Absolute Pressure Sensor IC **KP110**
Programmable Temperature Compensation and Calibration
On-Chip Signal Conditioning
Low Cost Bare Die Version

Data Sheet

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Features

- Ratiometric analog output
- Programmable transfer function performed by customer
- High accuracy over a large temperature range up to ± 1.2 kPa (10 ... 85 °C)
- CMOS compatible surface micromachining
- Bare die

- Specific transfer functions programmable
- Broken wire detection

Type	Ordering Code	Minimum Order Quantity
KP110	Q62705-K432	1 Wafer

Product Description

The KP110 is a miniaturized absolute pressure sensor IC based on the capacitive principle. It is surface micromachined with a monolithic integrated signal conditioning circuit realized in the state-of-the-art 0.8 µm BiCMOS technology. As the KP110 is a high precision IC for cost critical solutions. High accuracy and high sensitivity enable the dedication in automotive applications as well as consumer products.

In the automotive field the manifold air pressure (MAP) and barometric air pressure (BAP) are important parameters to compute the air-fuel ratio provided to the engine and for controlling spark advance to optimize engine efficiency.

Pad Configuration
(top view of die)

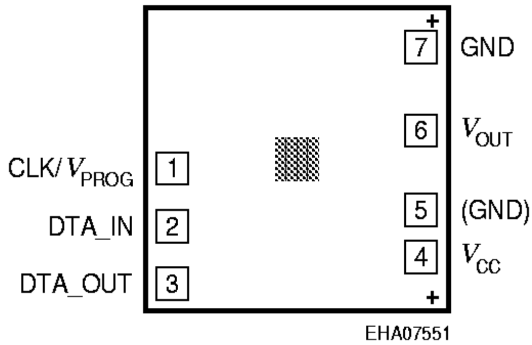

Figure 1

Pad Definitions and Functions

Pad No.	Symbol	Function
1	SERIAL_CLK/ PROG_VOLT	External clock for communication/ Programming voltage
2	DTA_IN	Serial in
3	DTA_OUT	Serial out
4	V_{CC}	Supply voltage
5	(GND)	Alternative ground pad
6	V_{OUT}	Analog pressure signal output
7	GND	0 V circuit ground potential

The pads described in the shaded rows of the table above are used during calibration only.

Die Data

- Semiconductor material: Silicon
- Surface passivation: Silicon-Nitride
- Die thickness: 675 µm
- Die dimension: 4.30 mm x 3.34 mm
- Pad metallisation: AlSiCu
- Size of the bondpads (area free of passivation): 200 x 200 µm
- Rear side metallisation of the chips: no used
- The rear side of the chip is electrical connected with GND-Pad

