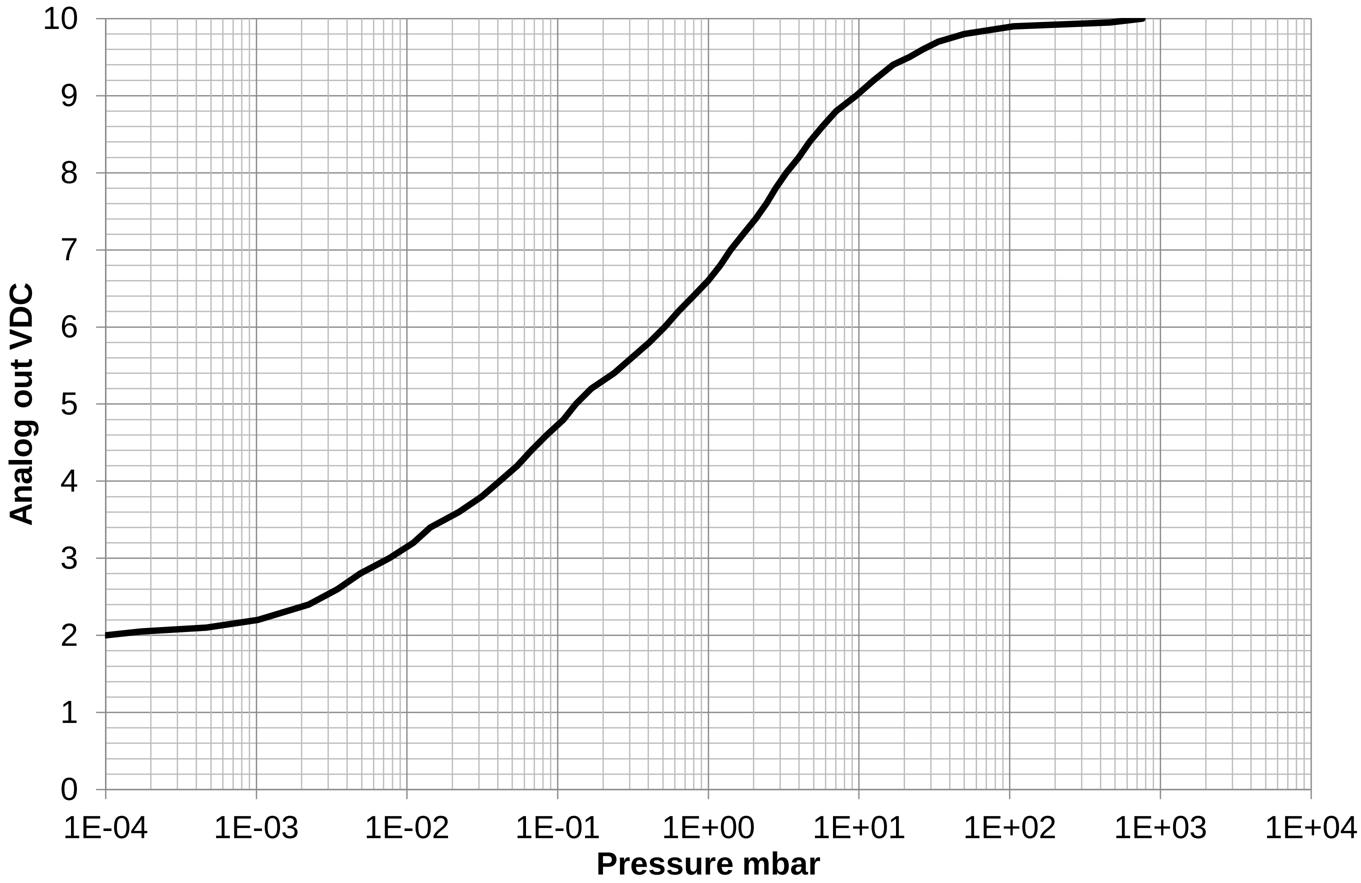
Torr	mbar	Pascal	Vout
0.1	1.33E-01	1.33E+01	5
1	1.33E+00	1.33E+02	5
2	2.67E+00	2.67E+02	5.005
4	5.33E+00	5.33E+02	5.015
5	6.67E+00	6.67E+02	5.02
10	1.33E+01	1.33E+03	5.045
25	3.33E+01	3.33E+03	5.12
50	6.67E+01	6.67E+03	5.245
75	1.00E+02	1.00E+04	5.37
100	1.33E+02	1.33E+04	5.495
250	3.33E+02	3.33E+04	6.245
500	6.67E+02	6.67E+04	7.495
750	1.00E+03	1.00E+05	8.745
1000	1.33E+03	1.33E+05	9.995

Analog out calibration = 21 (Edwards DV6M emulation)
The Edwards DV6M emulation provides a strongly non-linear output with up to 10 Torr.



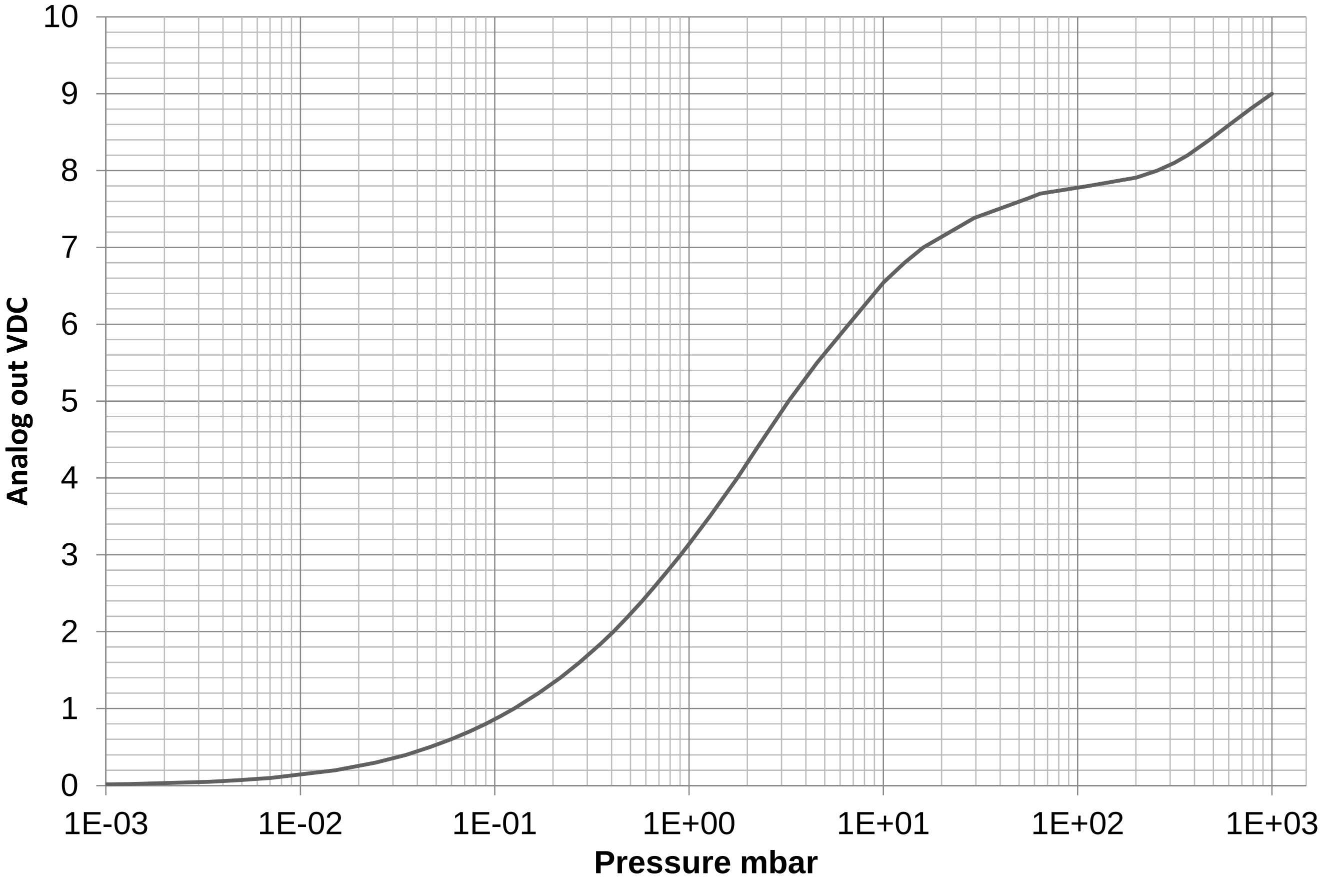
Torr	mbar	Pascal	Vout
0.0001	1.33E-04	1.33E-02	2
0.0005	6.67E-04	6.67E-02	2.19
0.001	1.33E-03	1.33E-01	2.25
0.002	2.67E-03	2.67E-01	2.38
0.004	5.33E-03	5.33E-01	2.62
0.006	8.00E-03	8.00E-01	2.84
0.008	1.07E-02	1.07E+00	3.06
0.01	1.33E-02	1.33E+00	3.27
0.02	2.67E-02	2.67E+00	4.16
0.04	5.33E-02	5.33E+00	5.56
0.05	6.67E-02	6.67E+00	6.01
0.06	8.00E-02	8.00E+00	6.46
0.08	1.07E-01	1.07E+01	7.04
0.1	1.33E-01	1.33E+01	7.42
0.2	2.67E-01	2.67E+01	8.59
0.4	5.33E-01	5.33E+01	9.4
0.5	6.67E-01	6.67E+01	9.5
0.6	8.00E-01	8.00E+01	9.6
0.8	1.07E+00	1.07E+02	9.71
1	1.33E+00	1.33E+02	9.76
2	2.67E+00	2.67E+02	9.89
4	5.33E+00	5.33E+02	9.96
5	6.67E+00	6.67E+02	9.97
10	1.33E+01	1.33E+03	10

Analog out calibration = 22 (Edwards APG-M emulation)
The Edwards APG-M emulation provides a strongly non-linear output.



