

KELLER



Sensors

Transducers

Transmitters

Instruments



Mandala (sanskrit: circle)

The becoming and being of life and universe was archetypically illustrated with concentric circles as in Mandalas or Gothic-church-windows with a focus representing each culture's origine: God, Buddha or nous in old Greece. Meditation should lead mankind through all the circles closer to the focus.

Science explains the creation of life along these lines. Out of a nucleus, a monad, life started. Always in danger to be destroyed, sensory cells evolved to recognize the danger. New forms of life evolved to evade the danger. Millions of cycles later, sensory cells evolved to recognize a prey. New forms of life evolved to incorporate the prey.

Billions of concentric circles, of creations of new sensory cells and new forms of life.

As sensor engineers, we strive to cross some of these circles towards the center.

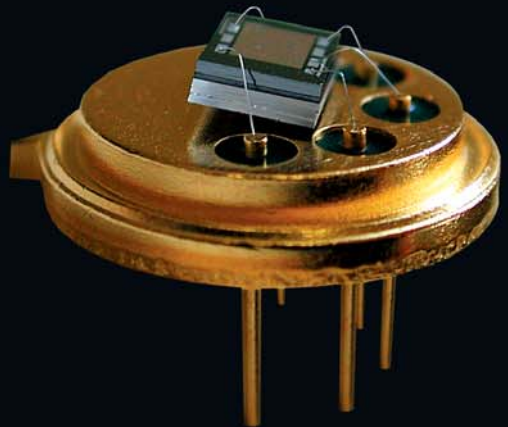
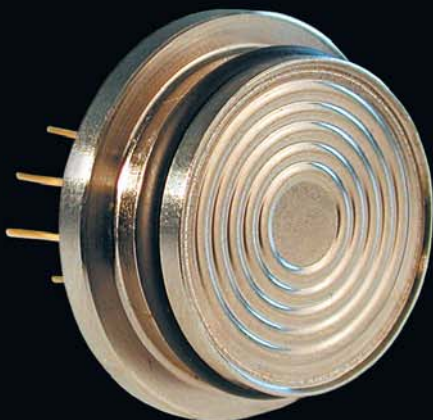
On the Trail of Swiss Watchmakers

High precision mechanics has a long tradition in Switzerland, renowned mainly for the mechanical Swiss watches. These handmade masterpieces find a growing clientele who see in this item – as the marketing approach successfully infuses – a friend they can rely on when achieving extraordinary accomplishments as sportsmen, pioneers, scientists or as a 007-hero.

What is the secret? Does material have a soul striving for perfection as many philosophers have postulated? Is the watchmaker conveying his soul through many hours of manufacturing into this piece of art? Is it more than just a timepiece?

We believe so. A simple item such as a diaphragm is not just a diaphragm. There is more to it...

H. L. Kell

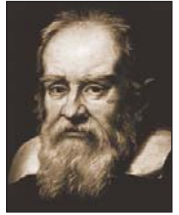


History of Pressure

1594



Galileo Galilei, born in Pisa (Italy), obtains the patent for a machine to pump water from a river for the irrigation of land. The heart of the pump was a syringe. Galileo Galilei found that 10 meters was the limit to which the water would rise in the suction pump, but had no explanation for this phenomenon. Scientists were then devoted to find the cause for this.



1644



Evangelista Torricelli (Torr), Italian physicist, filled a tube 1 meter long, hermetically closed at one end, with mercury and set it vertically with the open end in a basin of mercury. The column of mercury invariably fell to about 760 mm, leaving an empty space above its level. Torricelli attributed the cause of the phenomenon to a force on the surface of the earth, without knowing, where it came from. He also concluded that the space on top of the tube is empty, that nothing is in there and called it a "vacuum".



1648



Blaise Pascal, French philosopher, physicist and mathematician, heard about the experiments of Torricelli and was searching for the reasons of Galileo's and Torricelli's findings. He came to the conviction that the force, which keeps the column at 760 mm, is the weight of the air above. Thus, on a mountain, the force must be reduced by the weight of the air between the valley and the mountain. He predicted that the height of the column would decrease which he proved with his experiments at the mountain Puy de Dôme in central France. From the decrease he could calculate the weight of the air. Pascal also formulated that this force, he called it "pressure", is acting uniformly in all directions.



1656



Otto von Guericke, born in Magdeburg/Germany. Torricelli's conclusion of an empty space or "nothingness" was contrary to the doctrine of an omnipresent God and was thus attacked by the church. Guericke developed new air pumps to evacuate larger volumes and staged a dramatic experiment in Magdeburg by pumping the air out of two metal hemispheres which had been fitted together with nothing more than grease. 8 horses at each hemisphere were not strong enough to separate them (see title page).



1661



Robert Boyle, an Anglo-Irish chemist, used "J"-shaped tubes closed at one end to study the relationship between the pressure and volume of trapped gas and stated the law of $P \times V = K$ (P: Pressure, V: Volume, K: Constant) which means that if the volume of a gas at a given pressure is known, the pressure can be calculated if the volume is changed, provided that neither the temperature nor the amount of gas is changed.



1820



Almost 200 years later, Joseph Louis Gay-Lussac, French physicist and chemist, detects that the pressure increase of a trapped gas at constant volume is proportional to the temperature. 20 years later, William Thomson (Lord Kelvin) defines the absolute temperature scale with the zero point at -273°C (or 0 Kelvin).



History of Pressure Measurement

Mechanical Measurement Technologies

1843

Lucien Vidie, French scientist, invented and built the aneroid barometer, which uses a spring balance instead of a liquid to measure atmospheric pressure. The spring extension under pressure is mechanically amplified on an indicator system. Employing the indicator method of Vidie, Eugène Bourdon (founder of the Bourdon Sedeme Company) patented 1849 the Bourdon tube pressure gauge for higher pressures.