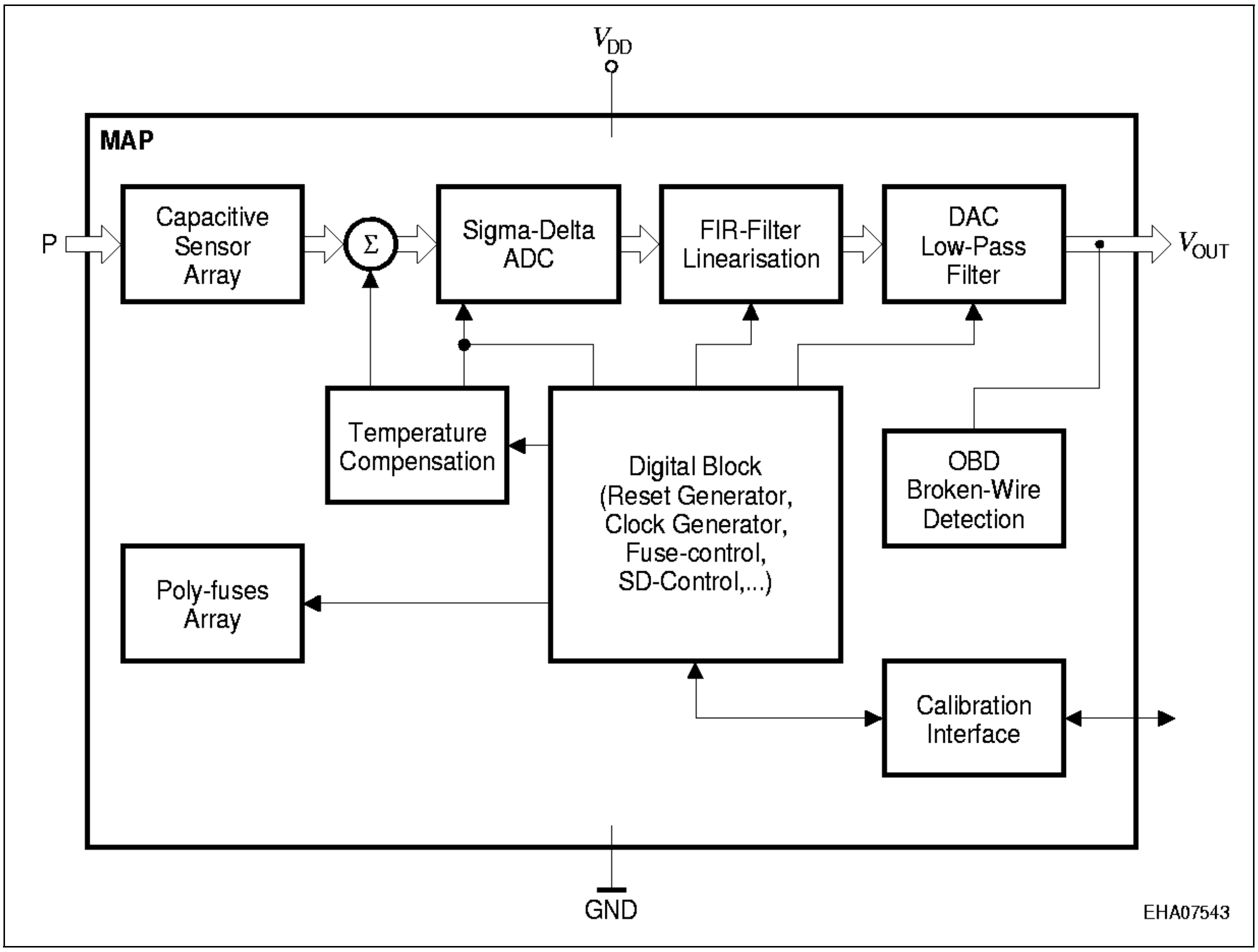

Figure 2 Functional Block Diagram

Functional Description

Digital Programming Interface

The KP110 digital interface is a 3 wire interface consisting of Data_In, Data_Out and Clock. A write cycle needs 13 Clock cycles. With the first 12 rising edges of the Clock the signal on Data_In is clocked into a shift register. The first 3 bits are interpreted as a register address, the last 9 as data bits. The address and the data word are starting with the LSB, respectively. During the falling edges of the first 11 Clock cycles the Data_In must be low. The falling edge of the 12th Clock cycle enables the write frame, at this time Data_In must be high. A 13th Clock cycle is needed for internal purposes, the signal at Data_In is ignored.

Simultaneously to the write cycle, a read cycle at Data_Out is performed. The signal at Data_Out is structured the same way as at Data_In, i.e. 3 address bits and 9 data bits. The selected register for reading depends on the content of the TESTREG register.

The first valid bit at Data_Out appears with the 13th rising edge of the Clock of the previous write frame.

