AMS 5812
Amplified pressure sensor with analog and digital output (I²C)

FEATURES

- **Amplified, calibrated and temperature compensated pressure sensor**
- **Differential/relative, bidirectional differential, absolute and barometric versions**
- **Ratiometric analog voltage output of 0.5 – 4.5V**
- **Digital output for pressure and temperature via I2C interface**
- **High accuracy at RT**
- **Small overall error within a temperature range of -25 ... 85°C**
- **Supply voltage range 4.75…5.25V**
- **High long term stability**
- **Programmable I²C-address**
- **Small DIP package**
- **Ready to use**
- **RoHS compliant**

GENERAL DESCRIPTION

AMS 5812 pressure sensors are a series of high-precision OEM sensors with an analog 0.5 – 4.5 V voltage output and a digital I2C-interface. They are calibrated and compensated for across a wide temperature range of -25 to +85°C.

AMS 5812 comes as a dual in-line package (DIP) for assembly on printed circuit boards (PCBs) and is fully operational without the need for any additional components. The electrical connection is made via the DIP solder pins; pressure is connected via two vertical metal tubes.

AMS 5812 combines micromachined, high quality piezoresistive measuring cells with a modern, signal conditioning mixed-signal ASIC on a ceramic substrate. This enables high precision measurements and excellent drift and long-term stability.

The sensors in the AMS 5812 series are available for various applications and pressure ranges: differential (relative) devices in pressure ranges from 0 – 0.075 PSI up to 0 – 100 PSI, absolute pressure variants for 0 – 15 PSI, 0 - 30 PSI and a barometric type. Bidirectional differential devices are available from -0.075 /+ 0.075 PSI up to -15/ +15 PSI. Custom specific pressure ranges and modifications are available on request.

TYPICAL APPLICATIONS

- Static and dynamic pressure measurement
- Barometric pressure measurement
- Vacuum monitoring
- Gas flow
- Fluid level measurement
- Medical instrumentation
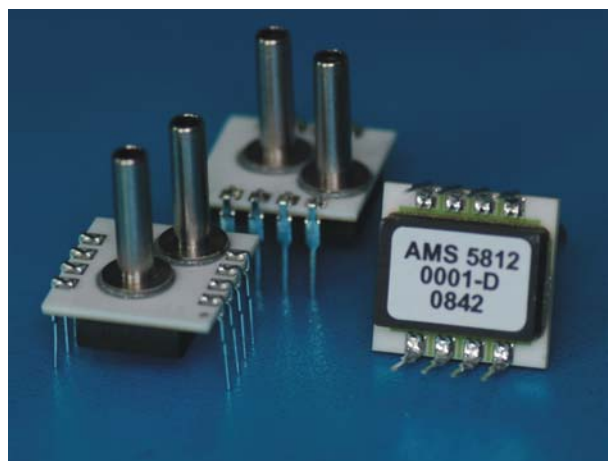- Heating, Ventilation and Air Conditioning (HVAC)

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PRESSURE RANGES

Sensor type (code)	Pressure type	Pressure range in PSI	Burst pressure[1] in PSI	Pressure range in mbar	Burst pressure[1] in bar
Ultra low pressure					
AMS 5812-0000-D	differential / relative	0…0.075	>5	0…5.17	>0.35
AMS 5812-0001-D	differential / relative	0 … 0.15	>5	0 ...10.34	>0.35
AMS 5812-0000-D-B	bidirectional differential	-0.075 / +0.075	>5	-5.17 / +5.17	>0.35
AMS 5812-0001-D-B	bidirectional differential	-0.15 / +0.15	>5	-10.34 / +10.34	>0.35
Low pressure					
AMS 5812-0003-D	differential / relative	0 … 0.3	>7	0 … 20.68	>0.5
AMS 5812-0008-D	differential / relative	0 … 0.8	>15	0 … 55.16	>1
AMS 5812-0015-D	differential / relative	0 … 1.5	>15	0 … 103.4	>1
AMS 5812-0003-D-B	bidirectional differential	-0.3 / +0.3	>7	-20.68 / +20.68	>0.5
AMS 5812-0008-D-B	bidirectional differential	-0.8 / +0.8	>15	-55.16 / +55.16	>1
AMS 5812-0015-D-B	bidirectional differential	-1.5 / +1.5	>15	-103.4 / +103.4	>1
Standard pressure					
AMS 5812-0030-D	differential / relative	0 … 3	72	0 … 206.8	5
AMS 5812-0050-D	differential / relative	0 … 5	72	0 … 344.7	5
AMS 5812-0150-D	differential / relative	0 … 15	72	0 … 1034	5
AMS 5812-0300-D	differential / relative	0 … 30	225	0 … 2068	15.5
AMS 5812-0600-D	differential / relative	0 … 60	225	0 … 4137	15.5
AMS 5812-1000-D	differential / relative	0 … 100	225	0 … 6895	15.5
AMS 5812-0030-D-B	bidirectional differential	-3 / +3	72	-206.8 / +206.8	5
AMS 5812-0050-D-B	bidirectional differential	-5 / +5	72	-344.7 / +344.7	5
AMS 5812-0150-D-B	bidirectional differential	-15 / +15	72	-1034 / +1034	5
AMS 5812-0150-B	barometric	11 … 17.5	72	758.4 … 1206	5
AMS 5812-0150-A	absolute	0 … 15	72	0 … 1034	5
AMS 5812-0300-A	absolute	0 … 30	72	0 … 2068	5