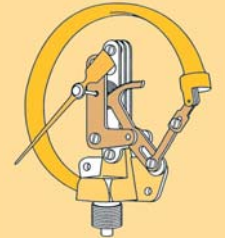


Aneroid Barometer

Electrical Measurement Technologies

1930

The first pressure transducers were transduction mechanisms where the movements of diaphragms, springs or Bourdon tubes are part of an electrical quantity. Pressure diaphragms are part of a capacitance, the indicator movement is the tap of a potentiometer.



Bourdon Tube

1938

The bonded strain gauges were independently developed by E. E. Simmons of the California Institute of Technology and A.C. Ruge of Massachusetts Institute of Technology. Simmons was faster to apply for a patent.

1955

The first foil strain gauges came up with an integrated full resistor bridge, which, if bonded on a diaphragm, see opposite stress in the center and at the edge.



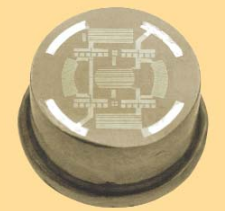
Foil Strain Gauge

1965

The bonding connection of the gauges to the diaphragm was always the cause for hysteresis and instability. In the 1960's, Statham introduced the first thin-film transducers with good stability and low hysteresis. Today, the technology is a major player on the market for high pressure.

1973

William R. Poyle applied for a patent for capacitive transducers on glass or quartz basis, Bob Bell of Kavlico on ceramic basis a few years later in 1979. This technology filled the gap for lower pressure ranges (for which thin film was not suited) and is today, also with resistors on ceramic diaphragms, the widest spread technology for non-benign media.



Thin Film

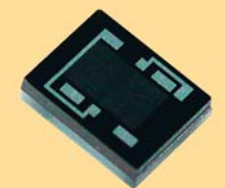
The Sensor Age

1967

Honeywell Research Center, Minneapolis/USA, 1967: Art R. Zias and John Egan applied for patent for the edge-constrained silicon diaphragm. 1969, Hans W. Keller applied for patent for the batch-fabricated silicon sensor. The technology is profiting from the enormous progresses of IC-technology.

A modern sensor typically weighs 0.01 grams. If all non-crystalline diaphragms have inherent hysteresis, the precision limit of this item is not detectable by today's means.

The piezoresistive technology is the most universal one. It applies for pressure ranges from 100 mbar to 1500 bar in the absolute, gauge and differential pressure mode. The slow spread of the technology in high volume applications for non-benign media resulted from the inability of US-companies to develop a decent housing. In 30 years, KELLER has perfected it at costs comparable to any other technology.



Piezoresistive Silicon Pressure Sensor

2000

Up to the 1970's, there were only transducer manufacturers.

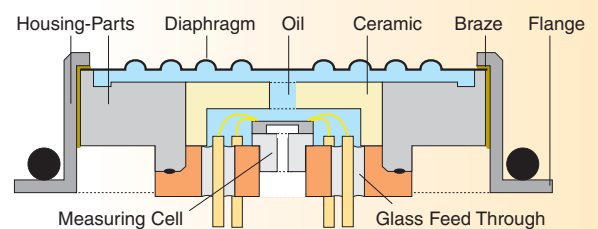
In 1977, KELLER introduced the first OEM modules, the Series 10 for lower pressures with Ø 19 mm, the Series 8 for higher pressures with Ø 15 mm, today a worldwide standard also in the imperial system.

This was the beginning of the modular design.

Basic Specifications (OEM's)

Ranges	0,1...1500 bar
Excitation	nom. 1 mA/constant current
Signal Output	nom. 150 mV/mA $\geq$ 1 bar nom. 200 mV/mA/bar $<$ 1 bar
Linearity	typ. 0,25 %FS / max. 0,5 %FS (best straight line through Zero)
TC Zero	$<$ 0,1 mV/K (-10...80 °C)
TC Gain	$<$ 0,02 %/K (-10...80 °C)
Overload	depending on range and design
Precision	0,002 %FS best * 0,02 %FS standard abs. * 0,05 %FS standard rel. *
Response Time	20 kHz
Material	DIN 1.4435 (AISI 316L) standard Option: Titanium, Hastelloy

* not smaller than 1 mbar



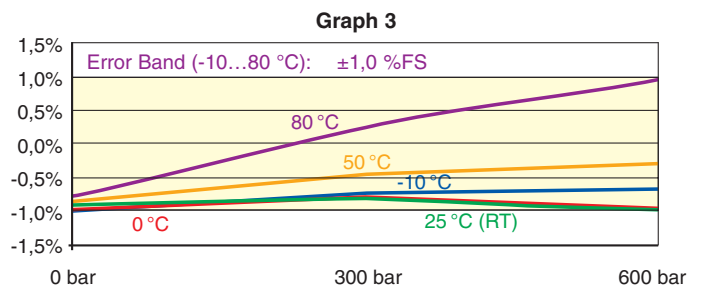
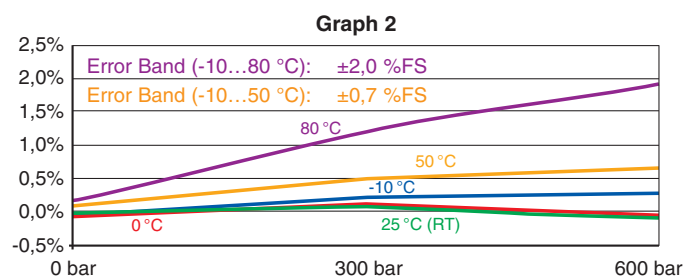
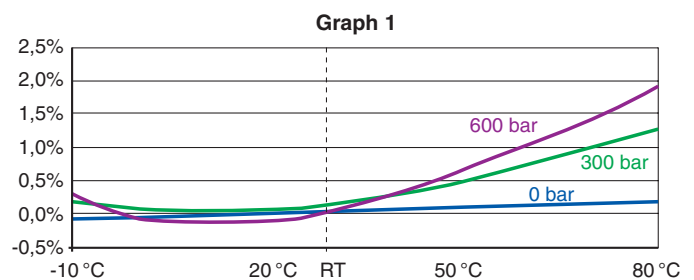


Error Bands (%FS)

The error band as a specification describes the maximum deviation in accuracy from the target value of a transmitter of any point in the specified pressure and temperature range.

