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DIGITALLY CALIBRATED SENSOR MODULE – DDS-0010T

- Integrated pressure sensor
- Pressure range 600-1100 mbar
- 6 coefficients stored in EEPROM for pressure calculation and temperature compensation
- Low voltage/low power

DESCRIPTION

This digitally calibrated sensor module is designed for watch applications thanks to its small size. All parameters of the sensor like sensitivity, temperature coefficient of sensitivity, offset, temperature coefficient of offset, and thermometer are stored in an EEPROM. The module mounted on a cheap epoxy substrate offers a low cost solution for all large volume consumer products. A low cost barometer could be made by using a low cost 4 bits MCU with internal or external ADC together with the DDS-0010T.

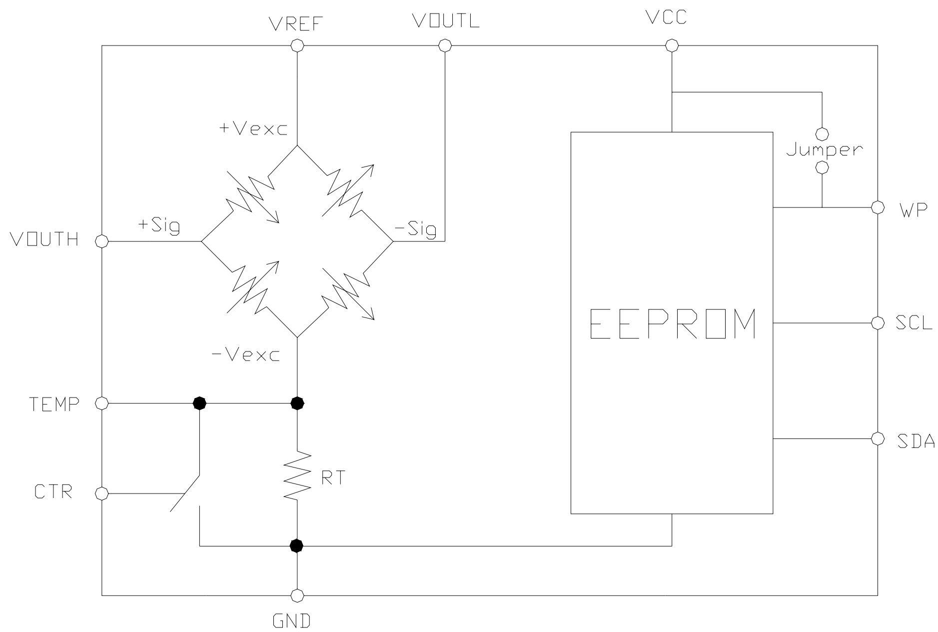
FEATURES

- Supply voltage from 2.4V to 5.5V
- Low supply current
- 10 ^{o}C to 50^{o}C
- Small size
- 12 bits calibration data in EEPROM

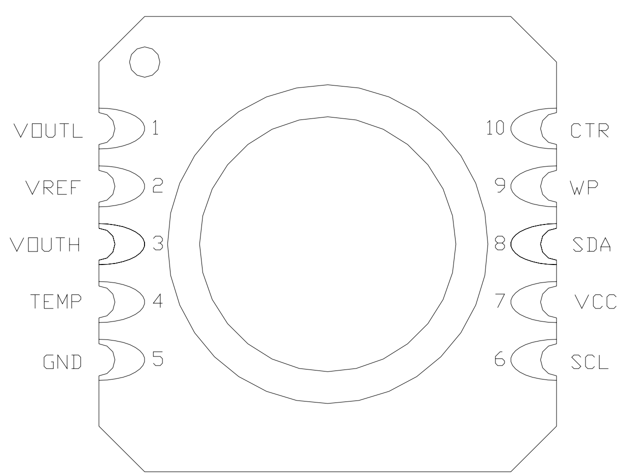
APPLICATION

- Low cost barometer
- Low cost altimeter
- Tire gauges

BLOCK DIAGRAM



PIN CONFIGURATION



PIN DESCRIPTION

Pin No.	Symbol	Description
1	VOUTL	Analog Output. Output of -Sig of sensor for pressure measurement
2	VREF	Analog Input. Referent voltage for ADC and DDS-0010T module.
3	VOUTH	Analog Output. Output of +Sig of sensor for pressure measurement
4	TEMP	Analog Output. Output of thermo resistor for temperature measurement