Table 1: **AMS 5812 standard pressure ranges (other ranges on request)**

Notes:

1) Burst pressure is defined as the maximum pressure which may be applied to one pressure port relative to the other port (or while only one pressure port is connected) without causing leaks in the sensor.

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MAXIMUM RATINGS

Parameter	Minimum	Typical	Maximum	Units
Maximum supply voltage: V_S (max)			6.0	V
Operating temperature: T_{op}	-25		85	°C
Storage temperature: T_{amb}	-40		125	°C
Common mode pressure p_{CM} [1]			175	PSI

Table 2: **Maximum ratings**

Notes:

1) The common mode pressure is defined as the maximum pressure that can be applied on both pressure ports of a differential pressure sensor simultaneously without damaging the sensors housing.

SPECIFICATIONS

All parameters apply to V_S = 5.0V and T_{op} = 25°C, unless otherwise stated.

Parameter	Minimum	Typical	Maximum	Units
Analog output signal (pressure only) [2]				
@ specified minimum pressure (see "pressure range")[1]		0.5		V
@ specified maximum pressure (see "pressure range")[1]		4.5		V
Full span output (FSO) [3]		4		V
without pressure (bidirectional differential)		2.5		V
Digital output signal (pressure) [4]				
@ specified minimum pressure (see "pressure range")[1]		3277		counts
@ specified maximum pressure (see "pressure range")[1]		29491		counts
Full span output (FSO) [3]		26214		counts
without pressure (bidirectional differential)		16384		counts
Digital output signal (temperature) [5]				
@ minimum temperature T = -25°C		3277		counts
@ maximum temperature T = 85°C		29491		counts
Accuracy [6] (pressure measurement) @ T = 25°C				
Ultra low pressure sensors (0.075, 0.15 PSI)			±1.5	%FSO
Low pressure sensors (0.3, 0.8, 1.5 PSI)			±1.0	%FSO
Standard pressure sensors			±0.5	%FSO
Overall error [7] (pressure meas.) @ T = -25...85°C				
Ultra low pressure sensors (0.075, 0.15 PSI)			±2.0	%FSO
Low pressure sensors (0.3, 0.8, 1.5 PSI)			±1.5	%FSO
Standard pressure sensors			±1.0	%FSO
Total error for temperature measurement				
All types of AMS 5812 T = -25...85°C			±3.0	%FSO
Long term stability			<0.5	%FSO/a
Ratiometricity error (@V_S = 4.75 …5.25V)			500	ppm

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Parameter	Minimum	Typical	Maximum	Units
Resolution A/D converter		14		bits
Resolution D/A converter		11		bits
Resolution analog output signal		0.05		%FSO
Resolution digital output signals	12			bit
Reaction time (10%...90% rise time)		1	2	ms
Supply voltage (V_S)	4.75	5	5.25	V
Current consumption			5	mA
Load resistance at output RL	2k			Ω
Capacitive load			50	nF
I2C-interface				
Input High Level	90		100	% V_S
Input Low Level	0		10	% V_S
Output Low Level	0		10	% V_S
Load capacitance @ SDA			400	pF
Clock frequency SCL			400	kHz
Pull-up resistor	500			Ω
Pressure changes	10^6			
Compensated temperature range	-25		85	°C
Weight		3		g
Media compatibility	See "Specification notes" [8] [9]			