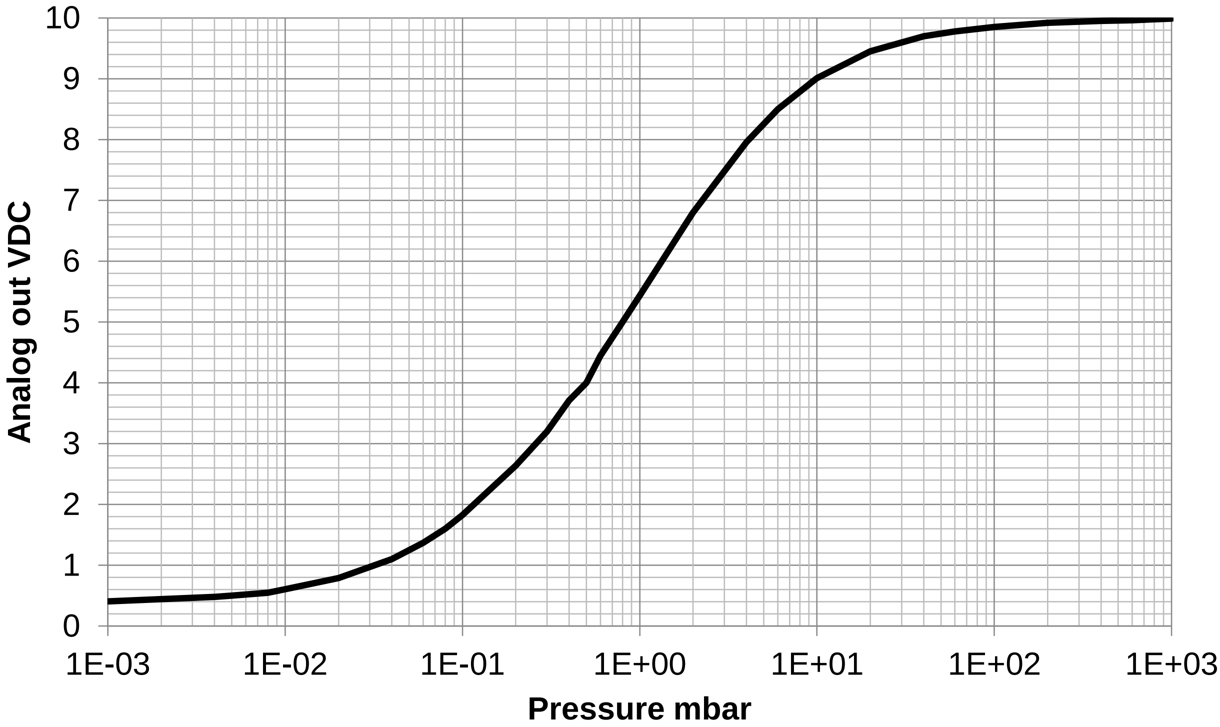
Torr	mbar	Pascal	Vout
1.00E-4	1.33E-4	1.33E-1	2.0
1.02E-3	1.36E-03	1.36E-01	2.2
7.65E-3	1.02E-02	1.02E+00	3
4.12E-2	5.49E-02	5.49E+00	4
1.32E-1	1.76E-01	1.76E+01	5
5.12E-1	6.83E-01	6.83E+01	6
1.4	1.87E+00	1.87E+02	7
3.29	4.39E+00	4.39E+02	8
9.53	1.27E+01	1.27E+03	9
16.8	2.24E+01	2.24E+03	9.4
26.5	3.53E+01	3.53E+03	9.6
49.9	6.65E+01	6.65E+03	9.8
106	1.41E+02	1.41E+04	9.9
462	6.16E+02	6.16E+04	9.95
760	1.01E+03	1.01E+05	10

Analog Output calibration = 23 (Brooks / Granville Phillips GP275 Emulation 9 VDC FS)
The GP275 with 9VDC full scale emulation provides a strongly non linear output with very poor resolution in the low range and close to atmospheric pressure.



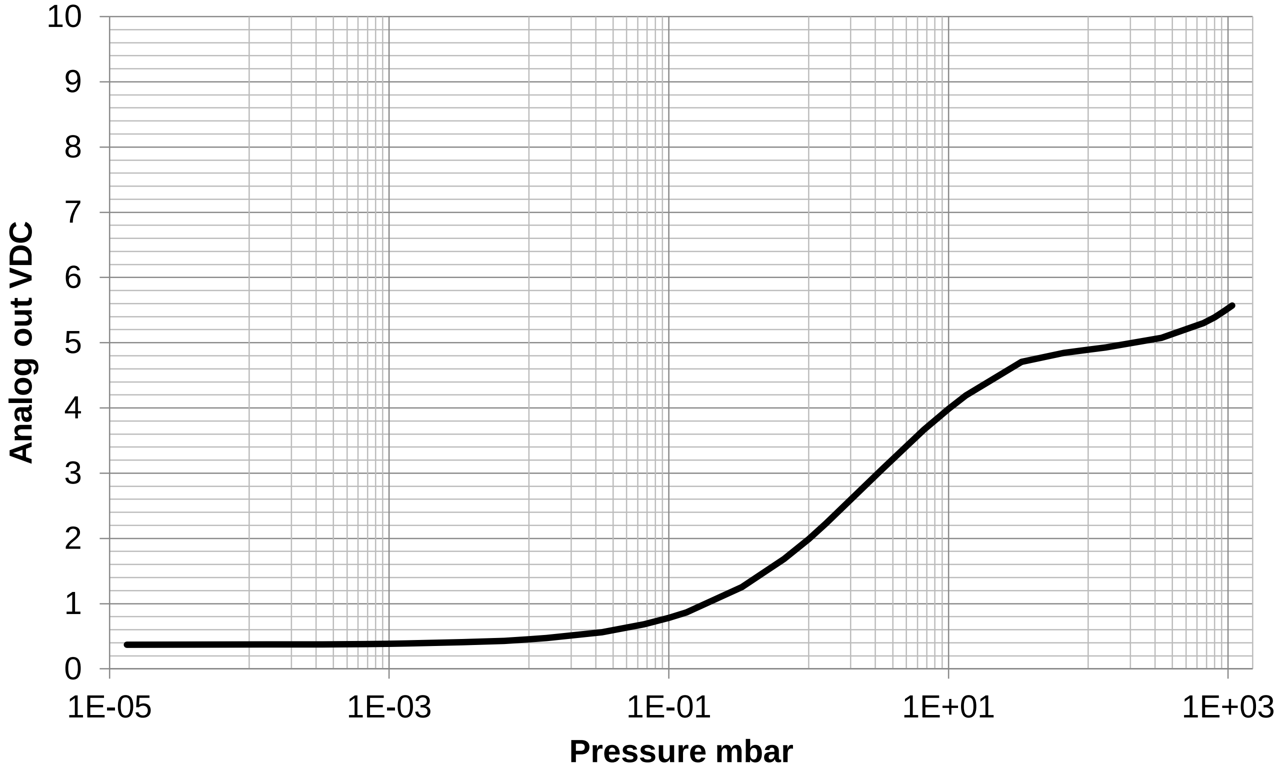
Torr	mbar	Pascal	Vout	Torr	mbar	Pascal	Vout
1.00E-03	1.34E-03	1.34E-01	0.015	0.7836	1.04E+00	1.04E+02	2.800
1.32E-03	1.76E-03	1.76E-01	0.020	0.9076	1.21E+00	1.21E+02	3.000
3.38E-03	4.51E-03	4.51E-01	0.050	1.02	1.36E+00	1.36E+02	3.164
4.81E-03	6.41E-03	6.41E-01	0.070	1.28	1.71E+00	1.71E+02	3.500
6.28E-03	8.37E-03	8.37E-01	0.090	1.77	2.37E+00	2.37E+02	4.000
7.03E-03	9.37E-03	9.37E-01	0.100	2.24	2.98E+00	2.98E+02	4.390
1.52E-02	2.02E-02	2.02E+00	0.200	3.26	4.34E+00	4.34E+02	5.000
2.45E-02	3.26E-02	3.26E+00	0.300	4.57	6.09E+00	6.09E+02	5.500
3.50E-02	4.66E-02	4.66E+00	0.400	6.65	8.86E+00	8.86E+02	6.000
4.67E-02	6.23E-02	6.23E+00	0.500	10.1	1.34E+01	1.34E+03	6.548
5.98E-02	7.97E-02	7.97E+00	0.600	12.9	1.71E+01	1.71E+03	6.800
7.42E-02	9.90E-02	9.90E+00	0.700	16.1	2.15E+01	2.15E+03	7.000
9.01E-02	1.20E-01	1.20E+01	0.800	29.4	3.92E+01	3.92E+03	7.383
1.07E-01	1.43E-01	1.43E+01	0.900	56.6	7.55E+01	7.55E+03	7.647
1.26E-01	1.68E-01	1.68E+01	1.000	64.1	8.55E+01	8.55E+03	7.700
1.69E-01	2.25E-01	2.25E+01	1.200	114.1	1.52E+02	1.52E+04	7.800
2.18E-01	2.90E-01	2.90E+01	1.400	200.7	2.68E+02	2.68E+04	7.910
2.74E-01	3.65E-01	3.65E+01	1.600	257.0	3.43E+02	3.43E+04	8.000
3.53E-01	4.71E-01	4.71E+01	1.846	314.3	4.19E+02	4.19E+04	8.100
0.4092	5.46E-01	5.46E+01	2.000	368.5	4.91E+02	4.91E+04	8.200
0.4879	6.51E-01	6.51E+01	2.200	478.0	6.37E+02	6.37E+04	8.400
0.5755	7.67E-01	7.67E+01	2.400	606.0	8.08E+02	8.08E+04	8.600
0.6734	8.98E-01	8.98E+01	2.600	773.1	1.03E+03	1.03E+05	8.800