Over the temperature range, the accuracy is a combination of Linearity, TC Zero and TC Gain. The error band can be found if the measured data of the sensor or transmitter are drawn up in constant pressure lines over temperature (Graph 1) or constant temperature lines over pressure (Graph 2). In both graphs, the transmitter has been adjusted for highest accuracy at room temperature.

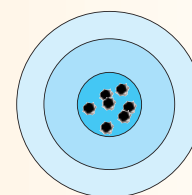
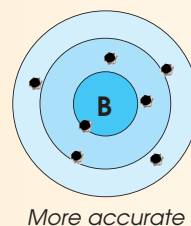
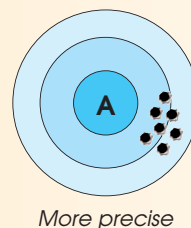
By offsetting the Zero to -1 % at room temperature, the error band of $\pm 2\%$ (-10...80 °C) can be reduced to $\pm 1\%$, a practice which is used in industrial or automotive transmitters (Graph 3).



"Every sensor is as accurate as it is precise!"

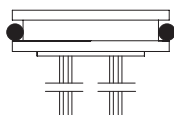
A. R. Zias (1968)

Accuracy and Precision should not be confused. Accuracy is the deviation from a target point. Precision is the deviation of the shots between them.

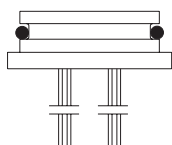


By correction, the accuracy of the target **A** can be improved. Target **B** cannot be improved.

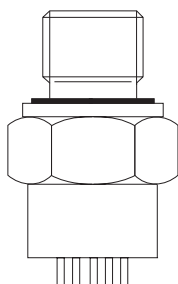
OEM: The KELLER Modular System



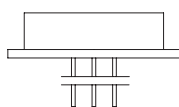
Form A (9 L)



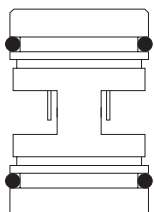
Form B (9 FL)



Form C (6 S)



Form D (9 S)



Form F (PD 10)

Today, the KELLER modular system contains many OEM sensor elements starting from only Ø 9,5 mm, suitable for mounting or welding. The most common are listed below. KELLER has developed various important technologies to amplify and compensate the signal from the

OEM sensor. Examples of the available circuit boards can be seen on the following pages. All 500 KELLER standard transmitters are just a combination of one of these sensor elements and the appropriate circuit board. A small selection of transmitters are presented on the next pages.

Absolute and Gauge

Type	Form	Dimensions in mm	Ranges in bar
3 L	A	Ø 9,5 x 4,2	20...200
4 L	A	Ø 11 x 4,2	10...200
5 L	A	Ø 12 x 4,5	10...200
6 L	A	Ø 13 x 4,5	10...200
6 LHP	A	Ø 13 x 8	400...1200
6 FL	C	G1/4", SW 19	10...200
6 S ¹	C	G1/4", SW 19	5...200
7 L	A	Ø 15 x 5	10...200
7 S	D	Ø 15 x 5	10...200
7 LHP	A	Ø 15 x 8	200...1000
8 L	A	Ø 17 x 7	0,2...50
9 L	A	Ø 19 x 5	0,2...200
9 S	D	Ø 17 / 21 x 5,5	0,5...20
9 FL	B	Ø 17 / 18 x 7	0,2...50
9 LHP	D	Ø 17 / 21 x 5,5	50...200
10 L	A	Ø 19 x 15	0,2...100
10 LHP	A	Ø 19 x 15	200...1500

Differential

Type	Form	Dimensions in mm	Ranges in bar
9 L	F	Ø 19 x 14	0,1...200 ²
10	F	Ø 19 x 26 (35)	0,1...1000 ²

¹ Fully brazed, no O-rings

² Base pressure



Signal Amplifiers



Conventional Amplifiers

For highest adjustment accuracy, Zero and Gain are optimally set by potentiometer at room temperature. Accuracy is defined by the linearity error.

Board: Ø 16,8 mm. Output: 0...10 V, 4...20 mA, 0,5...4,5 V.

All available ranges in absolute or gauge version.

Error Band

RT	0,25 %
0...50 °C	0,5 %
-10...80 °C	1 %



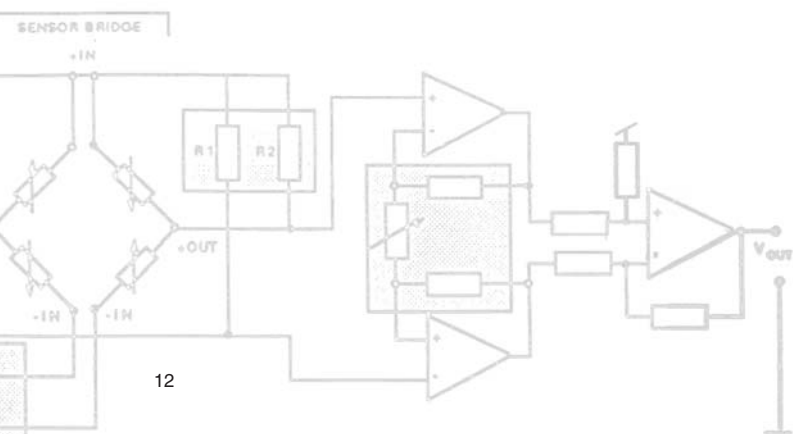
Industrial Amplifiers (ProgRes)

The industry requires reliable measurements within a certain temperature range. The error band describes the maximum deviation at any pressure within the compensated temperature range. Accuracy at room temperature is normally not of interest.