5	GND	Ground Terminal.
6	SCL	Digital Input. Serial clock data input.[1]
7	VCC	Power supply input for digital circuit.
8	SDA	Digital Input/Output. Serial data input/output (open drain).[1]
9	WP	Digital Input. Write Protect, read only when connected to VCC, normal when connected to GND.
10	CTR	Digital Input. Input selects the operation mode. In pressure mode, this pin must be turned high. When CTR is turned low, the module operate in temperature mode.

Note: 1. SDA and SCL are used to read the calibration data of DDS-0010T module.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Min	Max	Unit
Supply Voltage	VCC		-0.3	6	V
Overpressure	P			5	bar
Storage Temperature	T_{Stg}		-20	80	^{o}C
Operating Temperature	T_{Opt}		0	50	^{o}C

Note: Storage and operation in an environment of dry and non-corrosive gases.

ELECTRICAL CHARACTERISTICS:

T_A = 25°C and VCC = 3.0V, Vref connect to VDD

Parameter	Symbol	Test condition	Min	Typ	Max	Unit
Supply Voltage	VCC		2.4	-	5.5	V
Supply Current	$I_{BAT(NORMAL)}$	VCC = 3.0 V EEPROM OFF			1.25	mA
	$I_{BAT(READ)}$	VCC = 3.0 V READ EEPROM at 100kHz			3.5	mA
	$I_{BAT(SLEEP)}$	VCC = 3.0 V SENSOR OFF			1	uA
Sensitivity	S	T = 0°C… 50°C	15			mV/V/bar
Linearity		T = + 25°C	-0.5	-0.15	+0.5	%FS
Input High Voltage	V_{IH}	VCC=2.4..5.5V	0.7VBat		VBat+0.5	V
Input Low Voltage	V_{IL}	VCC=2.4..5.5V	-1		0.3VBat	V
Output Low Voltage	V_{OL}	VCC=2.4V I_{OL}=2.1mA			0.4	V

* not yet defined

PRESSURE OUTPUT CHARACTERISTICS

With the calibration data provided by the DDS-0010T module (stored in the EEPROM) it should be possible to obtain the following characteristics:

Parameter	Symbol	Condition	Min	Typ	Max	Unit	Note
Resolution		12bit ADC	1		1.5	mbar	(1)
Absolute Pressure Accuracy		P=600….1100mbar at 25°C	-3		+3	mbar	
Relative Pressure Accuracy		P=600….1100mbar at 25°C	-1		+1	mbar	
Maximum Error over Temperature		From 10….50°C	-2		2	mbar	

Note:
(1) by amplifying the output signal by 10 and using a 12 bits ADC.

TEMPERATURE OUTPUT CHARATERISTICS

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Resolution		10bit ADC		0.5		°C
Accuracy		Versus ref. temperature	-3		+3	°C

GENERAL THEORY OF OPERATION

The DDS-0010T consists of a one bar piezoresistive sensor and one EEPROM. This latter contains all calibration parameters that allow user to calculate the pressure with temperature compensation. An external temperature sensor is necessary. The calibration data stored in EEPROM is formatted as 12 bits stream. The EEPROM of DDS-0010T is HT24LC02 (enclosing datasheet).

