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DIGITALLY CALIBRATED SENSOR MODULE – DDS-0010B

- Integrated pressure sensor
- Pressure range 600-1100 mbar
- 4 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, 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-0010B.

FEATURES

- Supply voltage from 2.4V to 5.5V
- Low supply current
- 0°C to 50°C
- Small size
- 12 bits calibration data in EEPROM

APPLICATION

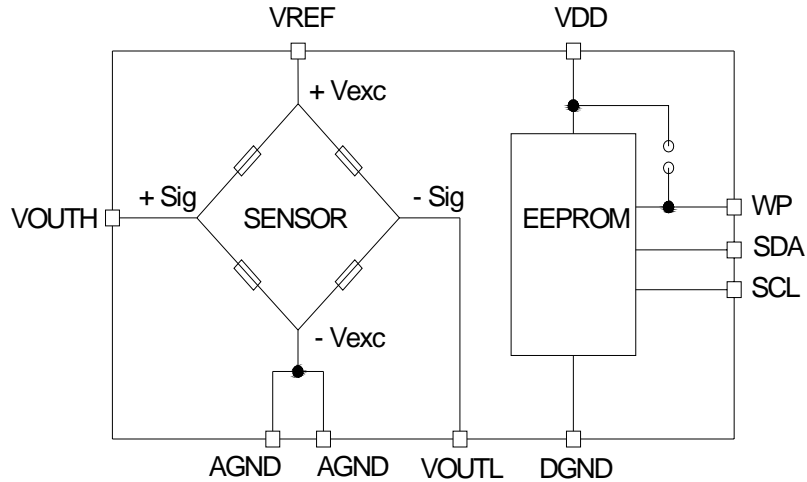
- Low cost barometer
- Low cost altimeter
- Tire gauges



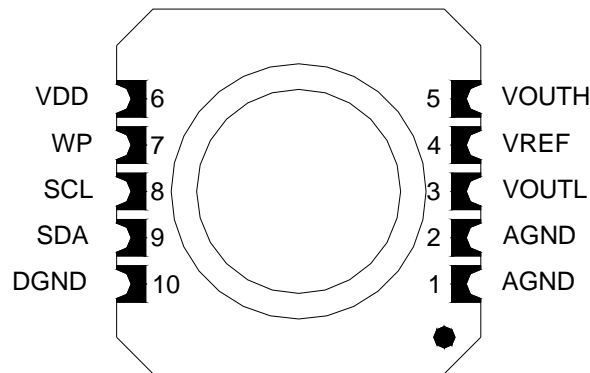
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BLOCK DIAGRAM



PIN CONFIGURATION



PIN DESCRIPTION

Pin No.	Symbol	Description
1	AGND	Analog Ground Terminal.
2	AGND	Analog Ground Terminal.
3	VOUTL	Analog Output. Output of +Sig of sensor for pressure measurement
4	VREF	Analog Input. Referent voltage for ADC and DDS-0010B module.
5	VOUTH	Analog Output. Output of -Sig of sensor for pressure measurement
6	VDD	Power supply input for digital circuit.
7	WP	Write Protect. Read/write when connected to DGND, read only when connected to VDD ¹ .
8	SCL	Digital Input. Serial clock data input. ²
9	SDA	Digital Input/Output. Serial data input/output (open drain). ²
10	DGND	Digital Ground Terminal



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- Note: 1. By default, WP is connected to VDD on module.
2. SDA and SCL are used to read the calibration data of DDS-0010B module.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Conditions	Min	Max	Unit
Supply Voltage	VBat		-0.3	6	V
Overpressure	P			5	bar
Storage Temperature	T _{Stg}		-20	80	°C
Operating Temperature	T _{Opt}		0	50	°C

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

PRELIMINARY



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ELECTRICAL CHARACTERISTICS:

$T_A = 25^{\circ}\text{C}$ and $V_{\text{Bat}} = 3.0\text{V}$, V_{Ref} connect to VDD

