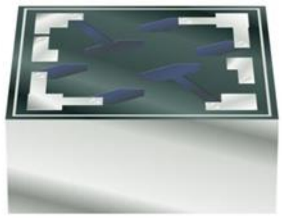
Pressure sensors

C33 series

Series/Type:	**Barometric pressure sensor die C33/1**
Ordering code:	**B58600E33xxBxxx**
Date:	2021-03-18
Version:	11

Applications

- Industrial and consumer applications
- Process control and automation
- Barometric applications



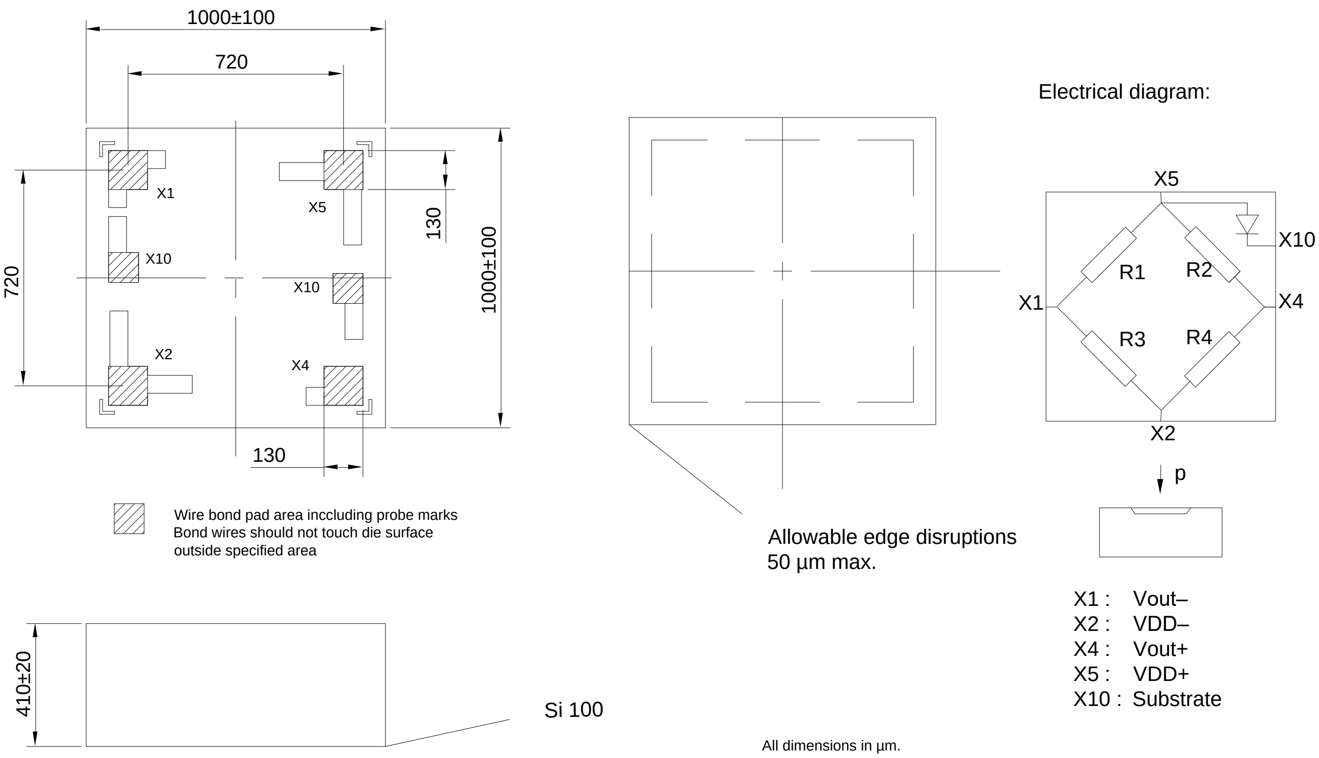
Features

- Piezoresistive MEMS technology
- Small dimensions: 1.0 × 1.0 mm
- Square diaphragm
- Measured media (front side):
  Dry non-aggressive gases.
  Unsuitable for substances,which react with silicon or aluminum.
- Wheatstone bridge with mV output,
  ratiometric to supply voltage
- Rated pressure ranges from 1 to 10 bar absolute
- Outstanding long-term stability