Factory calibration

The calibration of the module DDS-0010 is using 2 pressure points and 2 temperature points.
The DDS-0010 carries 12 bytes of EEPROM memory, which is subdivided in six 12bit words that store the compensation information in the form of six coefficients.
Values stored in EEPROM type 24LC02, which are measured at VREF=VCC=3VDC at room temperature 25°C unless otherwise specified.

Address (Hex)	Parameters	Symbol	Data size
00-01	Sensitivity	K1	12 bits
02-03	Temperature Coefficient of Sensitivity	K2	12 bits
04-05	Offset(1)	K3	12 bits
06-07	Temperature Coefficient of Offset	K4	12 bits
08-09	Temperature output voltage at 20°C	K5	12 bits
0A-0B	Temperature coefficient of bridge resistance	K6	12 bits

(1): Measured at 600mbar and 20°C
Alls parameters are a 12-bit word with the most significant bit is sign-bit (0: positive; 1: negative)

For a temperature measurement:

Read the calibration data:

K5: Temperature output voltage at 20°C [mV]

K6: Temperature coefficient of bridge resistance – TCR [mV/100°C]

in the EEPROM of the DDS-0010 module.

Assume that Vt is a temperature output voltage of the module, we have temperature is:

$$T = 100 * (\frac{Vt - K5 * 2^{-1}}{K6 * 2^{-3}} + 0.2) \quad [^0C]$$

For a pressure measurement:

Read the calibration data:

K1: Sensitivity at To [mV/bar]

K2: Temperature Coefficient of Sensitivity – TCS [mV/bar/100°C]

K3: Sensor Offset at To [mV]

K4: Temperature Coefficient of Offset – TCO [mV/100°C] in the EEPROM of the DDS-0010T module.

Vo is sensor output voltage at temperature T [mV]

Assume that the room temperature T (^{0}C) is known.

The sensitivity at temperature T is:

$$S = 2^{-4} * (K2 * 2^{-2} * (T/100 - 0.2) + K1) \quad \text{[mV/bar]}$$

The pressure offset at temperature T is:

$$Off = 2^{-5} * (K4 * 2^{-2} * (T/100 - 0.2) + K3) \quad \text{[mV]}$$

The temperature compensated pressure then becomes:

$$P = \frac{Vo - Off}{S} + 0.6 \quad \text{[bar]}$$

Numerical example:

The read coefficients in EEPROM of a module:
K1 = 54Ch, K2 = D04h, K3 = 5F9h, K4 = C0Fh, K5 = 548h and K6 = C46 are 12-bit word with the most significant bit is sign-bit (0: positive; 1: negative).
They are equivalent with
K1 = 1356, K2 = -1284, K3 = 1529, K4 = -1039, K5 = 1352 and K6 = -1094 in decimal number.
The output voltage at pin TEMP of module is Vt = 662.816 mV
The temperature is calculated by:

$$T = 100 * (\frac{Vt - K5 * 2^{-1}}{K6 * 2^{-3}} + 0.2)$$
$$= 100 * (\frac{662.816 - 1352 * 2^{-1}}{-1094 * 2^{-3}} + 0.2)$$
$$= 29.6\ (^0\text{C})$$

The differential output voltage between pin VOUTH and VOUTL is: Vo = 81.040 mV
The sensitivity is calculated by:

$$S = 2^{-4} * (K2 * 2^{-2} * (T/100 - 0.2) + K1)$$
$$= 2^{-4} * ((-1284) * 2^{-2} * (29.6/100 - 0.2) + 1356)$$
$$= 82.824\ \text{(mV)}$$

The offset is:

$$Off = 2^{-5} * (K4 * 2^{-2} * (T/100 - 0.2) + K3)$$
$$= 2^{-5} * ((-1039) * 2^{-2} * (29.6/100 - 0.2) + 1529)$$
$$= 47.002\ \text{(mV)}$$

Compensated pressure:

$$P = \frac{Vo - Off}{S} + 0.6$$

$$= \frac{81.040 - 47.002}{82.824} + 0.6$$
$$= 1.01089 \text{ (bar)}$$

So, the real pressure is 1010.89 mbar.