Parameter	Symbol	Test condition	Min	Typ	Max	Unit
Supply Voltage	V_{Bat}		2.4	-	5.5	V
Supply Current	$I_{\text{BAT(NORMAL)}}$	$V_{\text{Bat}} = 3.0\text{V}$ EEPROM OFF			1.25	mA
	$I_{\text{BAT(READ)}}$	$V_{\text{Bat}} = 3.0\text{V}$ READ EEPROM at 100kHz			3.5	mA
	$I_{\text{BAT(SLEEP)}}$	$V_{\text{Bat}} = 3.0\text{V}$ SENSOR OFF			1	uA
Sensitivity	S	$T = 0^{\circ}\text{C} \dots 50^{\circ}\text{C}$	23			mV/V/bar
Linearity		$T = +25^{\circ}\text{C}$	-0.3	0.2	+0.3	%FS
Input High Voltage	V_{IH}	$V_{\text{Bat}}=2.4..5.5\text{V}$	$0.7V_{\text{Bat}}$		$V_{\text{Bat}}+0.5$	V
Input Low Voltage	V_{IL}	$V_{\text{Bat}}=2.4..5.5\text{V}$	-1		$0.3V_{\text{Bat}}$	V
Output Low Voltage	V_{OL}	$V_{\text{Bat}}=2.4\text{V}$ $I_{\text{OL}}=2.1\text{mA}$			0.4	V

* not yet defined

PRESSURE OUTPUT CHARACTERISTICS

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

Parameter	Symbol	Condition	Min	Typ	Max	Unit	Note
Resolution		When using a 12 bits ADC	1		1.5	mbar	
Absolute Pressure Accuracy		$P=600 \dots 1100\text{mbar}$ at 25°C	-2		+2	mbar	
Relative Pressure Accuracy		$P=600 \dots 1100\text{mbar}$ at 25°C	-1		+1	mbar	
Maximum Error over Temperature		From $0 \dots 50^{\circ}\text{C}$	-3		3	mbar	

GENERAL THEORY OF OPERATION

The DDS-0010B 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-0010B 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 8 bytes of EEPROM memory, which is subdivided in four 12bit words that store the compensation information in the form of four coefficients.



Values stored in EEPROM type 24LC02, which are measured at VREF=VDD=3VDC at room temperature 20°C unless otherwise specified.

Address	Parameters	Symbol	Data size
(Hex)			
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

(1): Measured at 600mbar and 20°C
Alls parameters are a 12-bit word in two's complement format.

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-0010B module.

Vout (T) sensor output voltage at temperature T [mV]

Assume that the room temperature T (in °C) is known.

The sensitivity at temperature T is :

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

The pressure offset at temperature T is:

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

The temperature compensated pressure then becomes:

$$P = \frac{VOut(T) - Off(T)}{S(T)} + 0.6 \quad [\text{bar}]$$

Numerical example:

The read coefficients in EEPROM of a module:

K1 = 56Ch, K2 = C23h, K3 = 6FCh, and K4 = D20h are 12-bit word in two's complement format.

They are equivalent with

K1 = 1388, K2 = -1059, K3 = 1788, and K4 = -1312 in decimal number.



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The output voltage of this module at $T = 28.5^{\circ}\text{C}$ is: $V_{out}(28.5) = 89.747 \text{ mV}$
The sensitivity is calculated by:

$$\begin{aligned} S(T) &= 2^{-4} (2^{-2} K2(10^{-2}T - 0.2) + K1) \\ &= 2^{-4} (-2^{-2} 1059(10^{-2} 28.5 - 0.2) + 1388) \\ &= 85.543 \text{ (mV)} \end{aligned}$$

The offset is:

$$\begin{aligned} Off(T) &= 2^{-5} (2^{-2} K4(10^{-2}T - 0.2) + K3) \\ &= 2^{-5} (-2^{-2} 1312(10^{-2} 28.5 - 0.2) + 1788) \\ &= 55.003 \text{ (mV)} \end{aligned}$$

Compensated pressure:

$$\begin{aligned} P &= \frac{V_{Out}(T) - Off(T)}{S(T)} + 0.6 \\ &= \frac{89.747 - 55.003}{85.343} + 0.6 \\ &= 1.0071 \text{ (bar)} \end{aligned}$$

So, the real pressure is 1007.1 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

Theoretical adc counts: $100\text{mV} * 20 * 4096 / 3000 \text{ mV} = 2731 \text{ counts}$

Check the real ADC counts.