The following figure shows the timing diagram:

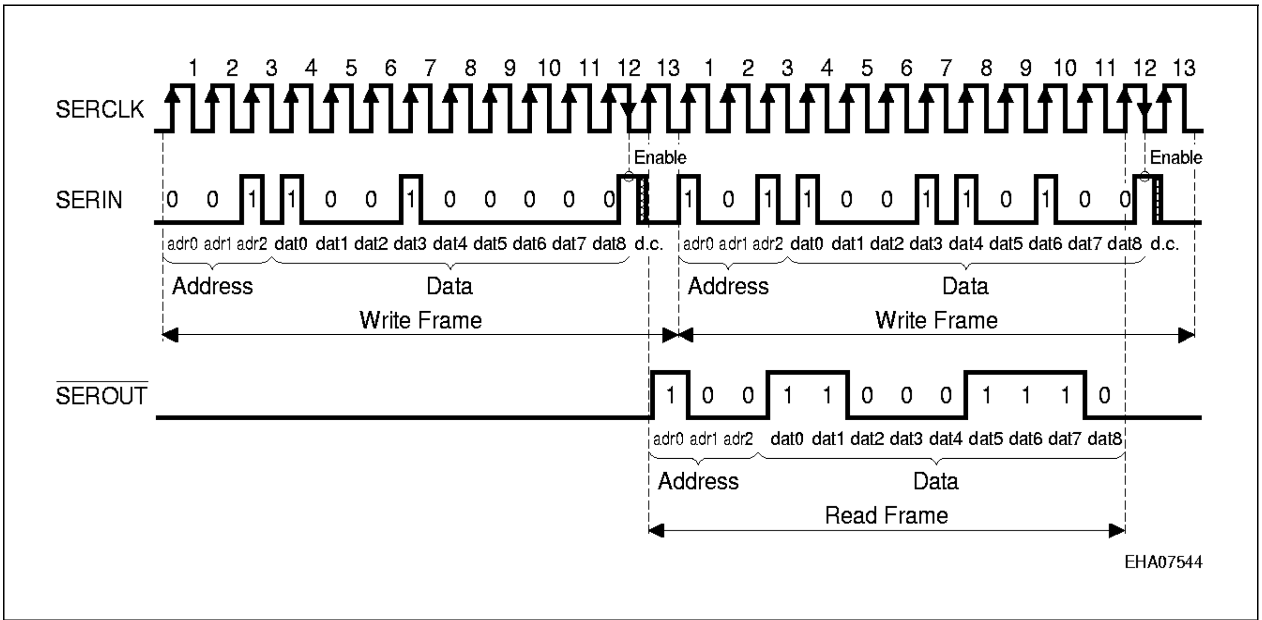

Figure 3 Timing Diagram

The table below shows the internal registers of the KP110. For the shaded registers PROM cells exist. The PROM cells are used for permanent programming of the calibration data.

In addition to the registers in the table below a 12 x 9 bit RAM table exists for the linearization and definition of the analog pressure signal. This RAM table is also overlayed by PROM cells.

To write a 9 bit word to the RAM table at first the data content must be written into the MEMDAT register. In a further write cycle the desired word is addressed by the 4 LSBs of the MEMCTL register.

Register	Function
MEMDAT	Data bit 0 to 9
MEMCTL	Selection of register of linearization table
GLOBOFF	Global offset compensation
FUSE_NR	Fuse number
TESTREG	Selection of register for read cycle
TGAIN	Temperature gain compensation (linear and square)
TOFFL	Linear temperature offset compensation
TOFFQ	Square temperature offset compensation
MODEREG	Selection of registers for programming of PROM

The shaded registers in the table are overlayed with PROM

Nonvolatile Memory

Each PROM cell consists of a thin polysilicon wire located in a small evacuated cavity. The cells are called HR-fuses. In order to write a logic "1" to a HR-cell the wire has to be cut with a current pulse. Since the current can reach up to 100 mA only a single HR-fuse can be programmed at a time.

The desired bit within a HR-fuse register is addressed by a register called FUSE_NR. In case of the linearization table the desired PROM register itself is addressed by the MEMCTL-register. In order to program the GLOBOFF, TGAIN, TOFFL and TOFFQ register the MODREG-register is used for addressing.

After the correct addressing of PROM register and bit a fuse pulse has to be applied to pad 1. The requirements for the pulse voltage, length and slew rate are given in the electrical characteristics.

The exact sequences for RAM/PROM reading/writing are available on request.