ProgRes is an amplifier with 4 programmable resistors for Zero, Gain, TC Zero and TC Gain (reprogrammable). The adjustment accuracy is $\pm 0,25$ %. Board: Ø 14,8 mm. Output: 4...20 mA, 0,5...4,5 V. Absolute or gauge versions ≥ 5 bar.

Error Band

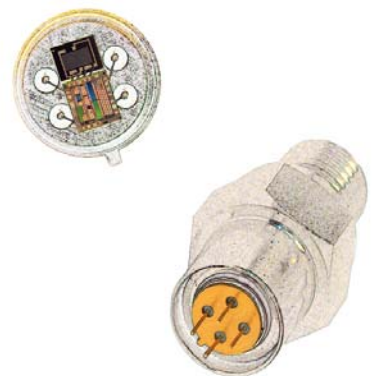
0...50 °C	1 %
-10...80 °C	2 %
-20...120 °C	4 %





CIO: Chip-In-Oil (ProgRes)

The ProgRes ASIC for 0,5...4,5 V output is integrated within the oil filled sensor housing, whereby the programmable amplifier-ASIC is mounted and contacted beside the actual absolute pressure measuring element on the same glass-feed-through. Only one pin is needed for the programming of the finished sensor. Output: 0,5...4,5 V. Absolute versions ≥ 5 bar.

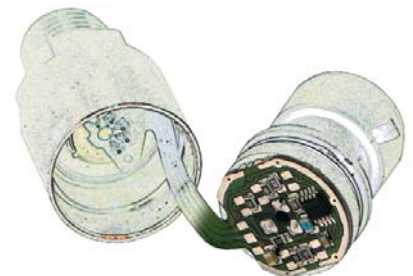


Error Band

0...50 °C	1 %
-10...80 °C	2 %
-20...120 °C	4 %

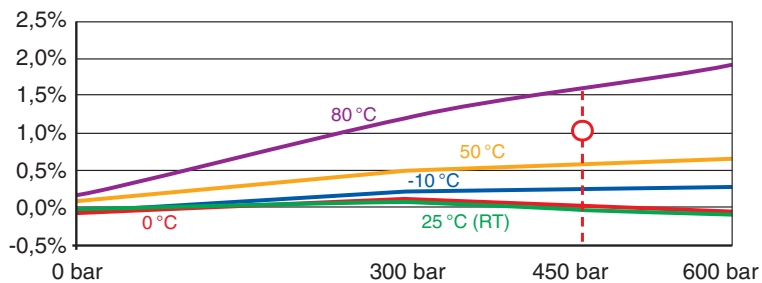
Automotive

Highest reliability at lowest cost is of priority for applications in the automotive field. A large temperature range from -40...135 °C and a high level EMC-protection is required. Adjustment and compensation either by fixed or laser trimmed resistors. Output: 4...20 mA, 0,5...4,5 V. Absolute versions ≥ 5 bar.



Error Band

-40 °C...135 °C	3 %...4 %
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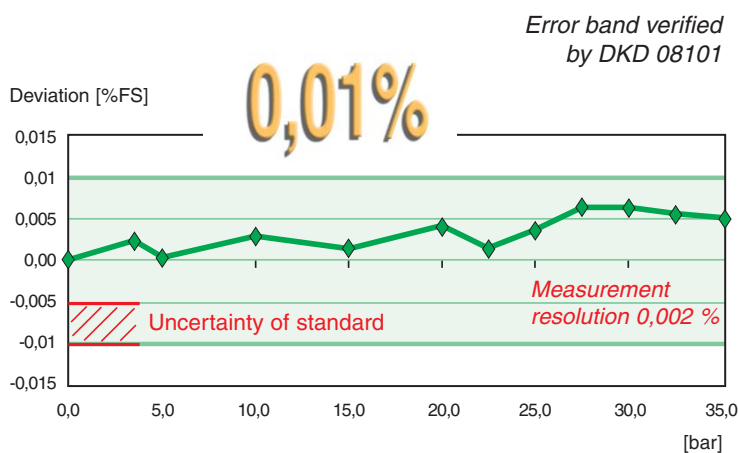


The graphs in the error band description can be used to considerably improve the accuracy of certain measurements.

For instance, a measurement is made at 65 °C at 450 bar: By interpolation between the 50 °C and the 80 °C line at 450 bar, the deviation is roughly +1 %. Subtracting 1 % from the measured value improves the accuracy to approximately 0,1 %.

Digital Compensation with μP's

μP-based signal conditioners create a coherent map of the deviations from the target value from a set of measurements at defined pressures and temperatures. This map is defined by a set of coefficients.



In operation, the μP attributes the exact pressure value to a set of pressure and temperature signals. By this method, called mathematical modelling, the error band is typically narrowed down by a factor of 100.