Analog Output calibration = 24 (Thyracont MT241.1-5 emulation)
The MT241 emulation provides a strongly none linear output with limited resolution in the low range and close to atmosphere.



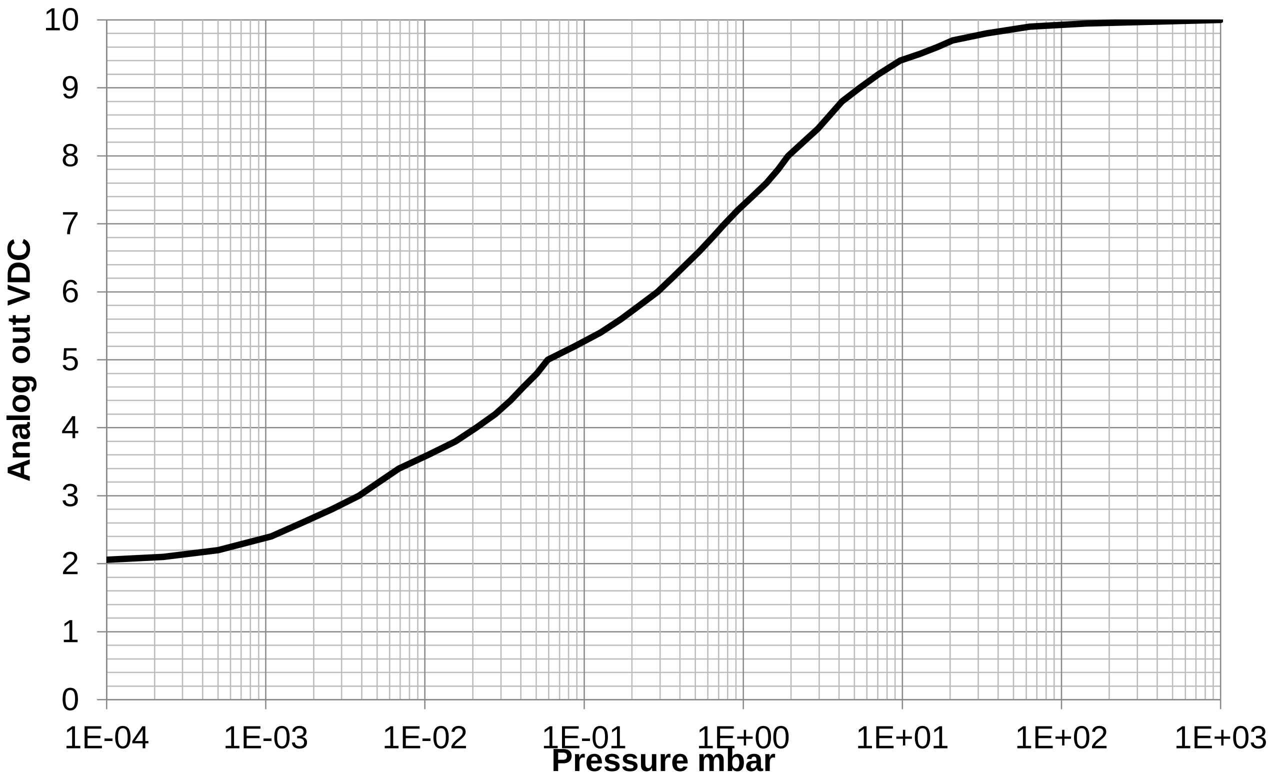
Torr	mbar	Pascal	Vout
7.50E-4	1.00E-03	1.00E-01	0.41
3.00E-3	4.00E-03	4.00E-01	0.48
3.75E-3	5.00E-03	5.00E-01	0.5
6.00E-3	8.00E-03	8.00E-01	0.55
7.50E-3	1.00E-02	1.00E+00	0.61
1.50E-2	2.00E-02	2.00E+00	0.79
3.00E-2	4.00E-02	4.00E+00	1.1
4.50E-2	6.00E-02	6.00E+00	1.37
6.00E-2	8.00E-02	8.00E+00	1.6
7.50E-2	1.00E-01	1.00E+01	1.83
1.50E-1	2.00E-01	2.00E+01	2.64
2.25E-1	3.00E-01	3.00E+01	3.2
3.00E-1	4.00E-01	4.00E+01	3.71
3.75E-1	5.00E-01	5.00E+01	4
4.50E-1	6.00E-01	6.00E+01	4.45
6.00E-1	8.00E-01	8.00E+01	5
7.50E-1	1.00E+00	1.00E+02	5.44
3	4.00E+00	4.00E+02	7.96
5	6.00E+00	6.00E+02	8.5
8	1.00E+01	1.00E+03	9.01
15	2.00E+01	2.00E+03	9.45
30	4.00E+01	4.00E+03	9.7
45	6.00E+01	6.00E+03	9.78
75	1.00E+02	1.00E+04	9.85
150	2.00E+02	2.00E+04	9.92
300	4.00E+02	4.00E+04	9.95
450	6.00E+02	6.00E+04	9.96
600	8.00E+02	8.00E+04	9.98
750.06	1.00E+03	1.00E+05	9.99

Analog Output calibration = 25 (Brooks / Granville Phillips GP275 Emulation 5.6 VDC FS emulation)
The GP275 emulation with 5.6VDC full scale provides a strongly non-linear output with very poor resolution in the low range and close to atmospheric pressure.