Delivery mode

- Tape

Dimensional drawings



Technical data

Absolute maximum ratings

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage						
Maximum supply soltage	V_{DD}	Without damage [1]			10	V
Temperature ranges						
Operating temperature range	T_a	[2]	–40		150	°C
Storage temperature range	T_{st}	[3]	–50		165	°C
		For t <2 h	–50		175	°C
Pressure ranges						
Operating pressure ranges	p_r	Absolute pressure [4]	1.2		12	bar
Over pressure	p_{ov}	Absolute pressure [5]	See next table			
Burst pressure	p_{burst}	Absolute pressure [6]	See next table			

Electrical specifications

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage / bridge resistance						
Operating supply voltage	V_{DD}	[7]	1.0	3.0	6.0	V
Total bridge resistance	R_b	@ 25 °C [8]	2.6	3.3	4.0	kΩ
Temperature coefficient of total bridge resistance	α_{Rb}	@ 25 °C [9]	2.1	2.4	2.7	10^{-3}/K
	β_{Rb}		0	5	8	10^{-6}/K^2
Output signal @ V_{DD} = 5 V						
Offset	V_o	@ 25 °C [10]	-30		30	mV
Sensitivity	S	@ 25 °C [13]	See next table			mV/bar
Temperature coefficient of offset	TCVo+	Unglued [11]	See next table			µV/V/K
	TCVo-		See next table			µV/V/K
Temperature coefficient of the sensitivity	α_S	@ 25 °C [15]	–2.5	–2.1	–1.9	10^{-3}/K
	β_S		0	5	8	10^{-6}/K^2
Pressure hysteresis	p_{Hys}	[16]	–0.1		0.1	% FS[12]
Long-term stability (Full scale normal output FSON = 100 mV)						
Temperature hysteresis of offset	THV_0	[17]	–0.3	±0.1	0.3	% FSON
Temperature cycle drift of offset	$TCDV_0$	[17]	–0.1	±0.05	0.1	% FSON
High temperature drift of offset	$HTDV_0$	[17]	–0.4	±0.1	0.4	% FSON
Long term stability of offset	$LTSV_0$	[17]	-0.35	0.15	0.35	% FSON

Operating pressures and ordering codes

Parameter @ 25 °C, V_{DD} = 5 V	Symbol	Typ.	Typ.	Typ.	Typ.	Typ.	Units
Operating pressure [4]	p_r	1.2	2.5	4	7	10	bar
Temperature coefficient of offset (unglued) [11] [min/typ/max]	TCV_0^-	-15/-5/5					µV/V/K
	TCV_0^+	-15/-5/5					µV/V/K
Nonlinearity [14] [typ/max]	L	±0.2/±0.4	±0.1/±0.2	±0.15/±0.3	±0.15/±0.3		% FS[12]
Sensitivity [13] [min/typ/max]	S	60/80/100	40/50/60		12/15/18		mV/bar
Over pressure [5] [min]	p_{ov}	3.6	7.5		21		bar
Burst pressure [6] [min]	p_{burst}	6	12.5		35		bar
Product type		AEA 1.200 C33/1	AEA 2.500 C33/1		AEA 7.000 C33/1		
Ordering code Delivery form on tape		B58600E3314B518	B58600E3344B090		B58600E3394B091		

Conversion table		mbar	bar	Pa	kPa	Psi	Torr	mWS
mbar	(hPa)	1	0.001	100	0.100	0.0145	0.750	0.0102
bar		1000	1	100000	100	14.500	750	10.200
Pa	(N/m[2])	0.010	0.00001	1	0.001	0.000145	0.00750	0.000102
kPa		10.000	0.0100	1000	1	0.145	7.50	1.02
Psi	(Lb/inch[2])	68.9	0.0689	6895	6.89	1	51.7	0.703
Torr		1.33	0.00133	133	0.133	0.0193	1	0.0136
mWS		98.100	0.0981	9807	9.81	1.42	73.6	1

Symbols and Terms

1) **Maximum power supply V_{DD}**
This is the maximal allowed voltage, which may be applied to the piezoresistive bridge circuit without damage.

2) **Operating temperature range T_a**
This is the operating temperature range $T_{a,min}$ to $T_{a,max}$. Because most of the sensor parameters depend on assembling conditions like glueing, wire bonding etc, the die has to be tested over the operating temperature range by the customer fully assembled. For design verification and process control, samples, mounted in TDK Sensors standard transducer packages, are tested over the temperature range of $T_{a,min}$ to $T_{a,max}$.

3) **Storage temperature range T_{st}**
If the pressure sensor dies are stored in the temperature range $T_{st,min}$ to $T_{st,max}$ without applied voltage power supply, this will not affect the performance of the pressure sensor dies.