Important notes:

1/ User must calibrate the amplifier and ADC for an accurate conversion.

Example:

ADC reference voltage: 3.000V

Difference amplifier: gain 20

ADC resolution: 12 bits

Set differential input voltage: 100mV

Theorical adc counts: 100mV * 20 * 4096 / 3000 mV = 2731 counts

Check the real ADC counts.

In example, they are 2690 counts.

Calculate the correction coefficient called Kcorr.

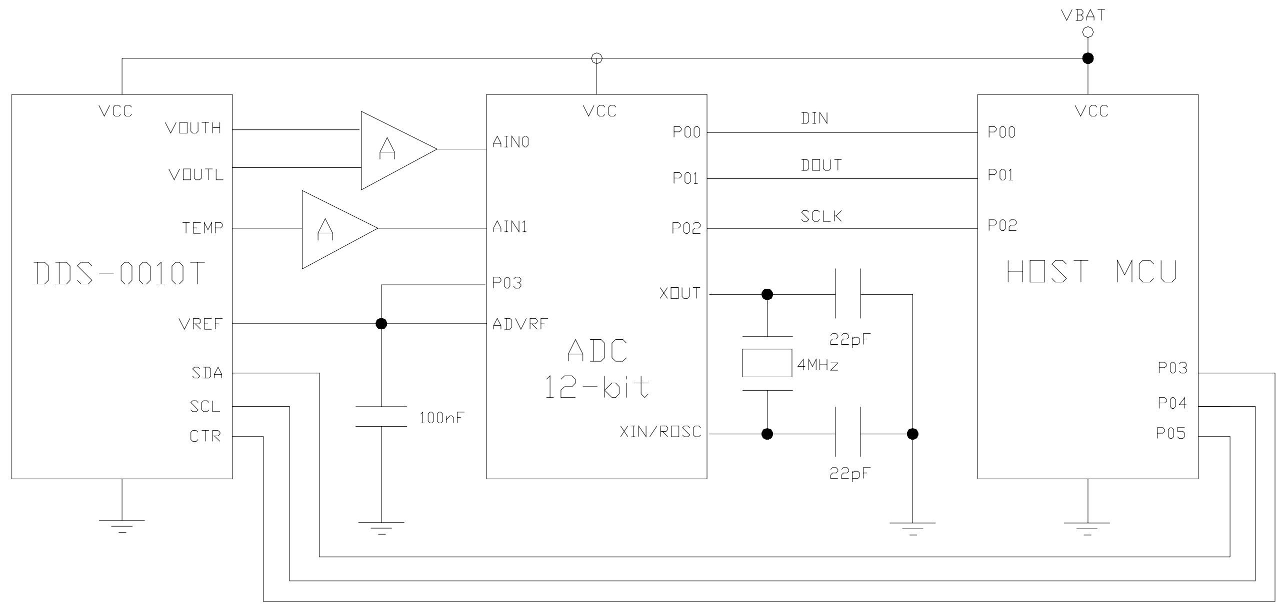
Kcorr. = 2731/2690 = 1.0152

All conversion reading must be multiplied by Kcorr.

Once the correct adc count is known, user can calculate Vo.

2/ The ADC could be used in a ratio metric configuration. However, user must make sure that the used ADC is really ratio metric. It could happen that some low cost ADC has some error when the battery voltage is changing.