1



2

Characteristics Series 30 X (μ P-based amplifier)

Resolution:

0,002 % FS (FS $\geq$ 60 mV/mA)

Measurement Rate:

500 times per second

Output Signals:

RS485 / 4...20 mA / 0...10 V

Sensor Ports:

2 pressure and 2 temperature

Error Band (20 ± 5 °C):

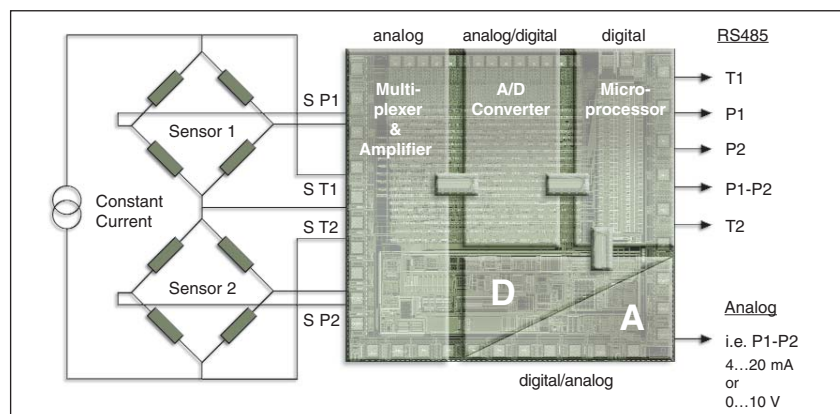
0,01 % best (verified by DKD)

Error Band ($-20 \dots 80$ °C):

0,05 % or 1 mbar

1 Circular board $\varnothing$ 16,8 mm for RS485 and 4...20 mA output

2 Double sensor for differential measurements with Series 30 X board



S T1 / S T2 Temperature Signals

The sensor bridges are excited with constant current. The voltage S T1 resp. S T2 over the bridge increases by 22% over +100 K. S T1 resp. S T2 is the perfect correlation for the compensation of S P1 resp. S P2 over temperature. Accuracy and precision are limited by the pressure and temperature references.



Autonomous Data Logger: The AA-technology (absolute/absolute) is the realisation of a gauge or differential measurement with 2 absolute sensors and with digital signal conditioning, offering a completely sealed system for gauge measurements. The level sensor is connected by a cable to the electronics housing, which incorporates the electronics with the latest μ P-technology (16 Bit A/D converter). The waterproof mounted absolute pressure sensor has a stainless steel diaphragm for air pressure measurement and barometric correction of the depth sensor.

The processor circuit collects the signals of the two pressure and temperature sensors and calculates the differential pressure with an accuracy of 1 cm for ranges up to 10 mWC.

The data collector DCX-22 AA allows measuring stations to be set up at considerably lower costs compared to conventional systems, offering furthermore the following advantages:



- Autonomous: Easily replaceable battery with a lifetime ≥ 10 years
- High data security due to the use of a non-volatile memory
- 100 % waterproof (no ventilation tube)
- Combination of event-controlled recording and interval recording prevents unnecessary data being recorded
- Simple and well structured configuration- and read-out PC-software
- Option of recording the barometric pressure, water and ambient temperature
- Small level sensor diameter (19 mm and 21 mm)
- Installation data can be stored in the level sensor
- The system is configured for a wireless data transfer via modem



For conventional application with AA-technology, KELLER alternatively offers the DACS-2.

DACS-2 is a simpler, less expensive version to replace the relative level transmitter for 4...20 mA output. It contains the μ P-electronics and a barometric pressure sensor.

The level sensor signal is transferred via the RS485 over long distances to the DACS-2 which is located in the control room, taking the signals of the absolute level sensor and the barometric pressure and transfers the pressure difference into a 4...20 mA signal.





Industrial





Flush mounting

Indicators

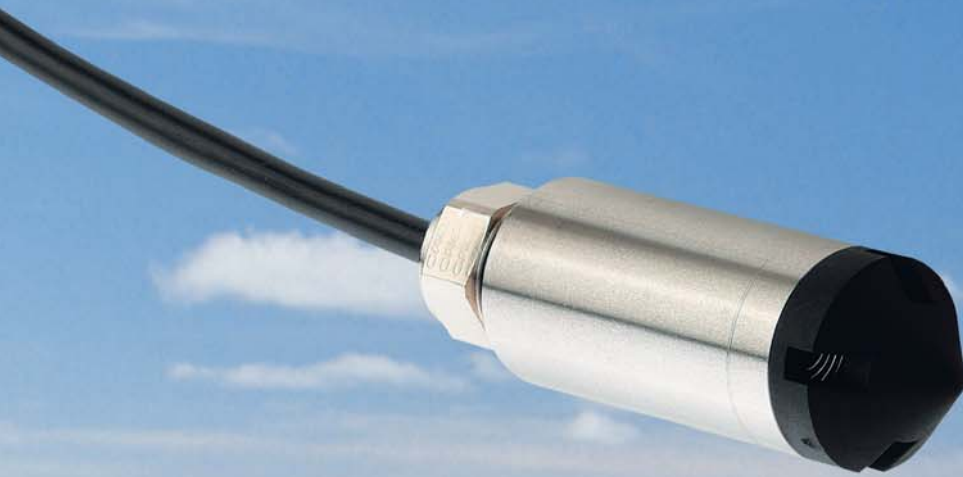




Automotive



Level



KELLER
druckmesstechnik
TYPE: P30
RANGE: 0...10 bar
OUTPUT: 4-20 mA
SUPPLY: 12-24 VDC
WH: GND
RD: +OUT
BK: +Vcc
Tel.: +41 76 21 723 21