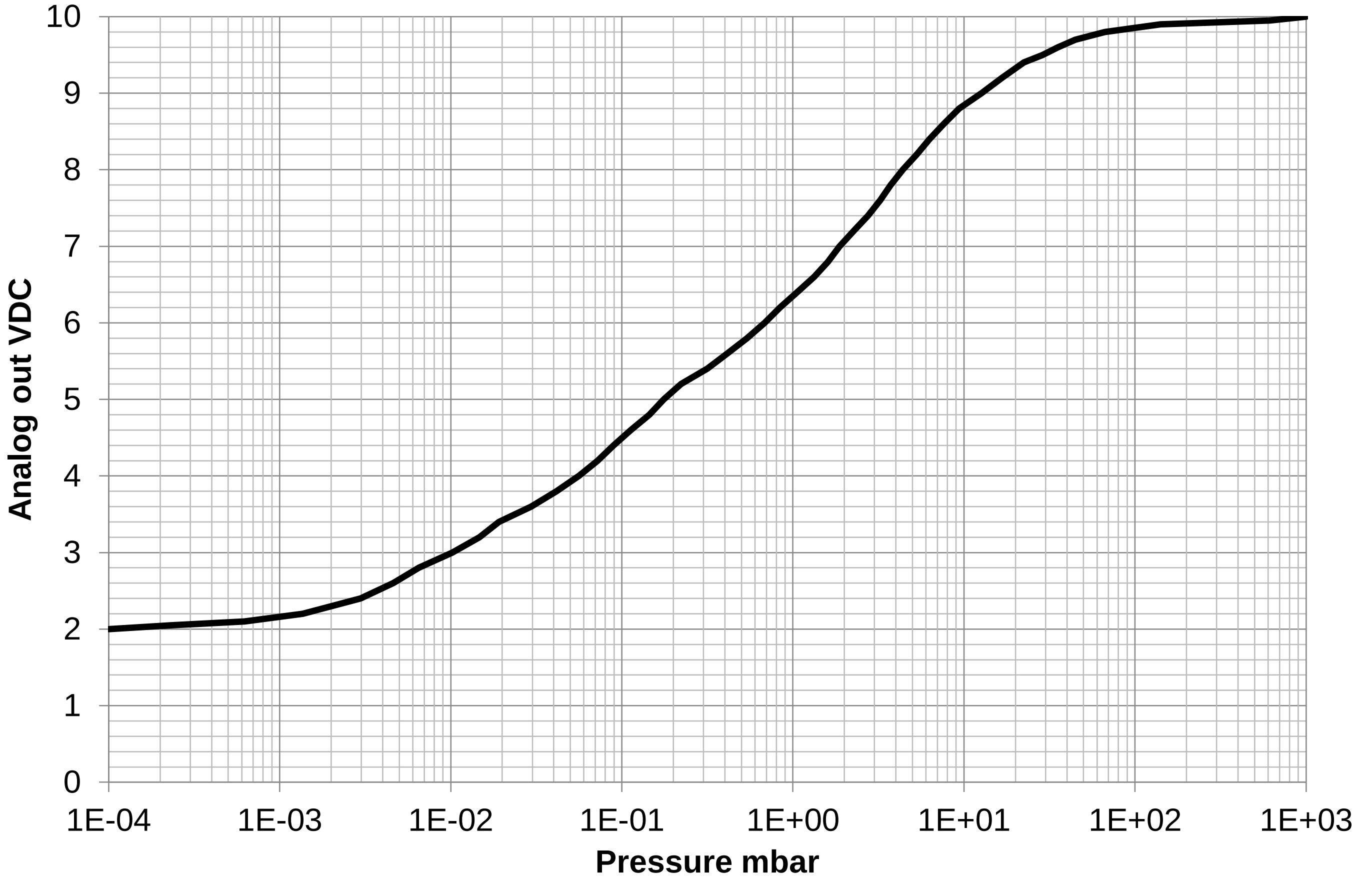
Torr	mbar	Pascal	Vout
1.00E-04	1.33E-04	1.33E-02	0.375
2.00E-04	2.67E-04	2.67E-02	0.377
5.00E-04	6.67E-04	6.67E-02	0.379
1.00E-03	1.33E-03	1.33E-01	0.384
2.00E-03	2.67E-03	2.67E-01	0.392
5.00E-03	6.67E-03	6.67E-01	0.417
1.00E-02	1.33E-02	1.33E+00	0.455
2.00E-02	2.67E-02	2.67E+00	0.523
5.00E-02	6.67E-02	6.67E+00	0.682
1.00E-01	1.33E-01	1.33E+01	0.878
2.00E-01	2.67E-01	2.67E+01	1.155
5.00E-01	6.67E-01	6.67E+01	1.683
1.00E+00	1.33E+00	1.33E+02	2.217
2.00E+00	2.67E+00	2.67E+02	2.842
5.00E+00	6.67E+00	6.67E+02	3.675
1.00E+01	1.33E+01	1.33E+03	4.206
2.00E+01	2.67E+01	2.67E+03	4.577
5.00E+01	6.67E+01	6.67E+03	4.846
1.00E+02	1.33E+02	1.33E+04	4.945
2.00E+02	2.67E+02	2.67E+04	5.019
3.00E+02	4.00E+02	4.00E+04	5.111
4.00E+02	5.33E+02	5.33E+04	5.224
5.00E+02	6.67E+02	6.67E+04	5.329
6.00E+02	8.00E+02	8.00E+04	5.419
7.00E+02	9.33E+02	9.33E+04	5.495
7.60E+02	1.01E+03	1.01E+05	5.534
8.00E+02	1.07E+03	1.07E+05	5.558
9.00E+02	1.20E+03	1.20E+05	5.614

Analog Output calibration = 26 (Edwards APG100-LC emulation)
The APG100-L emulation provides a strongly non-linear output with limited resolution in the low range and close to atmosphere.



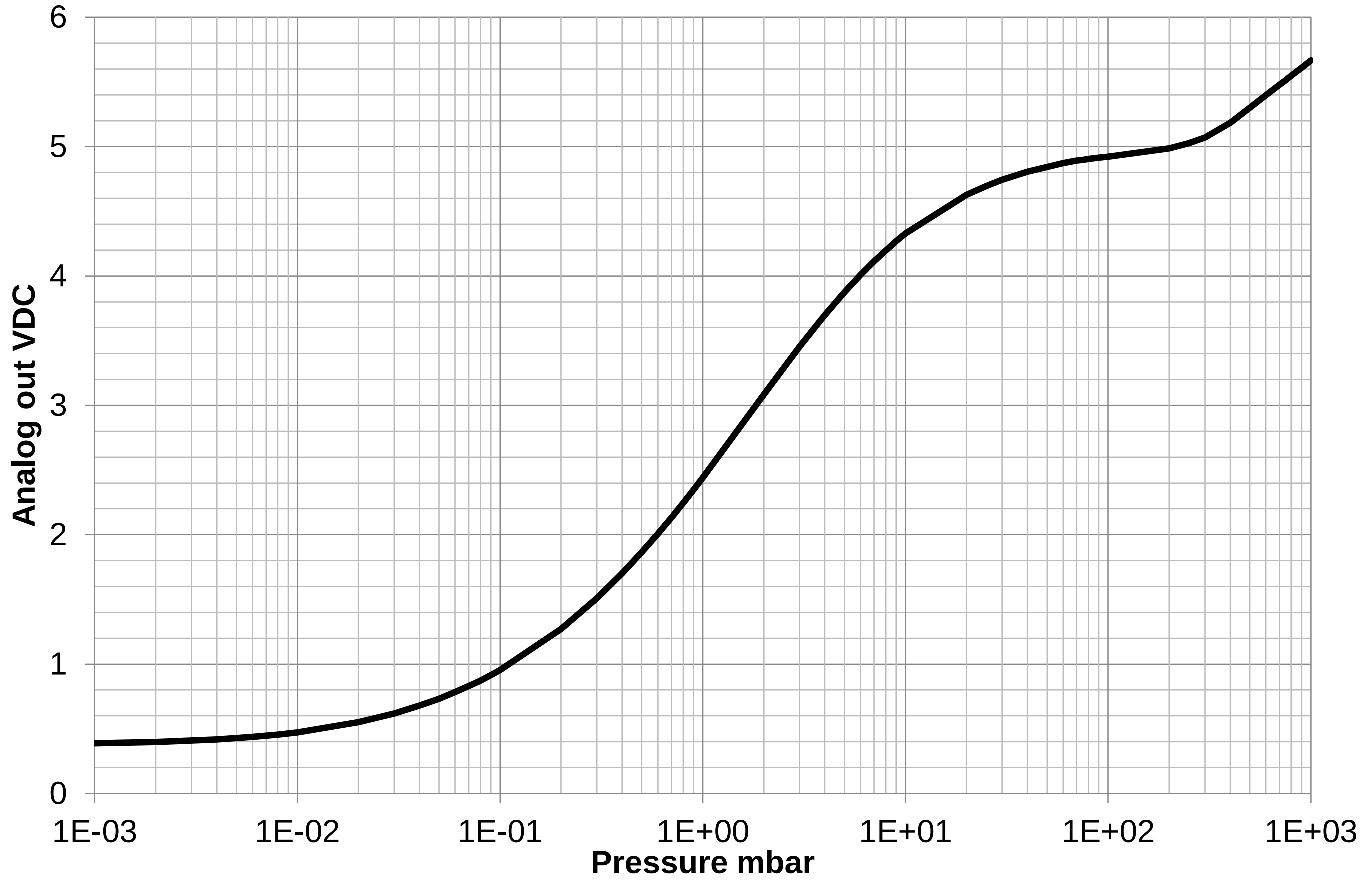
Torr	mbar	Pascal	Vout		Torr	mbar	Pascal	Vout
7.50E-06	1.00E-05	1.00E-03	2		3.26E-01	4.35E-01	4.35E+01	6.4
1.70E-04	2.27E-04	2.27E-02	2.1		4.00E-01	5.33E-01	5.33E+01	6.6
3.75E-04	5.00E-04	5.00E-02	2.2		4.80E-01	6.40E-01	6.40E+01	6.8
8.10E-04	1.08E-03	1.08E-01	2.4		5.75E-01	7.67E-01	7.67E+01	7
1.26E-03	1.68E-03	1.68E-01	2.6		6.92E-01	9.23E-01	9.23E+01	7.2
1.95E-03	2.60E-03	2.60E-01	2.8		8.55E-01	1.14E+00	1.14E+02	7.4
2.88E-03	3.84E-03	3.84E-01	3		1.05E+00	1.40E+00	1.40E+02	7.6
3.86E-03	5.15E-03	5.15E-01	3.2		1.25E+00	1.66E+00	1.66E+02	7.8
5.15E-03	6.87E-03	6.87E-01	3.4		1.44E+00	1.92E+00	1.92E+02	8
7.88E-03	1.05E-02	1.05E+00	3.6		1.79E+00	2.38E+00	2.38E+02	8.2
1.17E-02	1.56E-02	1.56E+00	3.8		2.21E+00	2.95E+00	2.95E+02	8.4
1.58E-02	2.10E-02	2.10E+00	4		2.63E+00	3.51E+00	3.51E+02	8.6
2.08E-02	2.77E-02	2.77E+00	4.2		3.13E+00	4.17E+00	4.17E+02	8.8
2.59E-02	3.45E-02	3.45E+00	4.4		4.05E+00	5.40E+00	5.40E+02	9
3.12E-02	4.16E-02	4.16E+00	4.6		5.30E+00	7.06E+00	7.06E+02	9.2
3.78E-02	5.04E-02	5.04E+00	4.8		7.27E+00	9.69E+00	9.69E+02	9.4
4.44E-02	5.92E-02	5.92E+00	5		9.68E+00	1.29E+01	1.29E+03	9.5
6.56E-02	8.74E-02	8.74E+00	5.2		1.25E+01	1.66E+01	1.66E+03	9.6
9.53E-02	1.27E-01	1.27E+01	5.4		1.55E+01	2.07E+01	2.07E+03	9.7
1.28E-01	1.71E-01	1.71E+01	5.6		2.54E+01	3.39E+01	3.39E+03	9.8
1.67E-01	2.23E-01	2.23E+01	5.8		4.74E+01	6.32E+01	6.32E+03	9.9
2.18E-01	2.90E-01	2.90E+01	6		1.08E+02	1.44E+02	1.44E+04	9.95
2.68E-01	3.57E-01	3.57E+01	6.2		7.60E+02	1.00E+03	1.00E+05	10