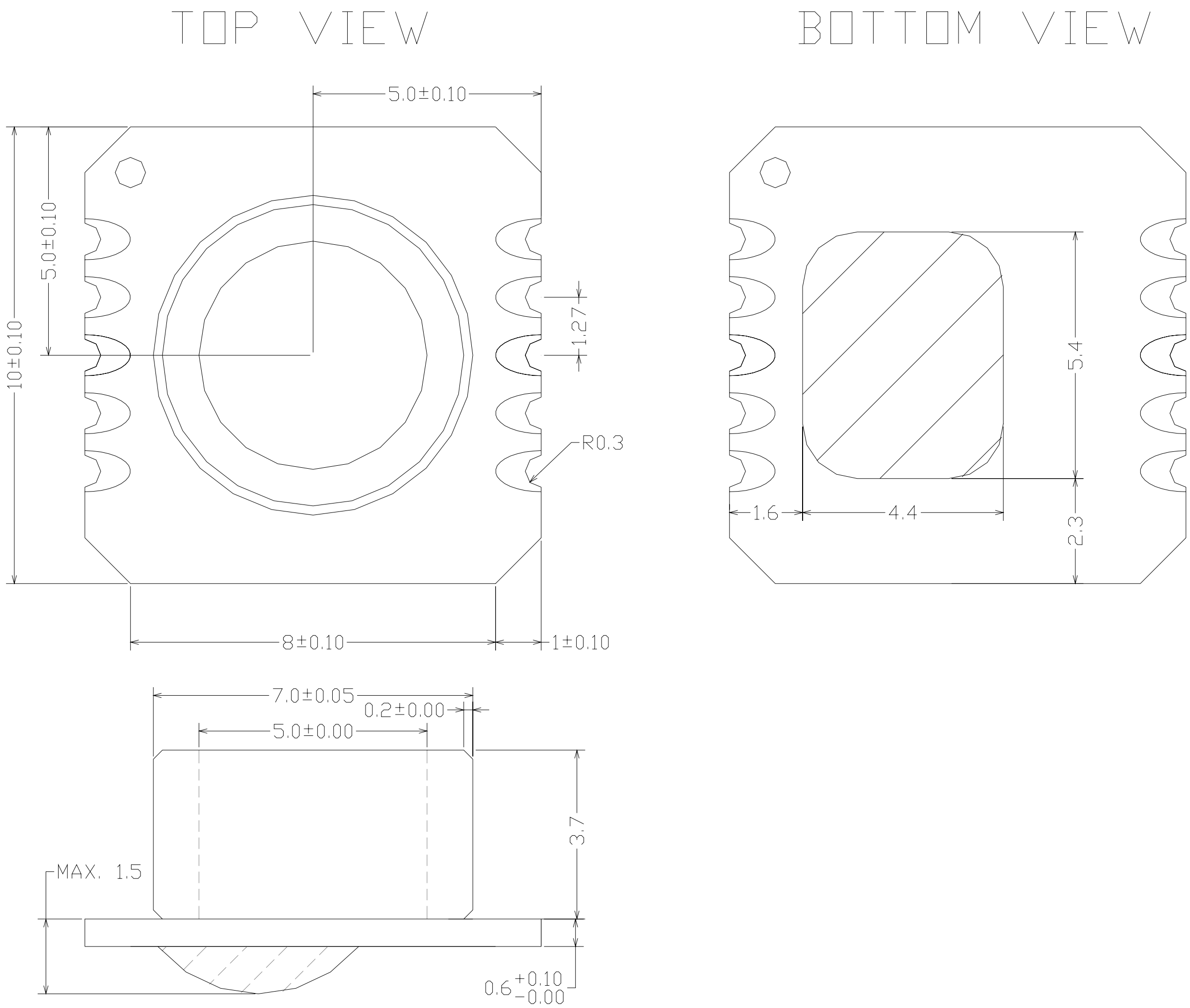
APPLICATION INFORMATION



Notes:

- Configuration ratio metric ADC
- For pressure measurement with ADC single ended analog input, read the voltage of VOUTH and VOUTL pins. The pressure voltage value equals VOUTH – VOUTL. This differential voltage will be amplified before conversion to get the wanted resolution. The calibration of the AD converter is necessary. The adjustment of the offset of the amplifier and the ADC is necessary. This could be done by software.

PACKAGE DIMENSIONS



ORDERING INFORMATION

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