Table 3: **Specifications**

SPECIFICATION NOTES

1) See *Table 1*
2) The analog output signal (pressure measurement only) is ratiometric to the supply voltage.
3) The Full Span Output (FSO) is the algebraic difference between the output signal at the specified minimum pressure and the output signal at the specified maximum pressure (see "Pressure range").
4) The digital output pressure signal is <u>not</u> ratiometric to the supply voltage.
5) The digital output temperature signal is <u>not</u> ratiometric to the supply voltage. The temperature value is measured at the piezoresistive measuring cell and is the sensor temperature (including self heating).
6) Accuracy is defined as the maximum deviation of the measurement value from the ideal characteristic curve at room temperature (RT) in %FSO including the adjustment error (offset and span), nonlinearity, pressure hysteresis and repeatability. Nonlinearity is the measured deviation from the best fit straight line (BFSL) across the entire pressure range. Pressure hysteresis is the maximum deviation of the output value at any pressure within the specified range when this pressure is cycled to and from the minimum or maximum rated pressure. Repeatability is the maximum deviation of the output value at any pressure within the specified range after 10 pressure cycles.
7) The overall error is defined as the maximum deviation of the measurement value from the ideal characteristic curve in %FSO across the entire temperature range (-25 … 85°C).
8) Media compatibility of pressure port 1 (for a description of port 1, see *Figure 5*): clean, dry gases, non-corrosive to silicon, RTV silicone rubber, gold (alkaline or acidic liquids can destroy the sensor).
9) Media compatibility of pressure port 2 (for a description of port 2, see *Figure 5*): fluids and gases non-corrosive to silicon, Pyrex, RTV silicone rubber.

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FUNCTIONAL DESCRIPTION

The pressure sensors in the AMS 5812 series combine a piezoresistive silicon sensing element with a signal conditioning mixed-signal CMOS ASIC with full digital correction on a ceramic substrate.

The functional principle of the AMS 5812 sensors is explained in *Figure 1*.
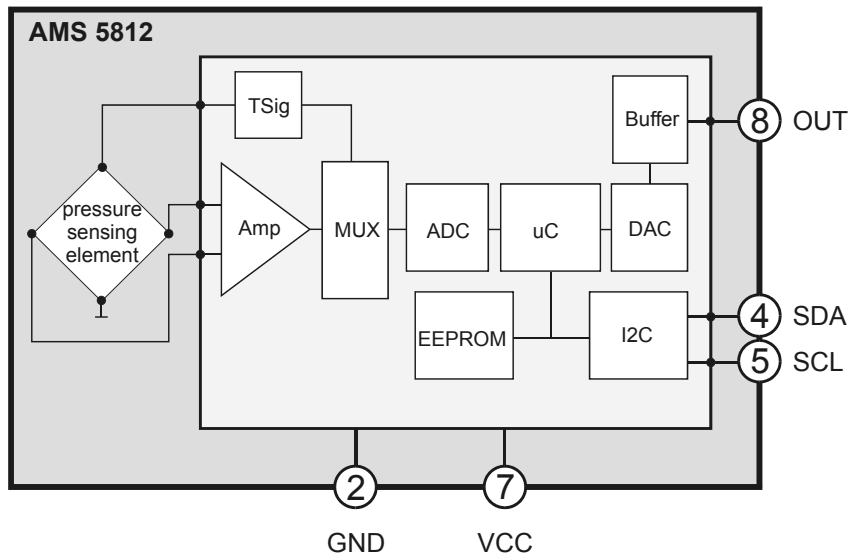

Figure 1: **Functional principle**

The physical pressure is measured at AMS 5812's piezoresistive pressure sensing element where the pressure is converted into a differential voltage signal which is almost proportional to the pressure. This differential voltage signal is corrected and conditioned by the ASIC in multiple steps.

Firstly, the differential voltage signal from the sensing element is pre-amplified by the amplifier and transmitted by a multiplexer to the A/D converter (ADC). The ADC converts the signal into digital values with a resolution of 14 bits. The digitized signal is corrected and calibrated in the follow-on ASIC microcontroller.

Factory precision calibration of AMS 5812 sets the sensor-specific correction coefficients and stores these in the EEPROM for each sensor. This permits sensor-specific calibration and correction (i.e. temperature compensation and linearization) of the digitized pressure signal. The temperature signal necessary for temperature compensation is also measured at the piezoresistive pressure sensing element and is transmitted by the multiplexer to the ADC, where it is digitized. The ASIC microcontroller runs a cyclic program which continuously calculates the current standardized and corrected digital pressure values. In addition, a standardized current digital temperature value is calculated. These calculated 15-bit digital values (pressure and temperature values) are written to the ASIC output registers and continuously updated (typically every 0.5 ms).

In order to use the digital signal readout for pressure and temperature, the I2C sensor interface at PIN4 (SDA) and PIN5 (SCL) must be connected to the I2C-bus. The corrected digital values for pressure and temperature at the I2C-interface are not ratiometric to the supply voltage.