Analog Output calibration = 27 (Edwards APG100-M emulation)
The APG100-M emulation provides a strongly non-linear output with limited resolution in the low range and close to atmosphere



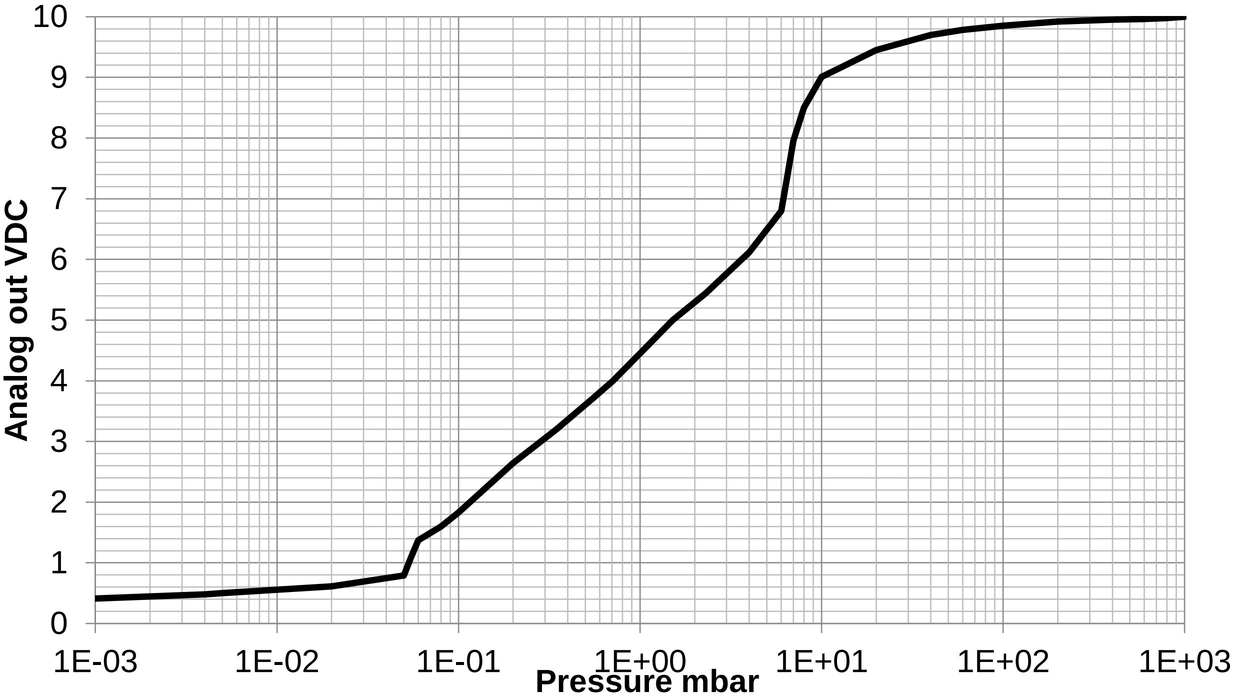
Torr	mbar	Pascal	Vout		Torr	mbar	Pascal	Vout
7.50E-05	1.00E-04	1.00E-02	2		7.95E-01	1.06E+00	1.06E+02	6.4
1.73E-04	2.31E-04	2.31E-02	2.05		9.98E-01	1.33E+00	1.33E+02	6.6
4.66E-04	6.21E-04	6.21E-02	2.1		1.20E+00	1.60E+00	1.60E+02	6.8
1.02E-03	1.36E-03	1.36E-01	2.2		1.40E+00	1.87E+00	1.87E+02	7
2.23E-03	2.97E-03	2.97E-01	2.4		1.70E+00	2.26E+00	2.26E+02	7.2
3.46E-03	4.61E-03	4.61E-01	2.6		2.06E+00	2.75E+00	2.75E+02	7.4
4.88E-03	6.51E-03	6.51E-01	2.8		2.43E+00	3.24E+00	3.24E+02	7.6
7.65E-03	1.02E-02	1.02E+00	3		2.80E+00	3.73E+00	3.73E+02	7.8
1.10E-02	1.47E-02	1.47E+00	3.2		3.29E+00	4.39E+00	4.39E+02	8
1.43E-02	1.91E-02	1.91E+00	3.4		3.97E+00	5.29E+00	5.29E+02	8.2
2.21E-02	2.95E-02	2.95E+00	3.6		4.70E+00	6.27E+00	6.27E+02	8.4
3.12E-02	4.16E-02	4.16E+00	3.8		5.72E+00	7.63E+00	7.63E+02	8.6
4.21E-02	5.61E-02	5.61E+00	4		7.04E+00	9.39E+00	9.39E+02	8.8
5.40E-02	7.20E-02	7.20E+00	4.2		9.53E+00	1.27E+01	1.27E+03	9
6.71E-02	8.94E-02	8.94E+00	4.4		1.25E+01	1.67E+01	1.67E+03	9.2
8.48E-02	1.13E-01	1.13E+01	4.6		1.68E+01	2.24E+01	2.24E+03	9.4
1.09E-01	1.45E-01	1.45E+01	4.8		2.16E+01	2.88E+01	2.88E+03	9.5
1.32E-01	1.76E-01	1.76E+01	5		2.65E+01	3.53E+01	3.53E+03	9.6
1.67E-01	2.22E-01	2.22E+01	5.2		3.36E+01	4.48E+01	4.48E+03	9.7
2.37E-01	3.16E-01	3.16E+01	5.4		4.99E+01	6.65E+01	6.65E+03	9.8
3.10E-01	4.13E-01	4.13E+01	5.6		1.06E+02	1.41E+02	1.41E+04	9.9
4.05E-01	5.40E-01	5.40E+01	5.8		4.62E+02	6.16E+02	6.16E+04	9.95
5.12E-01	6.82E-01	6.82E+01	6		7.60E+02	1.00E+03	1.00E+05	10
6.31E-01	8.41E-01	8.41E+01	6.2					

Analog Output calibration = 28 (MKS 907 emulation)