Digital Manometers





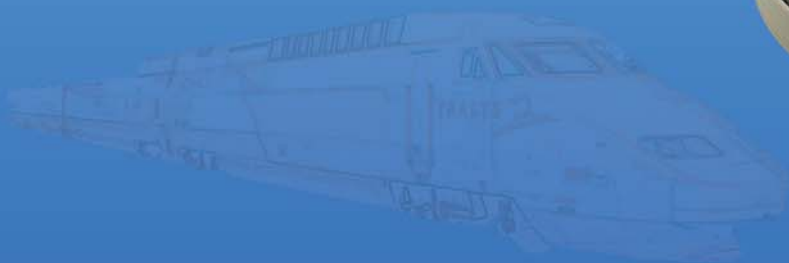
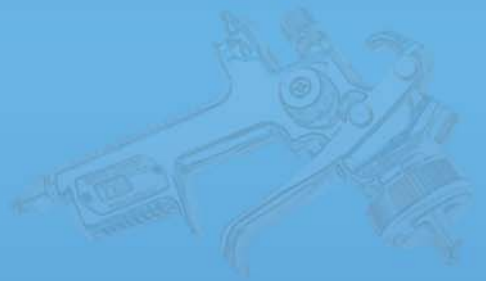
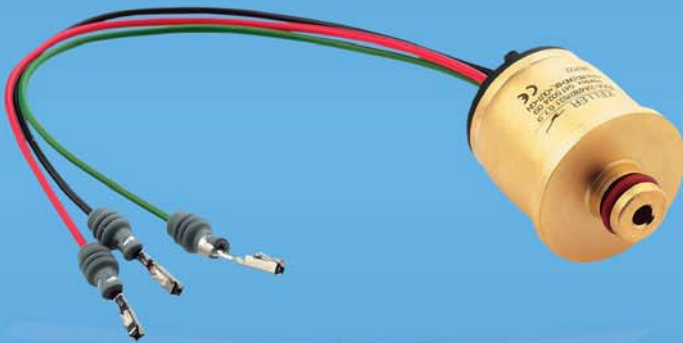
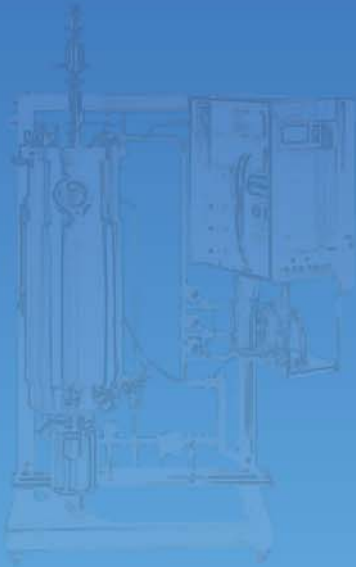
Pressure Calibrators

Pumps





Custom made



OEM Transducers



SERIES 3 L

Ø 9,5 x 4,2 mm
20...200 bar, abs. / gauge



SERIES 4 L

Ø 11 x 4,2 mm
10...200 bar, abs. / gauge



SERIES 5 L

Ø 12 x 4,5 mm
10...200 bar, abs. / gauge



SERIES 6 L

Ø 13 x 4,5 mm
10...200 bar, abs. / gauge



SERIES 6 LHP

Ø 13 x 8 mm
400...1200 bar, absolute



SERIES 6 FL

Flush mount diaphragm
10...200 bar, abs. / gauge



SERIES 6 S

Brazed steel diaphragm
0,5...200 bar, abs. / gauge



SERIES 7 L

Ø 15 x 5 mm
10...200 bar, abs. / gauge



SERIES 7 S

Ø 15 x 5 mm, brazed
10...50 bar, abs. / gauge



SERIES 7 LHP

Ø 15 x 8 mm
200...1000 bar, absolute



SERIES 8 L

Ø 17 x 7 mm
0,2...50 bar, abs. / gauge



SERIES 9 L

Ø 19 x 5 mm
0,2...200 bar, abs. / gauge



SERIES 9 S

Ø 17 / 21 x 5,5 mm, brazed
0,5...20 bar, abs. / gauge



SERIES 9 FL

Ø 17 / 18 x 7 mm
0,2...50 bar, abs. / gauge



SERIES 9 LHP

Ø 17 / 21 x 5,5 mm
50...200 bar, absolute



SERIES 10 L

Ø 19 x 15 mm
0,2...100 bar, abs. / gauge



SERIES 10 LHP

Ø 19 x 15 mm
200...1500 bar, absolute



SERIES PD 9 L DIFFERENTIAL

Ø 19 x 14 mm, wet/wet
0,1...50 bar diff.
Line pressure max. 200 bar



SERIES PD 10 DIFFERENTIAL

Ø 19 x 26 mm, wet/wet
0,1...50 bar diff.
Line pressure max. 1000 bar

OEM Transmitters

All OEM absolute transducers are available with 0,5...4,5 V amplifier (CIO = Chip In Oil).
(see page 13)

All OEM transducers (abs. or gauge) with Ø ≥ 15 mm are available with ProgRes amplifiers Ø 14,8 mm.
(see page 12)

All OEM transducers (abs. or gauge) with Ø ≥ 17 mm are available with conventional amplifiers Ø 16,8 mm.
(see page 12)

All OEM transducers with flex-board or free wire connection are available with µP-based amplifiers.
(see page 15)



The following transmitters are available in different error bands depending on signal conditioning, pressure and temperature range. They come with most common output signals, i.e. 4...20 mA / 0,5...4,5 V / 0...10 V.

Any modifications to these shown standard products, such as other materials, special temperatures, pressure ports, signal outputs and electrical connections are available upon request.

Our application engineers will support you in selecting or adapting one of these variants to your specific needs, both in terms of special construction, non-standard specifications as well as special EMC-protection.