To generate the analog output signal the corrected digital pressure value is converted into an analog voltage by an 11-bit D/A converter (DAC). The standardized analog output voltage (0.5…4.5V) at the sensor's PIN8 (OUT) is ratiometric to supply voltage.

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INITIAL OPERATION

The sensors are connected up electrically by mounting them on a PCB. The principle circuitry of the AMS 5812 sensor with the analog and the digital output in use is shown in *Figure 2.*

For single use of the analog output it is sufficient to connect up PIN2 (GND), PIN7 (VCC) and PIN8 (OUT).

For operation of the digital output only it is sufficient to connect up PIN2 (GND), PIN7 (VCC) and the I2C-bus lines to PIN4 (SDA) and PIN5 (SCL).

Important: Each I2C-bus communication line has to be connected up to the positive supply voltage VCC (or +5V) using pull-up resistors (4.7 kΩ is recommended). The additional serial resistors are optional (330 Ω is recommended).
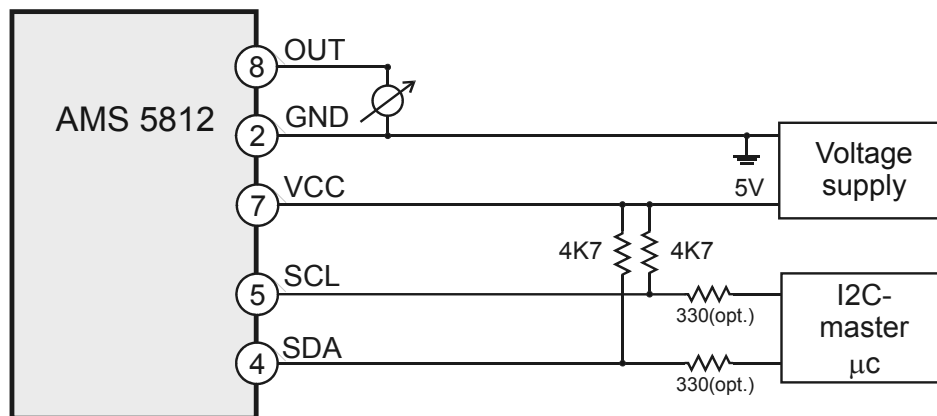
Figure 2: **Principle electric circuitry**

The sensor pressure connection is made using the two metal pressure ports (hose connectors) on the sensor. Depending on the type of sensor and measuring pressure one or two of the pressure ports are connected up to the measuring media / volume. For the pressures at port 1 and port 2 (see *Figure 5*) the following requirements have to be fulfilled (according to the definition p_1 = pressure at port 1 and p_2 = pressure at port 2):

Differential / relative pressure sensors: $p_1 > p_2$

Bidirectional differential sensors: $p_1 > p_2$ or $p_1 < p_2$ possible.

Absolute pressure sensors, barometric sensors: p_1 = measuring pressure.

The guidelines governing media compatibility must be taken into account here (see "Specification notes", 8 and 9).

Notes:
1. For pressure connections up to 30 PSI Analog Microelectronics recommends a silicone tubing (inner diameter Ø=2mm, outer diameter Ø=6mm).
2. ESD precautions are necessary, it is essential to ground machines and personnel properly during assembly and handling of the device

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I2C-INTERFACE

AMS 5812 pressure sensors have a digital output (I2C-interface). When connected to a bidirectional I2C-bus, the current corrected digital pressure and temperature values can be read out from the output register of the AMS 5812 via the I2C-interface.

Communication via the I2C-bus[1] follows a simple master-slave principle. Data transfer is always initialized by a master (such as a microcontroller, for example), which sends a data request to the sensor; the AMS 5812 sensor – which always operates as slave – then answers.

The I2C-bus requires just two bus lines: a serial data line (SDA) and a serial clock line (SCL). SDA and SCL are bidirectional lines which are connected to the positive supply voltage via pull-up resistors (see *Figure 2*).