Calibration

The GLOBOFF register is needed to adjust the sensor cell to the internal A/D converter range. The TGAIN, TOFFL and TOFFQ registers are used for the temperature compensation. These registers together with the linearization table have to be programmed to achieve the full sensor performance.

For a proper calibration of the compensation registers and the linearization table it is proposed to measure the sensor at a minimum of two different temperatures (e.g. 25 °C, 100 °C) and 3 pressures, depending on the desired pressure range. To set up an appropriate calibration sequence support of the IFX sensor application group is available.

Maximum Ratings

Parameter	Symbol	Limit Values		Unit
		min.	max.	
Supply voltage	V_{CC}	– 0.3	6.5	V
Supply voltage[1)]	V_{CC}	– 6.5[2)]	16.5	V
Supply current	I_{CC}		10	mA
Ambient temperature	T_{MAX}	– 40	140	°C
Storage temperature	T_S	– 60	150	°C
Burst pressure	p_{BURST}	400		kPa
Voltage at pad DTA_IN	V_{DTA_IN}	– 0.2	3.2	V
Voltage at pad SERIAL_CLK/ PROG_VOLT during clock mode	V_{SERIAL_CLK}	– 0.2	3.2	V
Voltage at pad SERIAL_CLK/ PROG_VOLT during fuse mode	V_{PROG}	– 0.2	12	V
"H" output peak current at pad DTA_OUT	I_{OHP}		2	mA
"L" output peak current at pad DTA_OUT	I_{OLP}	– 2		mA

1) 1h@70 °C
2) Reverse polarity; I_{CC} < 300 mA

Note: Stresse above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ESD Protection

Human Body Model (HBM) tests according to:
Standard EIA/JESD22-A114-B HBM (covers MIL STD 883D)

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
ESD-Protection	V_{ESD}			kV	R = 1.5 kΩ,
Pins V_{CC}, GND, V_{OUT}		–	± 2		C = 100 pF
Calibration Pins		–	± 1		

Operating Range

V_{CC} = 5.0 V, GND = 0 V, T_A = -40 °C to +140 °C, unless otherwise specified

Parameter	Symbol	Limit Values		Unit
		min.	max.	
Supply voltage[1]	V_{CC}	4.5	5.5	V
Output current (pad 6) Sink[2]	I_{OUT}	0.25		mA
Source[2]		0.25		mA
Operating temperature	T_A	– 40	140	°C
Minimum rated pressure	$p_{N, MIN}$	10	50	kPa
Maximum rated pressure	$p_{N, MAX}$	102	120	kPa
Pressure span	P_{SPAN}	70	105	kPa
Lifetime	t_{LT}	15		year

1) The output of the sensor is ratiometric to the supply voltage V_{CC} within its specified range of 4.50 to 5.50 V.
2) Sink: Current into device. Source: Current driven by device

Electrical Characteristics

V_{CC} = 5.0 V, GND = 0 V, T_A = -40 °C to +140 °C, unless otherwise specified

Parameter	Symbol	Limit Values			Unit
		min.	typ.	max.	
Output voltage at min. rated pressure[1]	$V_{OUT, MIN}$	0.25		0.5	V
Output voltage at max. rated pressure[1]	$V_{OUT, MAX}$	4.50		4.85	V
Overall accuracy	A_{CC}	see below			kPa
Ratiometricity[2]	Rat	-25		25	mV
Response time[3]	t_R			5	ms

Electrical Characteristics (cont'd)
V_{CC} = 5.0 V, GND = 0 V, T_A = -40 °C to +140 °C, unless otherwise specified

Parameter	Symbol	Limit Values			Unit
		min.	typ.	max.	
Output ripple @ f > 1 kHz @ f < 1 kHz			10 5	15 7.5	mVpp mVpp
Stabilization time[4)]	t_S			20	ms
Power up time	t_{UP}			5	ms

1) The output of the sensor is ratiometric to the supply voltage V_{CC} within its specified range of 4.50 to 5.50 V.