Industrial Transmitters



Flush Mounting



Automotive



SERIES 22
Laser-comp., G1/4" male
5...200 bar



SERIES 22
Laser-comp., G1/4" female
5...200 bar



SERIES 22
Laser-comp., with temperature sensor, 5...200 bar



SERIES 22 M
Laser-comp., Brass
5...200 bar



SERIES 22 M
Laser-comp., Brass
5...200 bar

Level Transmitters



SERIES 26
ProgRes, Low Cost
0.2...20 bar



SERIES 26 W / 36 WX
Conv. / µP-compensated
0.2...20 bar



SERIES 46 W
Capacitive
20...3000 mbar



SERIES DCX-22
Data logger
0.8...10 bar



SERIES DCX-22 AA
Data logger
800...2300 mbar

Digital Manometers



ECO 1
Low Cost
-1...300 bar



LEO 1 (with Peak function)
5000 meas./sec.
-1...1000 bar



LEO 2
High accuracy
-1...700 bar



LEO 3
With analog output
0...1000 bar



INTELLIGENT MANOMETER
Memory option
-1...1000 bar

Digital Indicators



EV-120
For Series 30 transmitters



EV-94
24 x 48 mm, RS485
Miniature format, low cost



EV-98/EV-99
48 x 96 mm
Highly precise, universal



EV-101...EV-104
48 x 96 mm
Most signal-inputs, RS485



EV-97
Digital on-site display
Supply from 4...20 mA

Pressure Calibrators



LP CALIBRATOR

Low pressure
Ranges: -1...10 bar



MP CALIBRATOR

Medium pressure
Ranges: -1...25 bar



HP CALIBRATOR

High pressure
Ranges: up to 700 bar



HTP 1 PUMP (Pump only)

High pressure hand pump
Ranges: up to 700 bar



K/P PUMP (Pump only)

Low pressure hand pump
Ranges: -0,85...30 bar

Custom Made Products



Diving computers,
circuit mounting



Circuit mounting,
abs./gauge/diff.



Helicopters,
turbines



Military helicopters,
filter monitoring



Display modules,
pneumatics



Medical,
air pressure tools



Chromatography,
high pressure pumps



Painting industry,
battery driven (100 kV)



Military application,
track vehicles



Industrial cleaners,
water purification



Ink-jet plotters,
CMYK



Aviation,
cabin pressure



Biotechnology,
fermentation



Metering systems,
pump control



High temp. 350 °C,
water cooled

Company Profile



*Administration and production facilities,
Headquarters Winterthur / Switzerland*

KELLER was founded in 1975 by Hans W. Keller who is the driving force within KELLER and a very active Company President.

Based in Switzerland, KELLER is Europe's largest manufacturer of piezoresistive stainless steel pressure capsules, transducers and transmitters. The KELLER product range is one of widest on offer from a single source.

KELLER manufactures everything from high volume OEM piezoresistive pressure sensors to high-accuracy digitally compensated transmitters and sophisticated digital manometers and calibrators.

KELLER specialises in the field of high volume industrial OEM sensors and transmitters which are produced using the latest automated techniques.

This philosophy has been extended to the signal conditioning circuits, most of which are programmable and can be fully calibrated and compensated using computer controlled test equipment.

By adopting modern methods KELLER has reduced manufacturing cost while achieving the unrivalled quality and performance that is normal for Swiss engineering. This is why KELLER leads the world in the transducer industry.

KELLER AG für Druckmesstechnik, the Group headquarters and main production plant, is located in Winterthur, Switzerland.

KELLER Gesellschaft für Druckmesstechnik mbH based in Jestetten, Germany, is the core of all KELLER European operations and is a single sales administration and distribution centre for all KELLER satellite companies within the European Union.

KELLER worldwide subsidiaries and representative network service all customers in the respective country, providing full technical and sales support for all KELLER products.

Both facilities, Winterthur in Switzerland and Jestetten in Germany, are certified ISO 9001:2000.



SWITZERLAND (HEADQUARTERS)

KELLER AG für Druckmesstechnik
St. Gallerstrasse 119
CH-8404 Winterthur
Tel. +41 (0)52 235 25 25
Fax +41 (0)52 235 25 00
marketing@keller-druck.com

ASIA / AUSTRALIA / ARABIAN COUNTRIES

KELLER SOUTH-EAST ASIA
419, A 3/1 Galle Road
LK-Colombo 3
Tel. +94 (0)11 485 11 25
EFax +41 (0)52 560 49 11
kellersea@keller-druck.ch

CZECHIA

KELLER / OFFICE CZECHIA
Družstevní 432
CZ-74719 Bohuslavice
Tel. +420 553 65 08 13
Fax +420 553 65 08 14
i.garcia@keller-druck.cz

ENGLAND / IRELAND

KELLER (UK) LTD.
Kimmeridge House • Dorset Green Technology Park
GB-Dorchester. DT2 8ZB
Tel. 0845 643 2855
Fax 0845 643 2866
sales@keller-pressure.co.uk

FRANCE

KELLER Métrologie de la Pression
3, Boulevard de l'Europe
FR-68100 Mulhouse
Tel. 0800 90 34 43
Fax 0800 91 88 87
keller.france@keller-druck.com

GERMANY

KELLER Ges. für Druckmesstechnik mbH
Schwarzwaldstrasse 17
DE-79798 Jestetten
Tel. +49 (0)7745 92 14 0
Fax +49 (0)7745 92 14 50
eurocenter@keller-druck.com

ITALY

KELLER ITALY SRL
Via Gonzaga, 7
IT-20123 Milano
Tel. 800 78 17 17
Fax 800 78 17 18
officeitaly@keller-druck.com

NETHERLANDS

KELLER MEETTECHNIEK B.V.
Businesspark "Zoutman", Leeghwaterstr. 25
NL-2811 DT Reeuwijk
Tel. +31 (0)182 399 840
Fax +31 (0)182 399 841
sales@keller-holland.nl