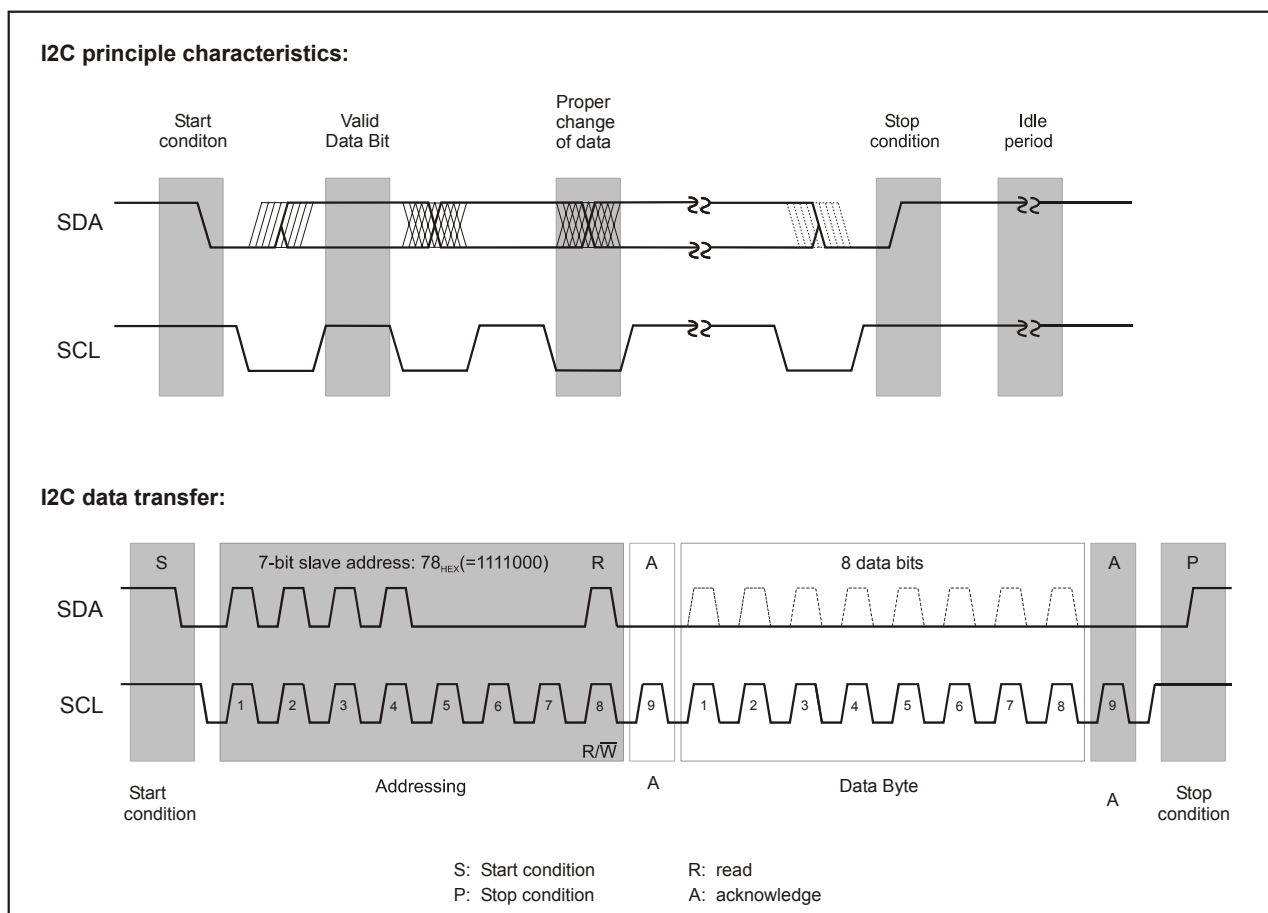I2C communication adheres to a standard I2C communication protocol (given in *Figure 3*).

Figure 3: **Standard I2C protocol**

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[1] The I2C-bus is a simple, 8-bit-oriented bus which enables communication between different I2C devices. Each device connected to the bus is software addressable using a unique address.

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The I2C communication phases are as follows:

Idle period (bus is free)

When the bus is free, both I2C-bus lines (SDA and SCL) are pulled up to supply voltage level ("high").

Start S (start condition)

Prior to any data transfer on the bus a start condition must be generated. The start condition is always sent by the I2C-master. The start condition is defined as a transition from level "high" to "low" on the SDA line while the level on the SCL line is "high". The digital data readout from the AMS 5812 output register is always initiated by a start condition.

Stop P (stop condition)

The stop condition is always generated by the I2C-master after a data transfer has been completed. The stop condition is defined as a transition from level "low" to "high" on the SDA line while the level on SCL line is "high". The digital data readout from the AMS 5812 output register is always terminated by a stop condition.

Valid data

Data is transmitted in bytes (8 bits), starting with the most significant bit (MSB). One data bit is transmitted with each clock pulse. The transmitted bits are only valid when, following a start condition, the level on the SDA line is constant for as long as the level on SCL line is "high". Changes to the SDA level must be made while the level on SCL line is "low".

