Constant current excitation for HMU and HDU pressure sensors

1 INTRODUCTION

Silicon based piezoresistive pressure sensors use a Wheatstone bridge implanted into a thin diaphragm to transform pressure into an electrical output. When pressure is applied to the diaphragm, the electrical resistivity changes due to the mechanical stress (piezoresistive effect). If the bridge circuit is supplied with a voltage, a sensor output signal proportional to pressure is generated.

The bridge resistors as well as the pressure sensitivity of the silicon diaphragm are temperature dependent and change over the operating temperature range of the sensor. For all piezoresistive silicon pressure sensors the bridge resistance increases with increasing temperature while the pressure sensitivity decreases with increasing temperature. In order to maintain a temperature stable output voltage all piezoresistive pressure sensors have to be temperature compensated. Different methods such as passive compensation with resistor networks or active compensation with op-amps as well as ASIC or microcontroller based digital compensation can be used. Under certain conditions a temperature compensation can also be achieved by applying a constant current across the sensor bridge.

2 CONSTANT CURRENT EXCITATION

Constant current excitation is a simple and low cost method for temperature compensation of span which uses the internal characteristics of the silicon sensor element. First Sensors HMU and HDU pressure sensor elements are designed in such a way that the bridge resistance as well as the sensitivity change over temperature with nearly the same absolute magnitude but with opposite signs (compare Fig. 1 and 2). Therefore, if the sensor is supplied with a constant current the voltage across the bridge increases with increasing temperature and compensates for the decreasing sensitivity. The result is a self-compensated HMU/HDU sensor with a typical span error of less than ±1.5 % FSS over an operating temperature range of -20...+50 °C (see Fig. 3).

3 CIRCUIT DESIGN

Two examples of a constant current excitation circuit for First Sensors HMU and HDU pressure sensors are shown in Fig. 4 and 5.

3.1 Constant current source with op-amp

The circuit shown in Fig. 4 designs a constant current source from a single operational amplifier. The current source is controlled by a ±1 % band-gap reference diode Z_R.

The bridge current I_B is defined by

$$I_B = \frac{(V_R - V_O)}{R_2}$$

where

V_R = Diode reference voltage (1.235 V ±1 %)
V_O = Amplifier offset voltage (~0 V)
R_2 = Current set resistor (820 Ω)

Selecting amplifier A_1 with an offset voltage <1 mV and a ±0.1 % tolerance resistor R_2 with a standard value of 820 Ω delivers a current of I_B = 1.51 mA with a typical accuracy of ±1.2 %.

3.2 Constant current source with shunt regulator

The circuit shown in Fig. 5 uses a LMV431A adjustable precision shunt regulator to achieve a constant current through the sensor bridge.

The bridge current I_B is defined by

$$I_B = \frac{V_R}{R_2}$$

where

V_R = Transistor reference voltage (1.235 V ±1 %)
R_2 = Current set resistor (820 Ω)

Selecting a ±0.1 % tolerance resistor R_2 with a standard value of 820 Ω delivers a current of I_B = 1.51 mA.