POLAND

KELLER / BIURO POLSKA
ul. Gorecka 89/3
PL-61-483 Poznan
Tel. +48 (0)61 832 77 28
Fax +48 (0)61 832 80 32
b.janiak@keller-druck.com

SWEDEN

KELLER SWEDEN AB
Varuvägen 9
SE-125 30 Älvsjö
Tel. +46 (0)18 10 27 00
Fax +46 (0)18 10 27 27
keller.sweden@telia.com

USA / CANADA

KELLER AMERICA, INC.
813 Diligence Drive, Suite 120
US-VA 23606 Newport News
Tel. +1 757 596 6680
Fax +1 757 596 6659
sales@kellerafrica.com

Representations

AUSTRALIA

BESTECH AUSTRALIA PTY LTD
Unit 7, 35 Taunton Drive
AU-Cheltenham VIC 3192
Tel. +61 (03) 9584 1133
Fax +61 (03) 9584 5477
sales@bestech.com.au

AUSTRIA

TECH TRADE GmbH
Güntherstrasse 8
AT-4040 Linz
Tel. +43 (0)732 733 311
Fax +43 (0)732 733 311 19
j.kletzenbauer@techtrade.at

BELGIUM (FLEMISH)

BIP
Diamantstraat 3
BE-2200 Herentals
Tel. +32 (0)1 425 75 50

info@b-i-p.be

BELGIUM (FRENCH)

TECHNOFLUID
Rue de l'Estampage, 7
BE-4340 Awans
Tel. +32 (0)4 344 97 00
Fax +32 (0)4 341 38 86
info@technofluid.be

BRAZIL

SUPPORT INT'L CONSULTANCY
Rua Borges Lagoa, 1080 Cj. 1103
BR-04038-002 Vila Clementino – São Paulo
Tel. +55 11 5908 4056
Fax +55 11 5908 4057
supportic@uol.com.br

CHINA

KISTLER SHANGHAI REPR. OFFICE
Room 1801-1802, Xin Yin Build. No. 888, Yi Shan Road
CN-200233 Shanghai
Tel. +86 (0)21 6432 0190
Fax +86 (0)21 6432 0196
li@kistler.com.cn

HUNAN HUA-RUI SENSORS MEASURING & CONTROLLING ENGINEERING CO. LTD.

Room 1303 Jianhongda 479 Md., Furong Road
CN-410005 Changsha, Hunan
Tel. +86 (0)731 8445 1008
Fax +86 (0)731 8445 1058
hua-rui@hrsensorm.com

DENMARK

TECH
Arresøvej 10
DK-8240 Risskov
Tel. +45 87 392 600
Fax +45 87 392 601
info@tech.dk

FINLAND

OY PROFIMEAS LTD
Hirsalantie 11
FI-02420 Jorvas
Tel. +358 (0)9 873 6000
Fax +358 (0)9 857 4018
myynti.sales@profimeas.fi

INDIA

WAAREE INSTRUMENTS LTD
36, Damji Shamji Indl. Complex, Andheri (E)
IN-400 093 Mumbai
Tel. +91 (0)22 6696 3030
Fax +91 (0)22 2687 3613
waaree@waaree.com

IRAN

DEGHAT GOSTAR TAJHIZ ENG. CO.
No. 2, 4th alley, Orak Str, Hamila Blvd, Poonak Sqr
IR-Tehran
Tel. +98 21 44 00 55 49
Fax +98 21 44 00 53 12
Sales@DeghatGostar.com

ISRAEL

T. BERKE LTD.
26 Hakishor St., Industrial Park
IL-Holon 58867
Tel. +972 (0)3 559 9070
Fax +972 (0)3 559 4858
berke@berke-ltd.com

JAPAN

SAYAMA CORPORATION
6-10-12, Higashi-jujo
JP-Kita-ku, Tokyo
Tel. +81 (0)3 39 03 21 81
Fax +81 (0)3 39 03 01 23
sales@sayama.com

KOREA

DAHO TRONIC LIMITED
904 World Meridian Venture Center I, 60-24 Gasan-dong
KR-153-801 Seoul
Tel. +82 (0)2 865-7001
Fax +82 (0)2 865-7109
dhlee@daho.co.kr

LEBANON

ADM ELECTRIC
MGM Building 5th Floor, Jal El Dib Internal Road, PO Box
LB-70231 Antelias
Tel. +961 4 71 83 18
Fax +961 4 71 83 19
Anthony@admelectric.com

NORWAY

TECK-SKOTSELV AS
Verksveien 7
NO-3330 Skotselv
Tel. +47 32 25 09 70
Fax +47 32 25 09 71
firmapost@skotselv.no

SPAIN

CATSENSORS
Villar, 22 2o 2a
ES-08041 Barcelona
Tel. +34 934 508 777
Fax +34 934 508 777
info@catsensors.com

TAIWAN

KISTLER SHANGHAI REPR. OFFICE
Room 1801-1802, Xin Yin Build. No. 888, Yi Shan Road
CN-200233 Shanghai
Tel. +86 (0)21 6432 0190
Fax +86 (0)21 6432 0196
li@kistler.com.cn

TURKEY

ZETA ENERJİ LTD. STİ.
Perpa Ticaret Merkezi B Blok K:11 NO:1657
TR-Okmeydanı – İstanbul
Tel. +90 212 210 97 50
Fax +90 212 220 39 81
nmeden@zetaenerji.com

SOUTH-AFRICA

INSTROTECH (PTY) LTD.
P.O. Box 418, Honeydew 2040
RSA- 0000 Kya Sand, Randburg
Tel. +27 (0)11 462 1920
Fax +27 (0)11 462 1958
yvonne.onions@instrotech.co.za

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Subject to change

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This catalog lists the most common products with their main features. Detailed technical information is available upon request or can be viewed on our website

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