4) **Operating pressure range p_r**
In the operating pressure range 0 to $p_{r,max}$ the pressure sensor die output characteristic is as defined in this specification.

5) **Over pressure p_{OV}**
Pressure cycles in the pressure range 0 to p_{ov} do not affect the performance of the pressure sensor dies.

6) **Burst pressure p_{burst}**
Up to the burst pressure p_{burst} the diaphragm of the sensor die will not be destroyed mechanically.

7) **Operating power supply V_{DD}**
The pressure sensor parameters are defined for a power supply voltage of V_{DD} = 5 V. In the operating power supply voltage range $V_{DD,min}$ to $V_{DD,max}$ the ratiometric parameters $r(V_{DD})$ like sensitivity, offset voltage and the temperature coefficient of the offset voltage are defined by:

$$\mathrm{r}(\mathrm{V_{DD}}) = \mathrm{r}(5[\mathrm{V}])\frac{\mathrm{V_{DD}}}{5[\mathrm{V}]}$$

8) **Total bridge resistance R_b**
The total bridge resistance is defined between pad X5 and X2 (see the dimensional drawing in this data sheet) of the closed piezoresistive bridge circuit. The total bridge resistance is in a good approximation the output impedance of the piezoresistive bridge circuit. This parameter is tested completely on a wafer (wafer level test measurement).

9) **Temperature coefficients of resistance α_{Rb} and β_{Rb}:**
The temperature coefficients of resistance are tested for design verification on samples, mounted in TDK Sensors standard transducer package over the temperature range $T_{a,min}$ to $T_{a,max}$ with T_R = 25 °C.
The temperature coefficients of first and second order are defined with the polynomial:

$$\mathrm{R_b(T) = R_b(T = 25°C)[1 + \alpha_{Rb}(T - 25°C) + \beta_{Rb}(T - 25°C)^2]}$$

The coefficients α_{Rb} and β_{Rb} are calculated using the three measurement points of $R_b(T)$ at $T_{a,min}$, T_R and $T_{a,max}$.

10) **Offset voltage V_0**
The offset voltage V_0 is the output voltage V_{out}(p = 0 bar abs) at zero absolute pressure and for a bridge voltage power supply V_{DD} = 5 V. The limits of the offset voltage V_0 are defined during the design verification on samples, which are mounted in TDK Sensors standard transducer package by extrapolating the output characteristic to zero bar.

During the wafer level test measurement the offset voltage Vo is completely tested at ambient pressure with limits, which depend on the pressure range.

Since the offset voltage depends on several assembling conditions, this parameter has to be verified by the customer with his assembling possibilities.

11) **Temperature coefficients of offset voltage TCV_0**
The temperature coefficients of offset voltage are defined for a bridge voltage power supply V_{DD} = 5 V. These parameters strongly depend on assembly conditions like gluing, wire bonding etc.. The temperature coefficients of offset voltage are tested for design verification on samples, mounted in TDK Sensors standard transducer package over the temperature range $T_{a,min}$ to $T_{a,max}$ with T_R = 25 °C.

TCV_{0+} and TCV_{0-} are defined for the measurement temperature range by:

$$\mathrm{TCVo^+} = \frac{1}{\mathrm{V_{DD}}}\frac{\mathrm{V_o(T_{a,max}) - V_o(25°C)}}{\mathrm{T_{a,max} - 25°C}} \qquad \mathrm{TCVo^-} = \frac{1}{\mathrm{V_{DD}}}\frac{\mathrm{V_o(T_{a,min}) - V_o(25°C)}}{\mathrm{T_{a,min} - 25°C}}$$

Since the TCV_0 depends on several assembling conditions, this parameter has to be verified by the customer with his assembling possibilities.

12) **Full scale value FS**

$$FS = V_{out}(p_{r\,max}) - V_o$$

13) **Sensitivity S**

The sensitivity is defined for a bridge voltage power supply V_{DD} = 5 V. It can be determined by the formula:

$$S = \frac{V_{out}(p_{r\,max}) - V_o}{p_{r\,max}}$$

This parameter is tested for process control on samples, mounted in TDK Sensors standard transducer package.

14) **Nonlinearity L**

This parameter may be influenced by assembly.
The nonlinearity is measured using the endpoint method. Assuming a characteristic, this can be approximated by a polynomial of second order, where the maximum is at $p_x = p_{rmax}/2$. The nonlinearity is defined at $p_x = p_{rmax}/2$, using the equation:

$$L = \frac{V_{out}(p_x) - V_o}{V_{out}(p_{r\,max}) - V_o} - \frac{p_x}{p_{r\,max}}$$

This parameter is tested for process control on samples, mounted in TDK Sensors standard transducer package.