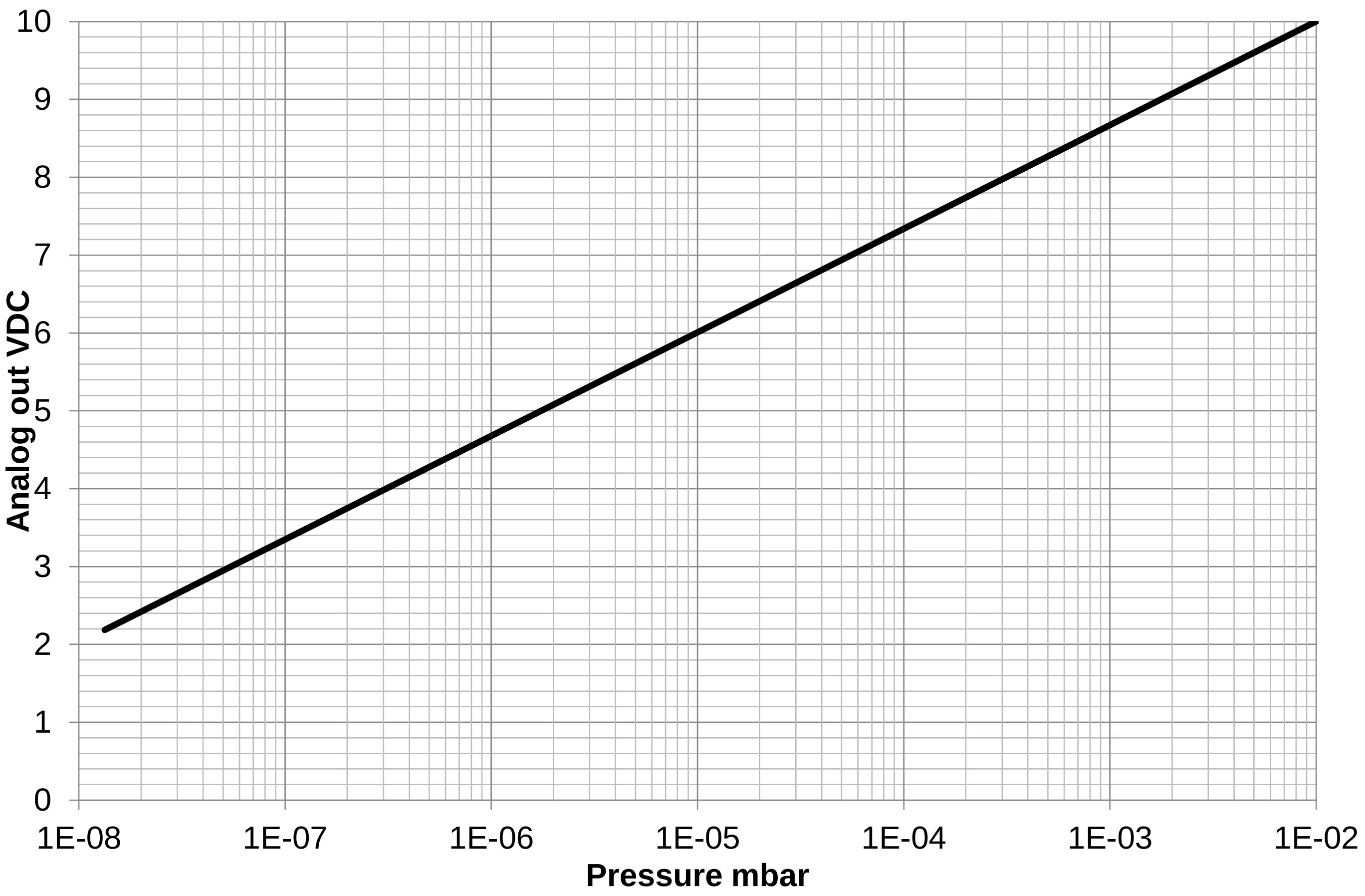
Torr	mbar	Pascal	Vout	Torr	mbar	Pascal	Vout
7.50E-04	1.00E-03	1.00E-01	0.387	4.50E+00	6.00E+00	6.00E+02	4.009
1.50E-03	2.00E-03	2.00E-01	0.397	5.25E+00	7.00E+00	7.00E+02	4.114
3.00E-03	4.00E-03	4.00E-01	0.418	6.00E+00	8.00E+00	8.00E+02	4.198
4.50E-03	6.00E-03	6.00E-01	0.437	6.75E+00	9.00E+00	9.00E+02	4.268
6.00E-03	8.00E-03	8.00E-01	0.456	7.50E+00	1.00E+01	1.00E+03	4.327
7.50E-03	1.00E-02	1.00E+00	0.473	1.50E+01	2.00E+01	2.00E+03	4.627
1.50E-02	2.00E-02	2.00E+00	0.551	1.88E+01	2.50E+01	2.50E+03	4.695
2.25E-02	3.00E-02	3.00E+00	0.619	2.25E+01	3.00E+01	3.00E+03	4.743
3.00E-02	4.00E-02	4.00E+00	0.679	3.00E+01	4.00E+01	4.00E+03	4.805
3.75E-02	5.00E-02	5.00E+00	0.733	3.75E+01	5.00E+01	5.00E+03	4.843
4.50E-02	6.00E-02	6.00E+00	0.783	4.50E+01	6.00E+01	6.00E+03	4.872
5.25E-02	7.00E-02	7.00E+00	0.83	5.25E+01	7.00E+01	7.00E+03	4.891
6.00E-02	8.00E-02	8.00E+00	0.874	5.63E+01	7.50E+01	7.50E+03	4.898
6.75E-02	9.00E-02	9.00E+00	0.915	6.00E+01	8.00E+01	8.00E+03	4.904
7.50E-02	1.00E-01	1.00E+01	0.955	6.75E+01	9.00E+01	9.00E+03	4.914
1.50E-01	2.00E-01	2.00E+01	1.271	7.50E+01	1.00E+02	1.00E+04	4.923
2.25E-01	3.00E-01	3.00E+01	1.508	1.50E+02	2.00E+02	2.00E+04	4.987
3.00E-01	4.00E-01	4.00E+01	1.701	1.88E+02	2.50E+02	2.50E+04	5.025
3.75E-01	5.00E-01	5.00E+01	1.864	2.25E+02	3.00E+02	3.00E+04	5.071
4.50E-01	6.00E-01	6.00E+01	2.007	3.00E+02	4.00E+02	4.00E+04	5.183
5.25E-01	7.00E-01	7.00E+01	2.133	3.75E+02	5.00E+02	5.00E+04	5.301
6.00E-01	8.00E-01	8.00E+01	2.246	4.50E+02	6.00E+02	6.00E+04	5.397
6.75E-01	9.00E-01	9.00E+01	2.348	5.25E+02	7.00E+02	7.00E+04	5.478
7.50E-01	1.00E+00	1.00E+02	2.442	5.63E+02	7.50E+02	7.50E+04	5.514
1.50E+00	2.00E+00	2.00E+02	3.083	6.00E+02	8.00E+02	8.00E+04	5.548
2.25E+00	3.00E+00	3.00E+02	3.452	6.75E+02	9.00E+02	9.00E+04	5.61
3.00E+00	4.00E+00	4.00E+02	3.698	7.60E+02	1.00E+03	1.00E+05	5.666
3.75E+00	5.00E+00	5.00E+02	3.875				

Analog Output calibration = 29 (K6080 emulation)



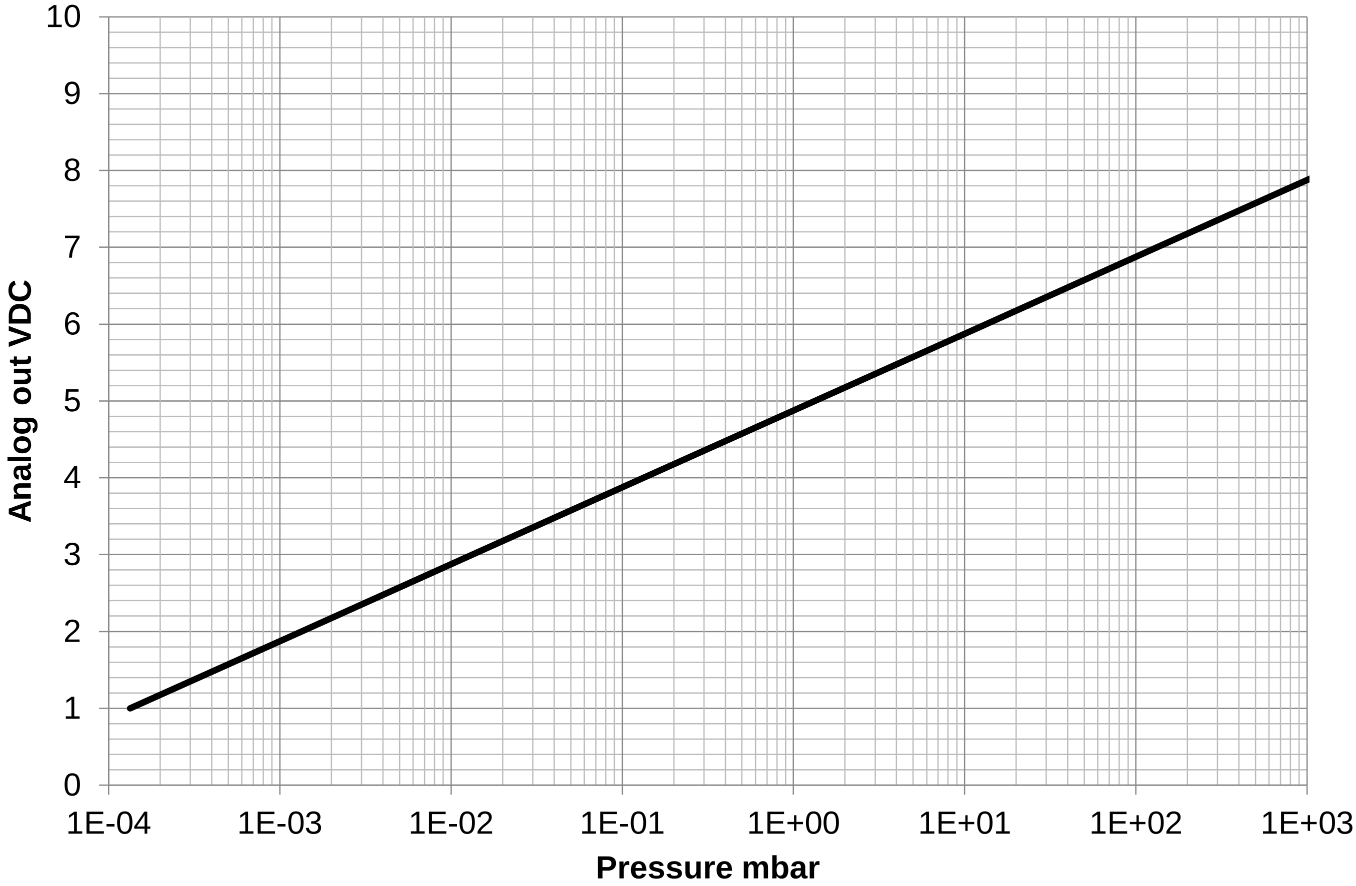
Torr	mbar	Pascal	Vout
7.50E-06	1.00E-05	1.00E-03	0.4
3.75E-05	5.00E-05	5.00E-03	0.4
7.50E-05	1.00E-04	1.00E-02	0.4
3.00E-04	4.00E-04	4.00E-02	0.4
6.00E-04	8.00E-04	8.00E-02	0.4
7.50E-04	1.00E-03	1.00E-01	0.41
3.00E-03	4.00E-03	4.00E-01	0.48
3.75E-03	5.00E-03	5.00E-01	0.5
6.75E-03	9.00E-03	9.00E-01	0.55
1.50E-02	2.00E-02	2.00E+00	0.61
3.75E-02	5.00E-02	5.00E+00	0.79
4.13E-02	5.50E-02	5.50E+00	1.1
4.50E-02	6.00E-02	6.00E+00	1.37
6.00E-02	8.00E-02	8.00E+00	1.6
7.50E-02	1.00E-01	1.00E+01	1.83
1.50E-01	2.00E-01	2.00E+01	2.64
2.60E-01	3.47E-01	3.47E+01	3.2
4.12E-01	5.50E-01	5.50E+01	3.71
5.31E-01	7.08E-01	7.08E+01	4
7.50E-01	1.00E+00	1.00E+02	4.45
1.14E+00	1.51E+00	1.51E+02	5
1.72E+00	2.29E+00	2.29E+02	5.44
3.00E+00	4.00E+00	4.00E+02	6.12
4.50E+00	6.00E+00	6.00E+02	6.8
4.88E+00	6.50E+00	6.50E+02	7.4
5.25E+00	7.00E+00	7.00E+02	7.96
6.00E+00	8.00E+00	8.00E+02	8.5
7.50E+00	1.00E+01	1.00E+03	9.01
1.50E+01	2.00E+01	2.00E+03	9.45
3.00E+01	4.00E+01	4.00E+03	9.7
4.50E+01	6.00E+01	6.00E+03	9.78
7.50E+01	1.00E+02	1.00E+04	9.85
1.50E+02	2.00E+02	2.00E+04	9.92
3.00E+02	4.00E+02	4.00E+04	9.95
4.50E+02	6.00E+02	6.00E+04	9.96
6.00E+02	8.00E+02	8.00E+04	9.98
7.60E+02	1.00E+03	1.00E+05	10