Acknowledge A

After a byte has been transmitted the respective receiver (master or slave) has to send an acknowledge (additional acknowledge bit) confirming the correct receipt of the data. To this end the master generates an extra acknowledge-related clock pulse. The receiver sends the acknowledge bit by pulling the level on SDA line down to "low" during the additional clock pulse.

Addressing / Slave address (I2C-address AMS 5812)

After the start condition the master sends an addressing byte (the first byte after the start condition) which determines which slave is selected. The addressing byte contains the individual 7-bit slave address of the selected slave (AMS 5812) and a data direction bit (R/$\overline{W}$). A "0" for the R/$\overline{W}$ bit indicates a transmission from master to slave (W: write; the master wishes to transmit data to the selected slave), a "1" a data request (R: read; the master requests data from the slave).

The pressure sensors in the AMS 5812 series have a standard, factory-programmed 7-bit slave address of 0x78Hex (1111000b).

If more than one AMS 5812 should be connected to the same I2C-bus, each pressure sensor requires an individual slave address. On request each AMS 5812 can be ordered with a second individual 7-bit slave address programmed at the factory; 7-bit addressing allows 128 different addresses. With the relevant USB starter kit the customer can also do the programming of the second individual slave address himself. AMS 5812 pressure sensors programmed in this way will then answer to both addresses.

DATA READOUT VIA THE I2C-INTERFACE

The (corrected) 15-bit digital values for pressure and temperature are read out from the AMS 5812 output register via the AMS 5812 I2C-interface. The data readout is described in *Figure 4*.
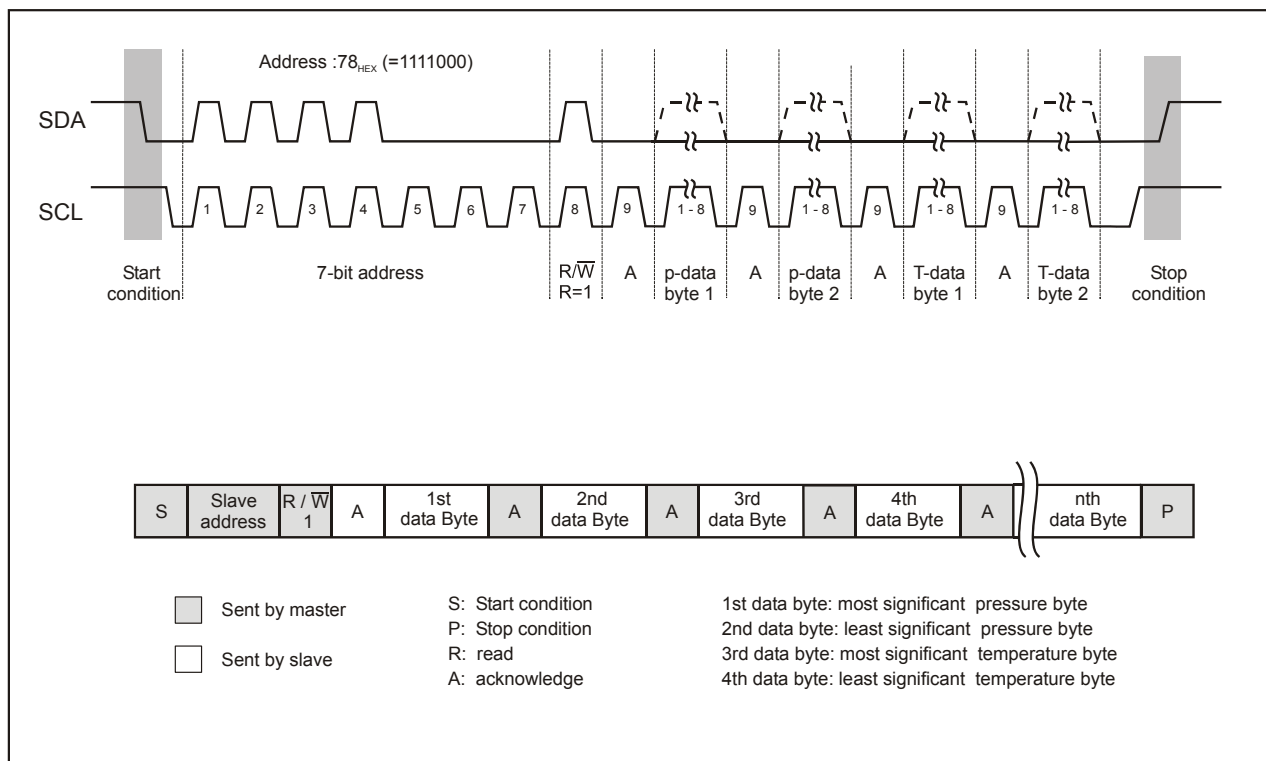