2) Definition:

$$\text{Rat} = V_{OUT}(@V_{CC}) - V_{OUT}(@5\text{ V})\frac{V_{CC}}{5\text{V}}$$

for V_{OUT} in the range of $0.1 \times V_{DD}$ to $0.9 \times V_{CC}$
and V_{CC} in the range of 4.50 V to 5.50 V
Ratiometric signal error is not included in the overall accuracy!

3) Response time is defined as the time for the incremental change in the output to go from 10% to 90% of its final value when subjected to a specified step change in pressure.

4) Stabilization time is defined as the time required for the product to meet the specified output voltage after the pressure has been stabilized.

Input Pad SERIAL_CLK / PROG_VOLT

Input voltage (fuse mode)	V_{PROGIN}	–	9	–	V
Input capacitance	C_{SERIAL_CLK}	–	–	160	pF
Input current (clock mode)	I_{CKLIN}	– 5	–	360	µA
Input current (fuse mode) for 10 ms	I_{VPROG}	10	–	100	mA
"H" Input voltage (clock mode)	$V_{HSERIAL\_CLK}$	2.2	–	–	V
"L" Input voltage (clock mode)	$V_{LSERIAL\_CLK}$	–	–	0.5	V
Input hysteresis	$V_{CINHYST}$	–	480	–	mV

Input Pad DTA_IN

Input capacitance	C_{DTA_IN}	–	2.5	–	pF
Input current	I_{DTA_IN}	–	–	360	µA
"H" Input voltage	V_{HDTA_IN}	2.2	–	3.2	V
"L" Input voltage	V_{LDTA_IN}	–	–	0.5	V
Input hysteresis	$V_{SINHYST}$	–	480	–	mV

Electrical Characteristics (cont'd)

V_{CC} = 5.0 V, GND = 0 V, T_A = -40 °C to +140 °C, unless otherwise specified

Parameter	Symbol	Limit Values			Unit
		min.	typ.	max.	
Output Pad DTA_OUT					
"H" output voltage (I_{OH} = 1 mA)	V_{OH}	2.4	–	–	V
"L" output voltage (I_{OL} = -1 mA)	V_{OL}	–	–	0.3	V
Timing and Tolerances					
Clock frequency SERIAL_CLK	f_{CLK}	1	–	250	kHz
CLKS "H" pulse width	t_{WH}	2	–	–	µs
CLKS "L" pulse width	t_{WL}	2	–	–	µs
DTA_IN setup time (At Pad DTA_IN)	t_{ISU}	500	–	–	ns
DTA_IN hold time (At Pad DTA_IN)	t_{ICH}	500	–	–	ns
DTA_OUT output delay time (At Pad DTA_OUT)	t_{OD}	0	–	200	ns
ENABLE setup time (At Pad DTA_IN)	t_{ENS}	500	–	–	ns
ENABLE hold time (At Pad DTA_IN)	t_{ENH}	500	–	–	ns
PROG_VOLT setup time (At Pad SERIAL_CLK)	t_{VPD}	1	–	–	µs
PROG_VOLT hold time (At Pad SERIAL_CLK)	t_{VPH}	10	–	–	ms
PROG_VOLT slew rate	SR	100	–	–	V/µs

Transfer Function

The sensor can be calibrated with a linear transfer characteristic between the applied pressure and the output signal:

$V_{OUT} = V_{CC} \times (\mathbf{a} \times p + \mathbf{b})$

The output is ratiometric. The gain **a** and the offset **b** can be calibrated. A feasible transfer function for the KP110 is for example:

$V_{OUT} = 5.000\ V \times (0.0106 \times p - 0.32666)$

With the parameters a and b the following calibration is adjusted:

$p_{N,\ MIN}$ = 40 kPa $\rightarrow V_{OUT}$ = 0.5 V and

$p_{N,\ MAX}$ = 115 kPa $\rightarrow V_{OUT}$ = 4.5 V (@V_{CC} = 5 V)