In example, they are 2690 counts.

Calculate the correction coefficient called Kcorr.

$$K_{corr} = 2731/2690 = 1.0152$$

All conversion reading must be multiplied by Kcorr.

Once the correct adc count is known, user can calculate $V_{Out}(T)$.



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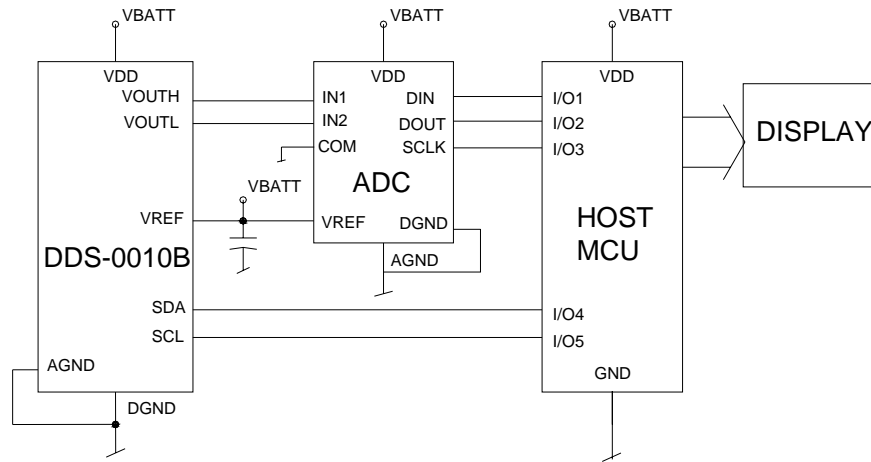
2/ The ADC could be used in a ratio metric configuration. However, user must make sure that the used ADC is really ratio metric. It could happen that some low cost ADC has some error when the battery voltage is changing.

PRELIMINARY

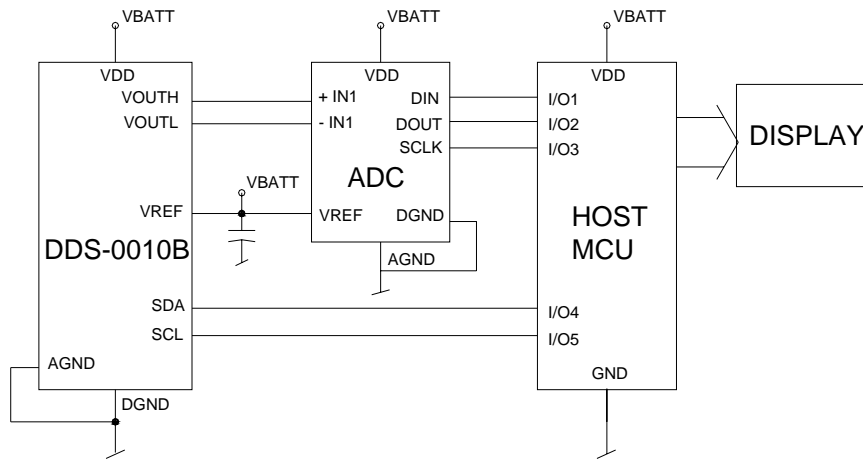


APPLICATION INFORMATION

For an ADC with single ended analog input



For an ADC with differential analog input.



Notes:

- Configuration ratio metric ADC
- For pressure measurement, read the voltage of VOUTH and VOUTL pins. The pressure voltage value equals $VOUTH - VOUTL$.



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PACKAGE DIMENSIONS