15) **Temperature coefficient of sensitivity α_S and β_S:**

These parameters may be influenced by assembly.
The temperature coefficients of sensitivity are tested for design verification on samples, mounted in TDK Sensors standard transducer package over the temperature range $T_{a,min}$ to $T_{a,max}$ with T_R = 25 °C.
The temperature coefficients of first and second order are defined with the polynomial:

$$S(T) = S(T = 25°C)[1 + \alpha_S(T - 25°C) + \beta_S(T - 25°C)^2]$$

The coefficients α_S and β_S are calculated using the three measurement points of S(T) at $T_{a,min}$, T_R and $T_{a,max}$.

16) **Pressure hysteresis p_{Hys}**

The pressure hysteresis is the difference between output voltages at constant pressure and constant temperature while applying a pressure cycle with pressure steps of $p_{r,\,min}$, p_1, p_2, p_3, $p_{r,max}$, p_3, p_2, p_1, $p_{r,\,min}$:

$$p_{Hys} = \frac{V_{out,2}(p_k) - V_{out,1}(p_k)}{FS}$$

With k = min, 1, 2, 3, max. The pressure steps are: $p_{rmin} = 0$, $p_1 = 0.25 \cdot p_{r,max}$, $p_2 = 0.5 \cdot p_{r,max}$, $p_3 = 0.75 \cdot p_{r,\,max}$, $p_{r,max}$.
This parameter is tested for design verification on samples, mounted in TDK Sensors standard transducer package. Since the p_{Hys} depends on several assembling conditions, this parameter has to be verified by the customer with his assembling possibilities.

17) **Reliability data**

For long-term stability of offset voltage $LTSV_0$ please refer to the defined TDK Sensors standard AS100001 in chapter “Long term stability parameter” on the internet. Since the $LTSV_0$ depends on several assembling conditions, this parameter has to be verified by the customer with his assembling possibilities.

Cautions and warnings

Storage (general)

All pressure sensors should be stored in their original packaging. They should not be placed in harmful environments such as corrosive gases, or be exposed to heat or direct sunlight, which may cause deformations. Similar effects may result from extreme storage temperatures and climatic conditions. Avoid storing the sensor dies in an environment where condensation may form, or in a location exposed to corrosive gases, which will adversely affect their performance. Plastic materials should not be used for wrapping/packing when storing or transporting these dies, as they may become charged. Pressure sensor dies should be used soon after opening their seal and packaging.

Storage conditions

Used materials for storage should be ESD protective according JESD625, non-outgassing, and chemically stable.
Furthermore the following storage conditions should be preserved:

1. Storage in cabinets (if shipment package is opened):
   a. Atmosphere: inert gas, dry air or dry nitrogen
   b. Temperature range (in cabinet): 20±3 °C
   c. Relative humidity range (in cabinet): < 40 %
   d. Particle count (in cabinet): Class 6 per ISO 14644:1999 (equivalent FED STD 209E Class 1000)
   e. Shelf life under these conditions: 24 months for deliveries in trays
   f. Shelf life under these conditions: 12 months for deliveries on tape
2. Storage in containers (if shipment package is sealed):
   a. Sealed as delivered or backfilled with inert gas, dry air or dry nitrogen and re-sealed
   b. Temperature range: 20±3 °C
   c. Relative humidity range: < 50 %
   d. Particle count (during backfill): Class 6 per ISO 14644:1999 (equivalent FED STD 209E Class 1000)
   e. Shelf life under these conditions: 12 months for deliveries in trays
   f. Shelf life under these conditions: 6 months for deliveries on tape

After delivery, the product can be stored under specific conditions for the specified shelf life.

This listing does not claim to be complete, but merely reflects the experience of TDK Electronics AG

Operation (general)

Media compatibility with the pressure sensors must be ensured to prevent their failure. The use of other media can cause damage and malfunction. Never use pressure sensors in atmospheres containing explosive liquids or gases.

Ensure pressure equalization to the environment, if gauge pressure sensors are used. Avoid operating the pressure sensors in an environment where condensation may form, or in a location exposed to corrosive gases. These environments adversely affect their performance.

If the operating pressure is above the rated overpressure range, it may change the output characteristics. This may also happen with pressure sensor dies if an incorrect mounting method is used. Be sure that the applicable pressure does not exceed the overpressure, as it may damage the pressure sensor.