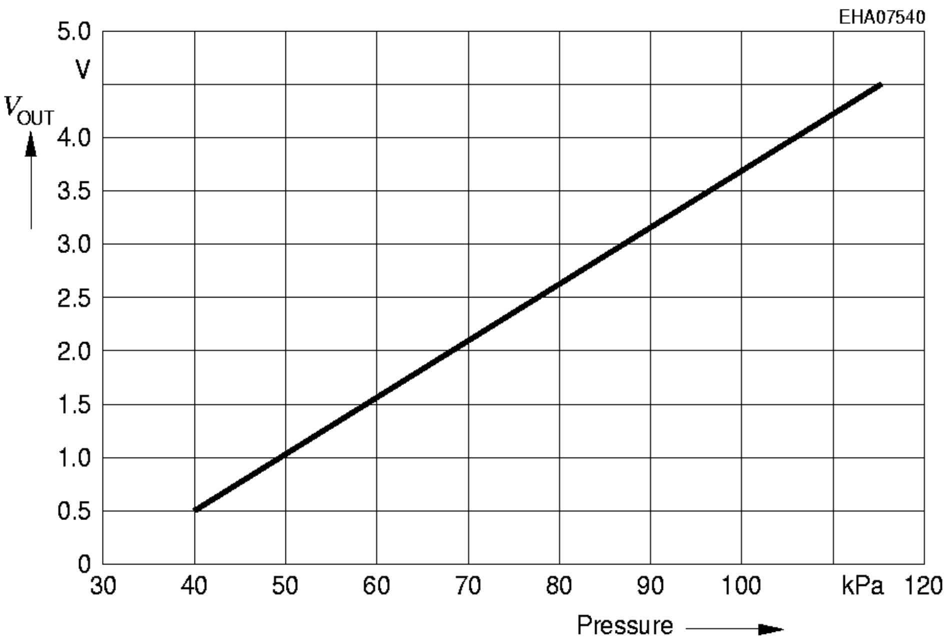

Figure 4 Possible Transfer Function of the KP110

The output circuit has a low pass filter (min. 1st .Order) with a cut off frequency greater than 500 Hz. The output circuit is protected against short circuit to V_{DD} and GND.

Accuracy

Accuracy is the deviation in actual output from nominal output over the entire pressure and temperature range according to figure below due to all sources of error including the following:

- Pressure:

Output deviation from target transfer function over the specified pressure range.

- Temperature:

Output deviation over the temperature range.

- Aging during operating time

The error band is determined by a continuous line through four relevant break points:

Break Point (°C)	Typical Accuracy (kPa)
– 40	± 2.4
10	± 1.2
85	± 1.2
140	± 2.4

Note: The gained output signal accuracy depends largely on the quality of the mounting and calibration process accomplished by the customer!