Analog Output calibration = 30 (Inficon PEG100 emulation)



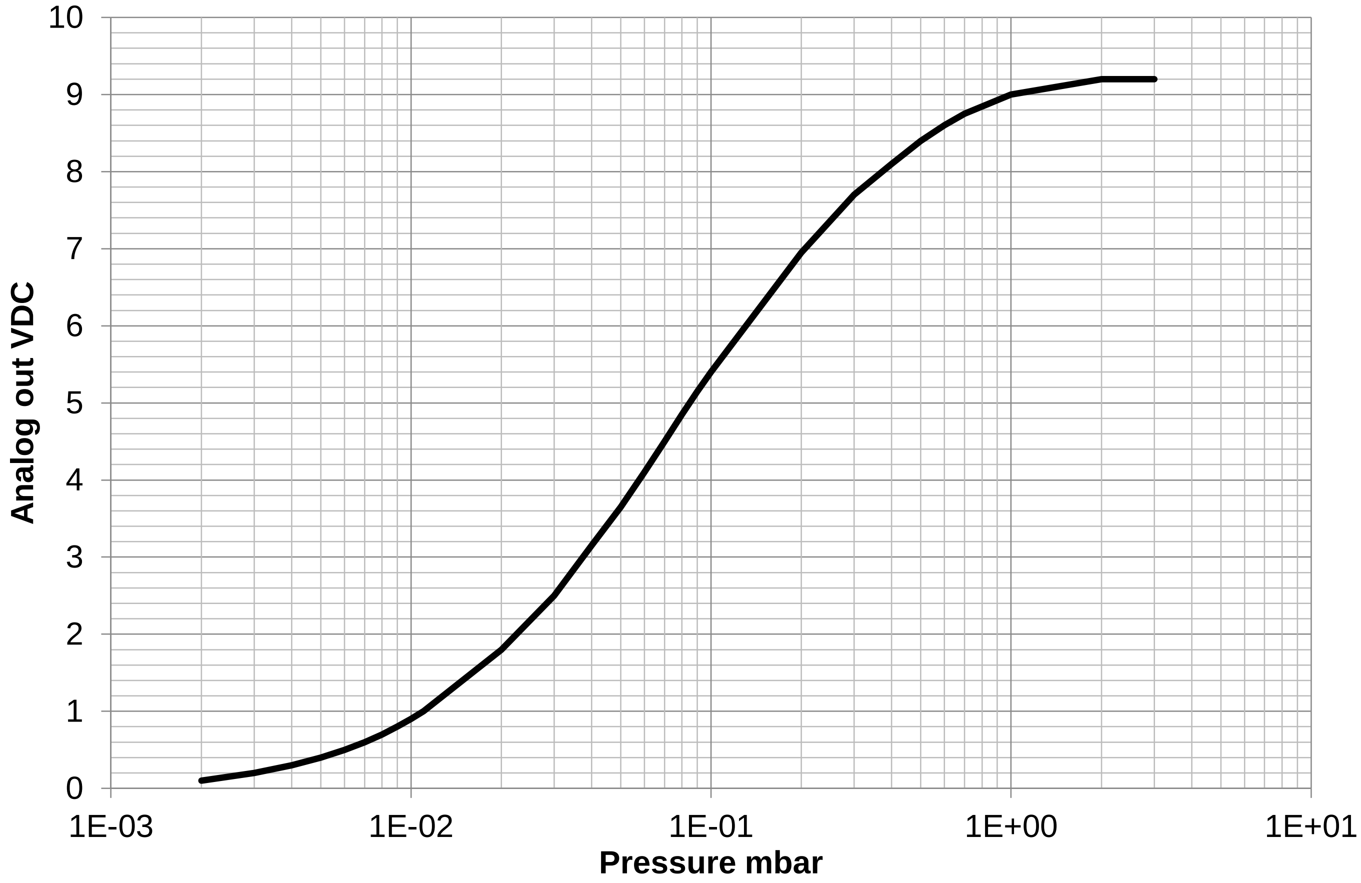
Torr	mbar	Pascal	Vout
1.00E-08	1.33E-08	1.33E-06	2.186111
1.00E-07	1.33E-07	1.33E-05	3.516111
1.00E-06	1.33E-06	1.33E-04	4.846111
1.00E-05	1.33E-05	1.33E-03	6.176111
1.00E-04	1.33E-04	1.33E-02	7.506111
5.00E-04	6.67E-04	6.67E-02	8.435741
1.00E-03	1.33E-03	1.33E-01	8.836111
1.00E-02	1.33E-02	1.33E+00	10.16611

Analog Output calibration = 31 (Varian Eysys emulation)