Figure 4: **Data readout of the digital pressure and temperature values**

Data transfer via the I2C-bus is always initialized by a data request from the I2C-master. For this purpose the I2C-master generates a start condition on the I2C-bus lines. Following the start condition the I2C-master then sends the addressing byte containing the 7-bit slave address of the selected pressure sensor (the AMS 5812 slave address is programmed to 0x78Hex = 1111000b at the factory) and the data direction bit $R/\overline{W} = 1$ which indicates a data request. The selected pressure sensor first answers with an acknowledge bit. The selected sensor then starts the data transfer from the output register. A total of four data bytes are transmitted from the pressure sensor to the I2C-master for the current 15-bit digital pressure value and the 15-bit digital temperature value. The two bytes for the current pressure value are first sent, followed by the two bytes for the current temperature value, always beginning with the most significant byte. On each transferred data byte the I2C-master sends an acknowledge bit confirming the correct receipt of data. If no acknowledge bit is generated by the receiving master, the pressure sensor is set to inactive. The I2C-master shuts down the data transfer by sending a stop condition instead of an acknowledge bit. If the master sends an additional acknowledge bit after the last of the four bytes, pressure sensor AMS 5812 continues to transfer the current pressure and temperature value from the output register, again starting with the most significant pressure byte.

Calculating the current pressure and temperature value from digital 15-bit words

The digital pressure and temperature values are 15-bit words[2] (without units) which have to be converted in order to generate the desired information on pressure and temperature in physical units.

The current pressure in PSI (or bar) is calculated from the digital pressure value using the following formulas:

$$p = \frac{Digoutp(p) - Digoutp_{min}}{Sensp} + p_{min} \qquad \text{with} \qquad Sensp = \frac{Digoutp_{max} - Digoutp_{min}}{p_{max} - p_{min}} \tag{1}$$

Therein p is the current pressure in PSI (or bar), p_{min} is the specified minimal pressure and p_{max} is the specified maximum pressure in PSI (or bar); depending on the specified pressure range, $Digoutp(p)$ is the current digital pressure value in counts, $Digoutp_{min}$ and $Digoutp_{max}$ are the digital pressure values at minimum and maximum specified pressure in counts and $Sensp$ is the sensitivity of the pressure sensor in counts/PSI (or counts/bar).

The current sensor temperature in °C is computed from the digital temperature value analogous to the above formulas by replacing the character "p" with a "T."

Example

At the digital output of a pressure sensor of the type AMS 5812-0015-D (0…1.5PSI differential) a current digital pressure value of

$Digoutp(p)$ = 550A$_{Hex}$ counts = 21770$_{Dec}$ counts (= 01010101 00001010 $_{bin}$)

and a digital temperature value of

$DigoutT(T)$ = 3A9A$_{Hex}$ counts = 15002$_{Dec}$ counts (= 00111010 10011010 $_{bin}$)

is read.

With p_{min} = 0 PSI, p_{max} = 1.5 PSI and $Digoutp_{min}$ = 3277, $Digoutp_{max}$ = 29491, the current pressure in PSI is calculated using Formula (1) as:

$$p = \frac{(21770 - 3277)\ \text{counts}}{26214/1.5\ \text{counts/PSI}} + 0\ \text{PSI} = 1.058\ \text{PSI}$$

With T_{min} = -25 °C, T_{max} = 85 °C and $DigoutT_{min}$ = 3277, $DigoutT_{max}$ = 29491, the current sensor temperature in °C is calculated using Formula (1) as:

$$T = \frac{(15002 - 3277)\ \text{counts}}{26214/110\ \text{counts/°C}} + (-25)\ \text{°C} = 24.2\ \text{°C}$$

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[2] Each pressure and temperature value is transmitted as a 15-bit word; the actual resolution of the internal A/D converter, however, is only 14 bits.

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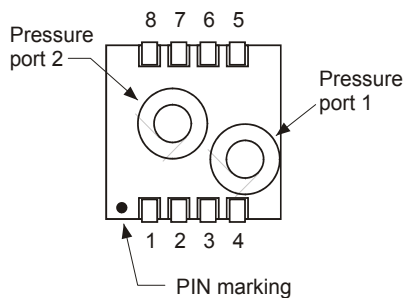## Amplified pressure sensor with analog and digital output (I²C)

DIMENSIONS AND PINOUT

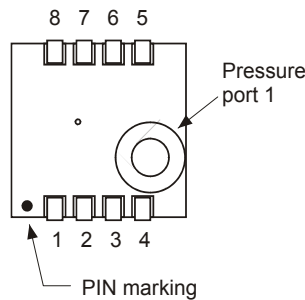AMS 5812 pressure sensors come in a dual-in-line package (DIP) for assembly on printed circuit boards.