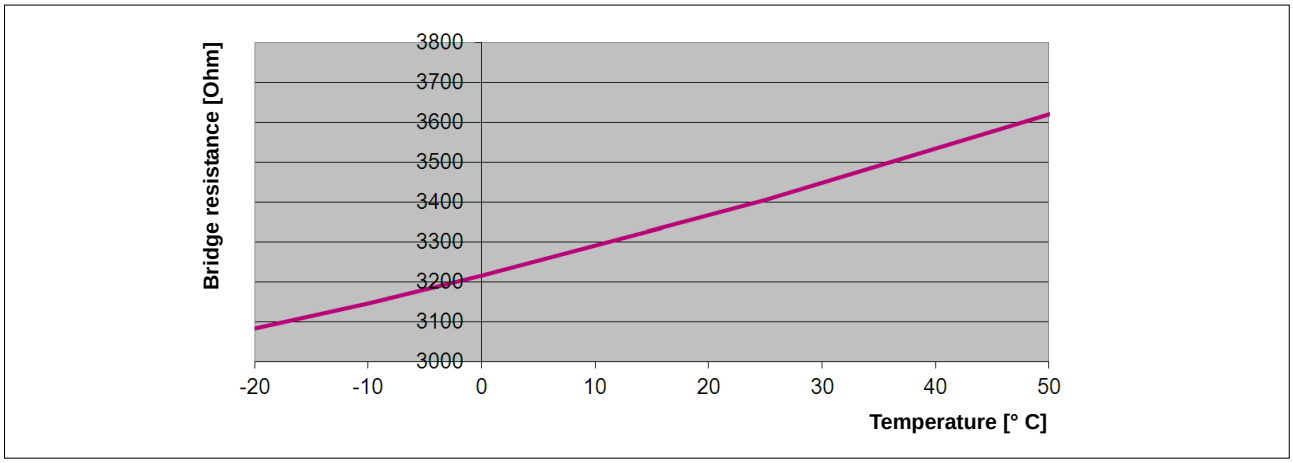


Fig. 1: Bridge resistance over temperature for HMU and HDU pressure sensors

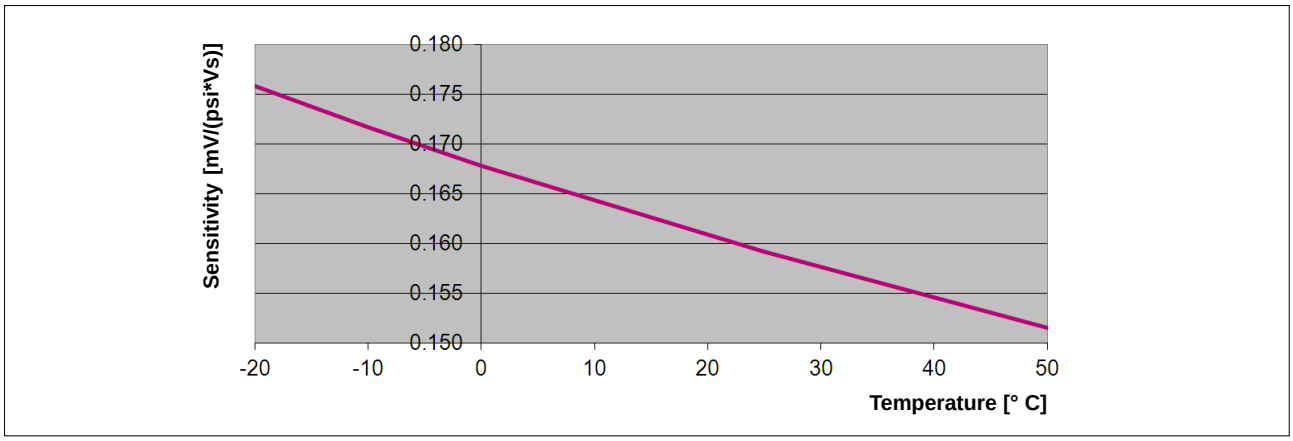


Fig. 2: Sensitivity over temperature for HMU and HDU pressure sensors

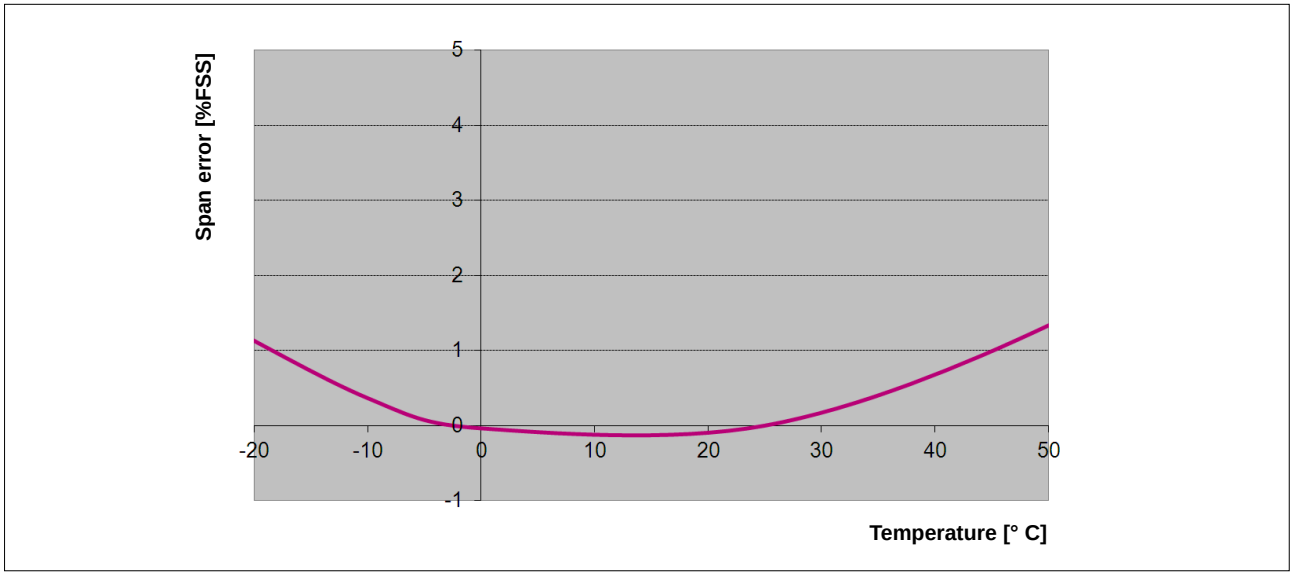
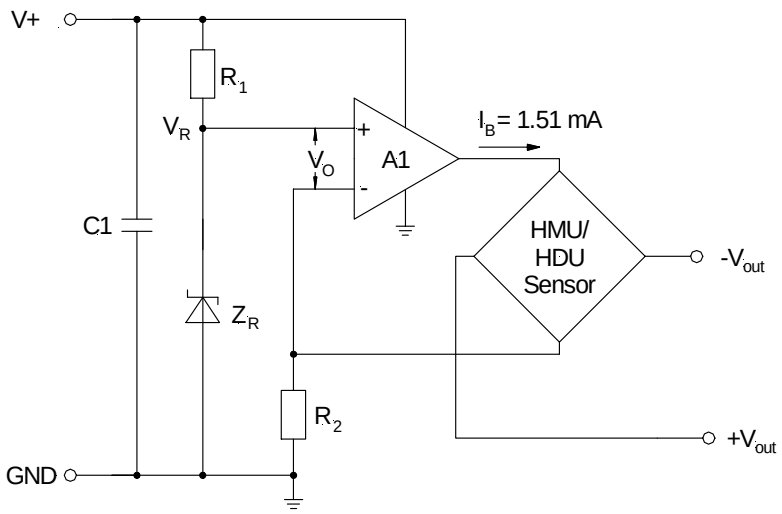


Fig. 3: Typical span error over temperature for constant current excitation of HMU and HDU pressure sensors

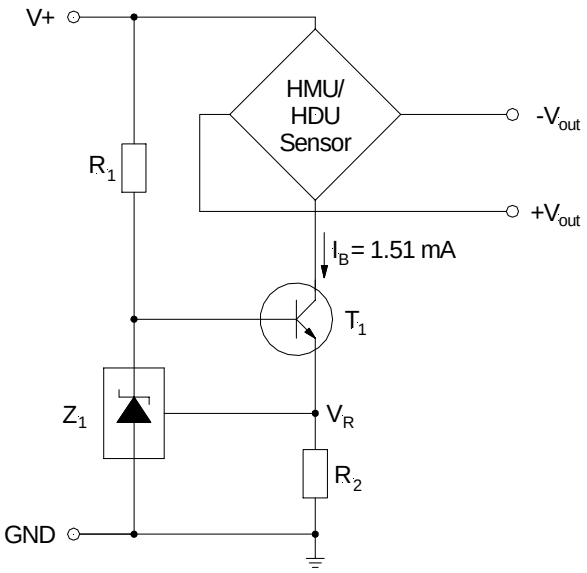
Constant current excitation for HMU and HDU pressure sensors



V+ = >10 V
A1 = LT1490A or LTC1051
ZR = LT1034-1.2 or LT1004-1.2

C1 = 0.1 µF
R1 = Select according to LT1034-1.2 or LT1004-1.2 data sheet
R2 = 820 Ohm

Fig. 4: Constant current source with op-amp for HMU and HDU pressure sensors



V+ = >10 V
T1 = BC847
Z1 = LMV431A

R1 = Select according to LMV431A data sheet, e.g. 62 kOhm
R2 = 820 Ohm

Fig. 5: Constant current source with shunt regulator for HMU and HDU pressure sensors