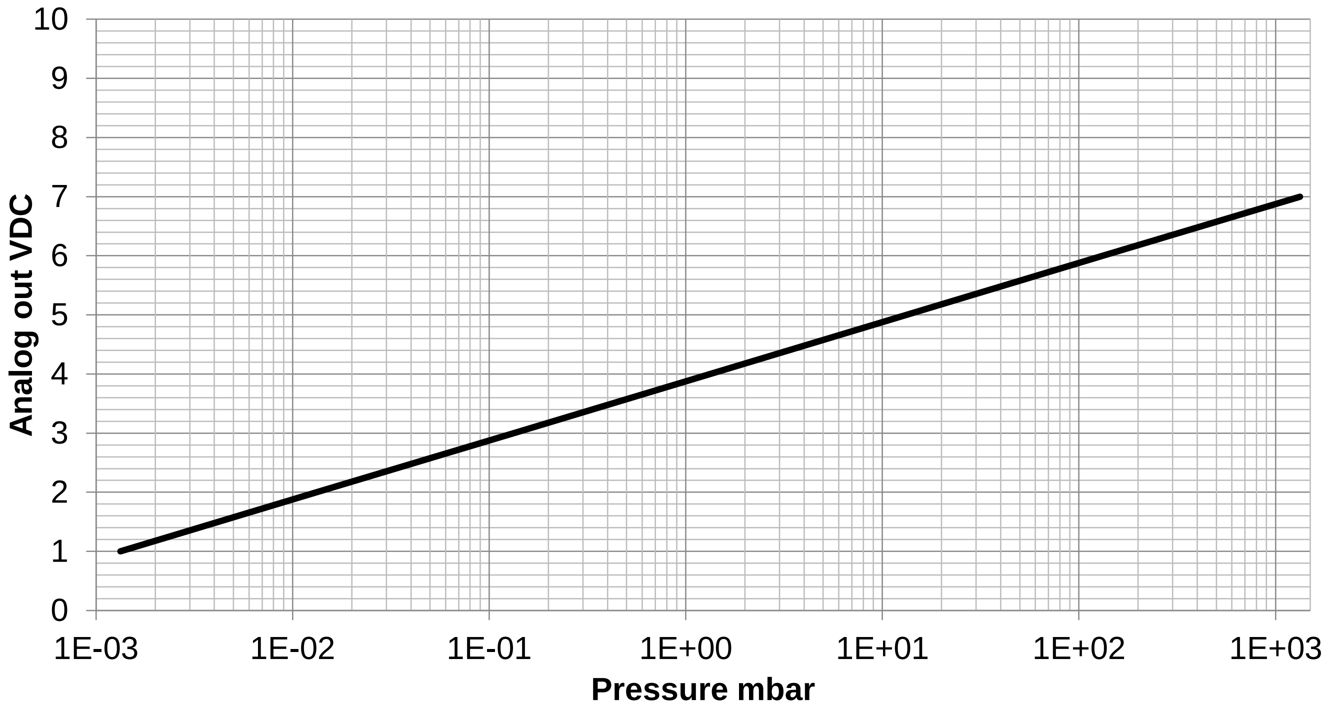
Torr	mbar	Pascal	Vout
1.00E-04	1.33E-04	1.33E-02	1
1.00E-03	1.33E-03	1.33E-01	2
1.00E-02	1.33E-02	1.33E+00	3
1.00E-01	1.33E-01	1.33E+01	4
1.00E+00	1.33E+00	1.33E+02	5
1.00E+01	1.33E+01	1.33E+03	6
1.00E+02	1.33E+02	1.33E+04	7
1.00E+03	1.33E+03	1.33E+05	8

Analog Output calibration = 32 (Alcatel TA111 emulation)



Torr	mbar	Pascal	Vout
1.50E-03	2.00E-03	2.00E-01	0.1
2.25E-03	3.00E-03	3.00E-01	0.2
3.00E-03	4.00E-03	4.00E-01	0.3
3.75E-03	5.00E-03	5.00E-01	0.4
4.50E-03	6.00E-03	6.00E-01	0.5
5.25E-03	7.00E-03	7.00E-01	0.6
6.00E-03	8.00E-03	8.00E-01	0.7
6.75E-03	9.00E-03	9.00E-01	0.8
7.50E-03	1.00E-02	1.00E+00	0.9
8.25E-03	1.10E-02	1.10E+00	1
1.50E-02	2.00E-02	2.00E+00	1.8
2.25E-02	3.00E-02	3.00E+00	2.5
3.00E-02	4.00E-02	4.00E+00	3.15
3.75E-02	5.00E-02	5.00E+00	3.65
4.50E-02	6.00E-02	6.00E+00	4.1
5.25E-02	7.00E-02	7.00E+00	4.5
6.00E-02	8.00E-02	8.00E+00	4.85
6.75E-02	9.00E-02	9.00E+00	5.15
7.50E-02	1.00E-01	1.00E+01	5.4
1.50E-01	2.00E-01	2.00E+01	6.95
2.25E-01	3.00E-01	3.00E+01	7.7
3.00E-01	4.00E-01	4.00E+01	8.1
3.75E-01	5.00E-01	5.00E+01	8.4
4.50E-01	6.00E-01	6.00E+01	8.6
5.25E-01	7.00E-01	7.00E+01	8.75
7.50E-01	1.00E+00	1.00E+02	9
1.50E+00	2.00E+00	2.00E+02	9.2
2.25E+00	3.00E+00	3.00E+02	9.2

Analog Output calibration = 33 (MKS 685 emulation)



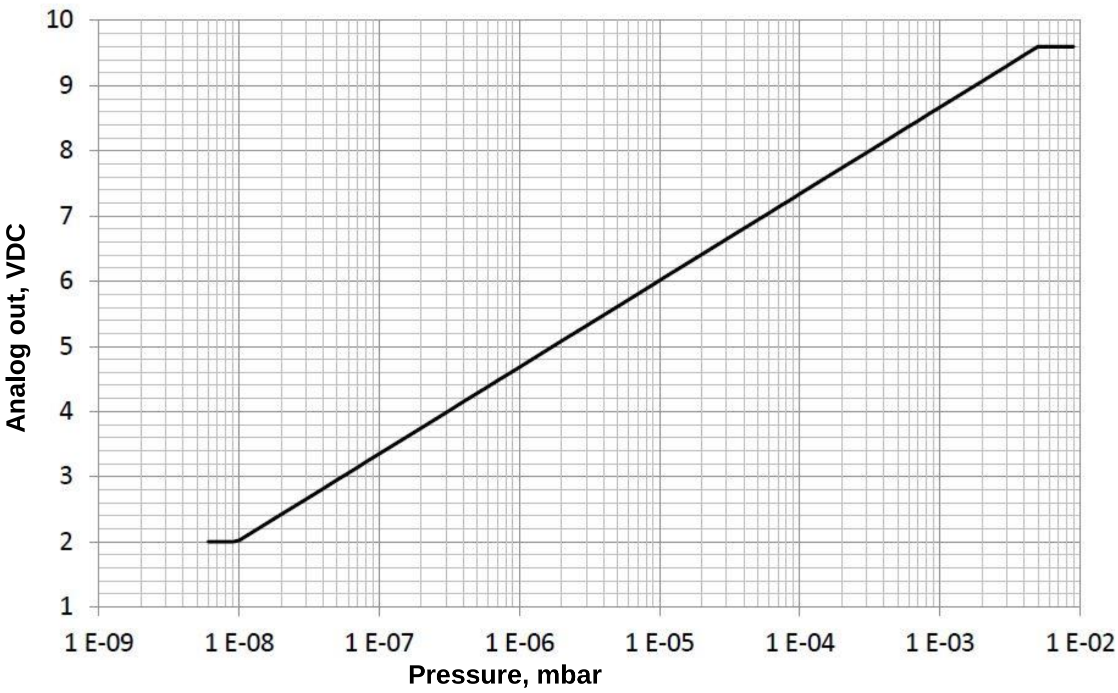
$P = 10^{(V_{out} - 4)}$

$V_{out} = 4 + \log_{10}(P)$

Torr	mbar	Pascal	Vout
1.00E-05	1.33E-05	1.33E-03	1.00
1.00E-04	1.33E-04	1.33E-02	1.00
1.00E-03	1.33E-03	1.33E-01	1.00
1.00E-02	1.33E-02	1.33	2.00
1.00E-01	1.33E-01	13.3	3.00
1.00	1.33	133.3	4.00
10.0	13.3	1333.2	5.00
100	133.3	1.33E+04	6.00
1000	1333.2	1.33E+05	7.00

Analog Output calibration = 49 (Leybold PTR 225 N, PTR 237N)
The PTR 225 N and PTR 237N PENNINGVAC analog output curve provides a voltage output as function of pressure (1.33 VDC/decade).

Conversion formulae:
$P_{mbar} = 10^{((Vout - 12.66)/1.33)}$ $V_{out} = \log10 (P_{mbar}) \times 1.33 + 12.66$



mbar	Vout	mbar	Vout	mbar	Vout
1.00E-08	2.0200	3.00E-06	5.3146	4.00E-04	8.1407
2.00E-08	2.4204	4.00E-06	5.4807	5.00E-04	8.2696
3.00E-08	2.6546	5.00E-06	5.6096	6.00E-04	8.3749
4.00E-08	2.8207	6.00E-06	5.7149	7.00E-04	8.4640
5.00E-08	2.9496	7.00E-06	5.8040	8.00E-04	8.5411
6.00E-08	3.0549	8.00E-06	5.8811	9.00E-04	8.6091
7.00E-08	3.1440	9.00E-06	5.9491	1.00E-03	8.6700
8.00E-08	3.2211	1.00E-05	6.0100	2.00E-03	9.0704
9.00E-08	3.2891	2.00E-05	6.4104	3.00E-03	9.3046
1.00E-07	3.3500	3.00E-05	6.6446	4.00E-03	9.4707
2.00E-07	3.7504	4.00E-05	6.8107	5.00E-03	9.5996
3.00E-07	3.9846	5.00E-05	6.9396	6.00E-03	9.6000
4.00E-07	4.1507	6.00E-05	7.0449		
5.00E-07	4.2796	7.00E-05	7.1340		
6.00E-07	4.3849	8.00E-05	7.2111		
7.00E-07	4.4740	9.00E-05	7.2791		
8.00E-07	4.5511	1.00E-04	7.3400		
9.00E-07	4.6191	1.20E-04	7.4453		
1.00E-06	4.6800	2.00E-04	7.7404		
2.00E-06	5.0804	3.00E-04	7.9746		