Figure 5 below gives the pinout and dimensions of the dual-in-line package.

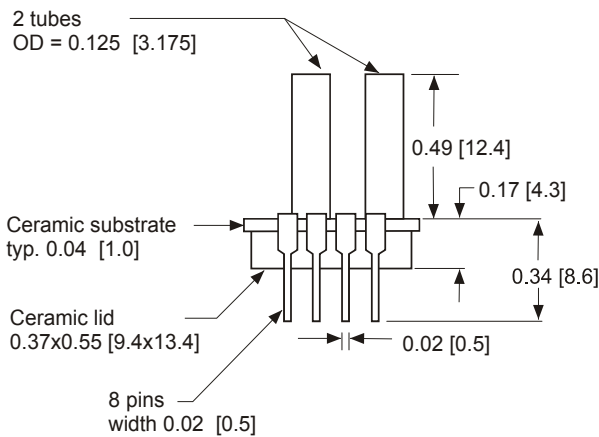**Pinout and pressure connection:**
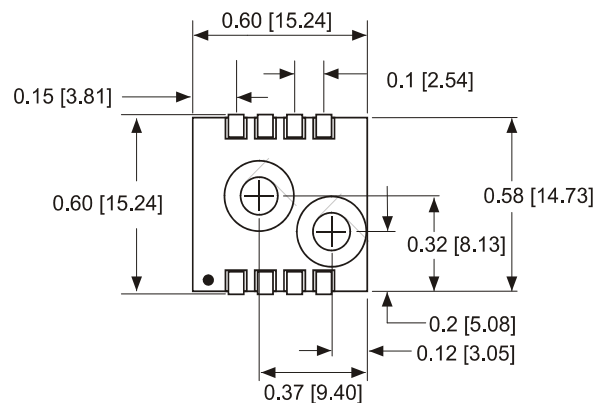
Differential types:

Absolute, barometric types:

Pin	Description
1	N.C.
2	GND
3	N.C.
4	SDA
5	SCL
6	N.C.
7	VCC
8	OUT

Package dimensions:

Side view :

Top view :

all dimensions in inch [mm]

Figure 5: Dimensions

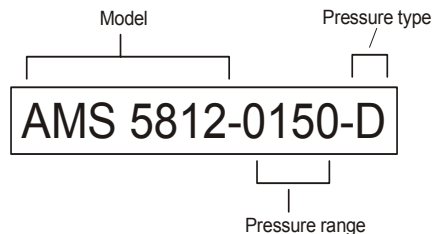All sensors in the AMS 5812 series are maintenance free during their lifetime.

Notes:

1. A package without tubes (for O-ring sealing) is also possible.
2. SMD Pins are available on request

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INFORMATION FOR ORDERING

Ordering code:

Model   Pressure type

AMS 5812-0150-D

Pressure range

Pressure range:

Pressure range code	PSI	mbar	kPa
0000	0.075	5.17	0.517
0001	0.15	10.34	1.034
0003	0.3	20.68	2.068
0008	0.8	55.16	5.516
0015	1.5	103.4	10.34
0030	3.0	206.8	20.68
0050	5.0	344.7	34.47
0150	15	1034	103.4
0300	30	2068	206.8
0600	60	4137	413.7
1000	100	6895	689.5

Table 4: Pressure ranges

Pressure type:

Pressure type code	Available pressure ranges
D differential / relative (gage)	0…0.075 PSI to 0…100 PSI
D-B bidirectional differential	-0.075/ 0.075 PSI to -100/ 100 PSI
A absolute	0…15 PSI and 0…30 PSI
B barometric (absolute)	11 … 17.5 PSI

Table 5: Pressure types

ADDITIONAL EQUIPMENT

A starter kit with software is available for AMS 5812 pressure sensors. The starter kit permits easy readout of the digital I2C output (pressure and temperature) by a standard PC with an USB-port. Furthermore, the starter kit can be used to program an individual (second) I2C slave address for the AMS 5812, which is valid in addition to the standard I2C slave address programmed at the factory (0x78Hex) and which allows the readout of multiple sensors via the I2C-bus.

Ordering code	Description
USB starter kit AMS5812	AMS5812 - starter kit (2 PCBs with software)

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