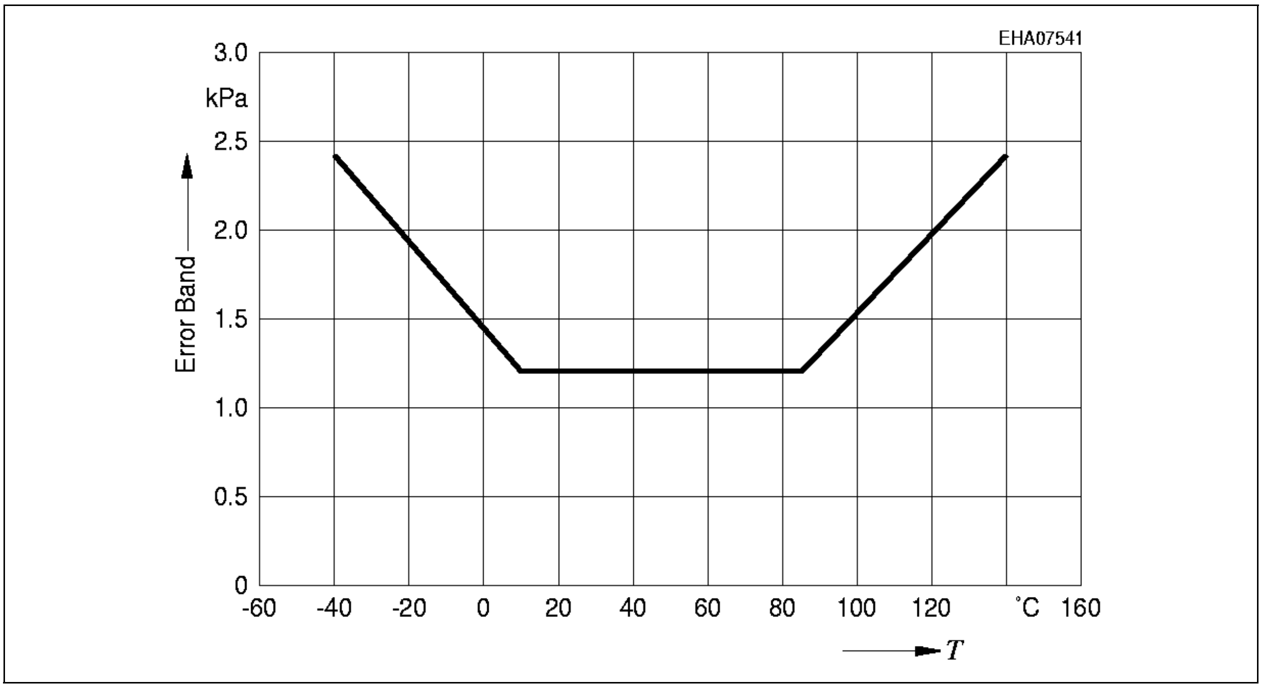

Figure 5 Overall Accuracy over Temperature

Application Circuit

It is recommended, that the circuit of the pressure sensor IC is protected against overload voltage and electro magnetic influences (like shown in **Figure 6**).

The output circuitry acts as a low pass decoupling filter between the output of the sensor IC and the A/D input of the µC.

Note: Circuitries of customer specific applications may deviate from this circuitry.

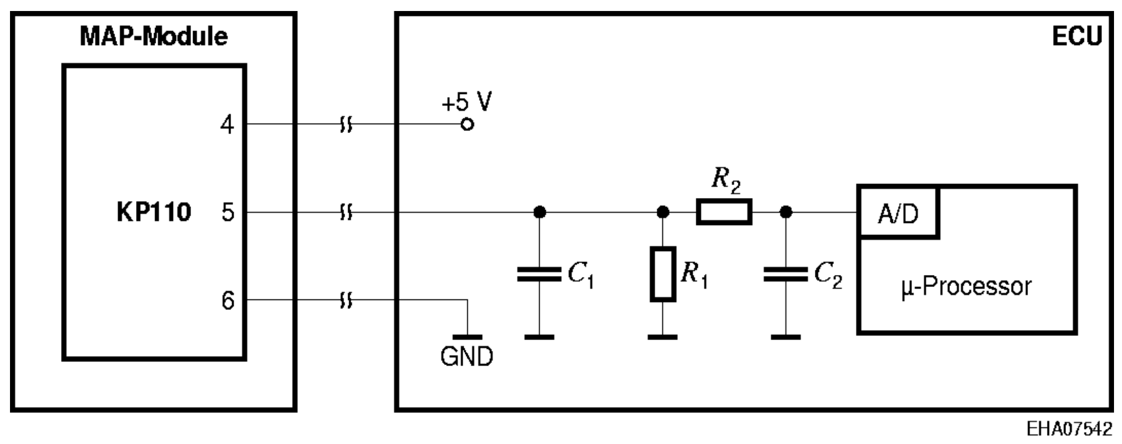

Figure 6 Typical Application Circuit of the KP110

Component	Range	Typ. value
R_1	20 kΩ < R_1 < 100 kΩ	59 kΩ
R_2	3.9 kΩ < R_1 < 100 kΩ	47 kΩ
C_1	0 < C_1 < 100 nF	0 nF
C_2	33 nF < C_2 < 100 nF	100 nF