Do not exceed the maximum rated supply voltage nor the rated storage temperature range, as it may damage the pressure sensor.

Temperature variations in both the ambient conditions and the media (liquid or gas) can affect the accuracy of the output signal from the pressure sensors. Be sure to check the operating temperature range and thermal error specification of the pressure sensors to determine their suitability for the application.

Connections must be wired in accordance with the terminal assignment specified in the data sheets. Care should be taken as reversed pin connections can damage the pressure transmitters or degrade their performance. Contact between the pressure sensor terminals and metals or other materials may cause errors in the output characteristics.

Design notes (dies)

This specification describes the mechanical, electrical and physical requirements of a piezoresistive sensor die for measuring pressure. The specified parameters are valid for the pressure sensor die with pressure application either to the front or back side of the diaphragm as described in the data sheet. Pressure application to the other side may result in differing data. Most of the parameters are influenced by assembly conditions. Hence, these parameters and the reliability have to be specified for each specific application and tested over its temperature range by the customer.

Handling/Mounting (dies)

Pressure sensor dies should be handled appropriately and not be touched with bare hands. They should only be picked up manually by the sides using tweezers. Their top surface should never be touched with tweezers. Latex gloves should not be used for handling them, as this will inhibit the curing of the adhesive used to bond the die to the carrier. When handling, be careful to avoid cuts caused by the sharp-edged terminals. The sensor die must not be contaminated during manufacturing processes (gluing, soldering, silk-screen process).

The package of pressure sensor dies should not to be opened until the die is mounted and should be closed after use. The sensor die must not be cleaned. The sensor die must not be damaged during the assembly process (especially scratches on the diaphragm).

Display of ordering codes for TDK Electronics products

The ordering code for one and the same product can be represented differently in data sheets, data books, other publications, on the company website, or in order-related documents such as shipping notes, order confirmations and product labels. **The varying representations of the ordering codes are due to different processes employed and do not affect the specifications of the respective products**. Detailed information can be found on the Internet under www.tdk-electronics.tdk.com/orderingcodes.

Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application.** As a rule we are either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether a product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
3. **The warnings, cautions and product-specific notes must be observed.**
4. In order to satisfy certain technical requirements, **some of the products described in this publication may contain substances subject to restrictions in certain jurisdictions (e.g. because they are classed as hazardous)**. Useful information on this will be found in our Material Data Sheets on the Internet (www.tdk-electronics.tdk.com/material). Should you have any more detailed questions, please contact our sales offices.
5. We constantly strive to improve our products. Consequently, **the products described in this publication may change from time to time**. The same is true of the corresponding product specifications. Please check therefore to what extent product descriptions and specifications contained in this publication are still applicable before or when you place an order.

   We also **reserve the right to discontinue production and delivery of products**. Consequently, we cannot guarantee that all products named in this publication will always be available. The aforementioned does not apply in the case of individual agreements deviating from the foregoing for customer-specific products.
6. Unless otherwise agreed in individual contracts, **all orders are subject to our General Terms and Conditions of Supply.**
7. **Our manufacturing sites serving the automotive business apply the IATF 16949 standard.** The IATF certifications confirm our compliance with requirements regarding the quality management system in the automotive industry. Referring to customer requirements and customer specific requirements (“CSR”) TDK always has and will continue to have the policy of respecting individual agreements. Even if IATF 16949 may appear to support the acceptance of unilateral requirements, we hereby like to emphasize that **only requirements mutually agreed upon can and will be implemented in our Quality Management System.** For clarification purposes we like to point out that obligations from IATF 16949 shall only become legally binding if individually agreed upon.

Important notes

8. The trade names EPCOS, CarXield, CeraCharge, CeraDiode, CeraLink, CeraPad, CeraPlas, CSMP, CTVS, DeltaCap, DigiSiMic, ExoCore, FilterCap, FormFit, LeaXield, MiniBlue, MiniCell, MKD, MKK, ModCap, MotorCap, PCC, PhaseCap, PhaseCube, PhaseMod, PhiCap, PowerHap, PQSine, PQvar, SIFERRIT, SIFI, SIKOREL, SilverCap, SIMDAD, SiMic, SIMID, SineFormer, SIOV, ThermoFuse, WindCap, XieldCap are **trademarks registered or pending** in Europe and in other countries. Further information will be found on the Internet at www.tdk-electronics.tdk.com/trademarks.

Release 2020-06