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AIR PRESSURE MEASUREMENT USING SILICON BASED ANALOG SENSOR SPD015A

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Abstract: *The aim of this work is to examine the properties of analog pressure sensor SPD015A and it's use in atmospheric pressure measuring system. Special attention has been paid at the problems related with the temperature dependence of the sensor. Two methods for temperature compensation are described: one by using mathematical procedure and other by using hardware means. Results from the measuring process are represented in order to examine the problems and the methods for their solution.*

Keywords: air pressure, temperature dependence, compensation

1. Introduction

Monitoring the air pressure is important issue in the contemporary meteorology. The pressure variations give a lot of information about many processes in the atmosphere. For example rainfalls are often preceded by low pressure front. Nowadays many pressure measuring devices have been developed – there is wide range of analog and digital sensors which can be easily integrated in systems for long term monitoring. SPD015A is a silicon based pressure sensor of absolute type. It consists of four strain gages in bridge circuit, etched on an elastic membrane which encloses small volume with low reference pressure (25mTorr or 3.33Pa). The membrane is deformed due to changes of the outside pressure and this results in resistance change. We can determine the air pressure by measuring the bridge unbalance.

2. Problem

For examining the sensor's properties a microcontroller based system has been used (fig.1). The sensor is supplied by voltage source (+5V). The output signal is amplified and than logged by the ADC module of the microcontroller. The temperature channel consists of analog sensor LM335 and amplifier A2. For further analysis the collected data is transmitted to a PC via RS232 interface. The system is calibrated by comparing the results with "ELV" PC Radio Weather Station.

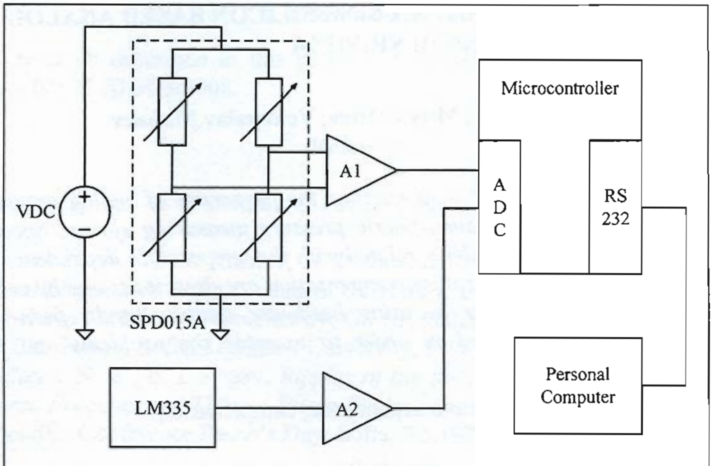

Fig. 1

Figure 2 shows data obtained from the system. In order to analyze the effect of temperature variations on the measuring process, during the experiment the temperature is decreased at rate of 0.7°K/min ($\Delta T/\Delta t = 0.7$°K/min).

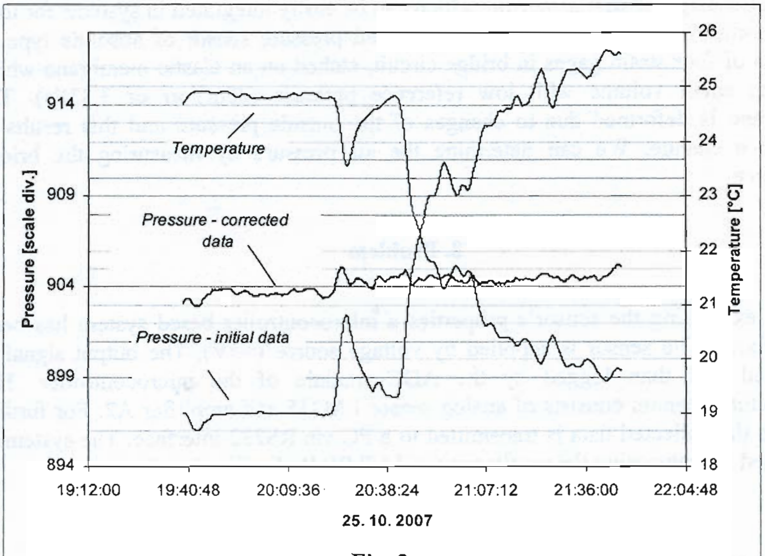

Fig. 2

As can be seen, there is strong temperature dependence in the pressure-sensor's output signal – about -4div/°K (one scale division corresponds to 0.5 hPa approximately). It is obvious that the collected data requires processing before it can be used.

3. Solution

3.1 Mathematical procedure for compensating the temperature dependence

One possible solution to the problem is to apply a mathematical procedure in order to compensate the temperature influence. In the present case MS Excel has been used. The first step is to determine the temperature coefficient of the pressure-sensor's output signal. We assume linear temperature dependence, i.e. the coefficient determined for part of the working range is valid for the whole range.

$$N_2 - N_1 = (P_2 - P_1)K_P + (T_2 - T_1)K_T \qquad (1)$$

N_1 and N_2 are two different readings corresponding to different values of pressure and temperature - N_1 for P_1 at temperature T_1, N_2 for P_2 at temperature T_2 . K_P and K_T are respectively the pressure and temperature coefficients. If the readings N_1 and N_2 are taken at the same pressure ($P_1 = P_2 =$ const) we can express K_T as follows :

$$K_T = \frac{N_2 - N_1}{T_2 - T_1} \quad [\text{div/°K}]. \qquad (2)$$

To ensure a closed volume at constant pressure and variable temperature is not an easy task. So the experiment can be made at free ambient conditions but for a short period of time in order to have insignificant changes of the air pressure. K_T is then determined by using linear approximation of the function $N=f(T)$, P=const, fig.7.

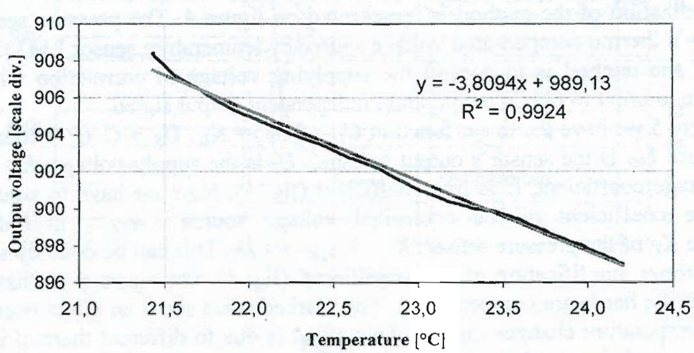

Fig. 3

K_T is taken directly from the approximating equation. The correction is applied for every couple N_i and T_i :

$$N_{C_i} = N_{0_i} + (T_0 - T_i)K_T \,. \qquad (3)$$

N_{0i} is the value taken from the pressure channel, N_{Ci} is the corrected value, T_0 is normalized temperature for the current conditions.

Results of the described compensation procedure are shown on fig. 1 . As can be seen the temperature dependence is reduced to acceptable level. Nevertheless, being a mathematical procedure it has certain drawbacks.

3.2 Hardware compensation of the temperature dependence

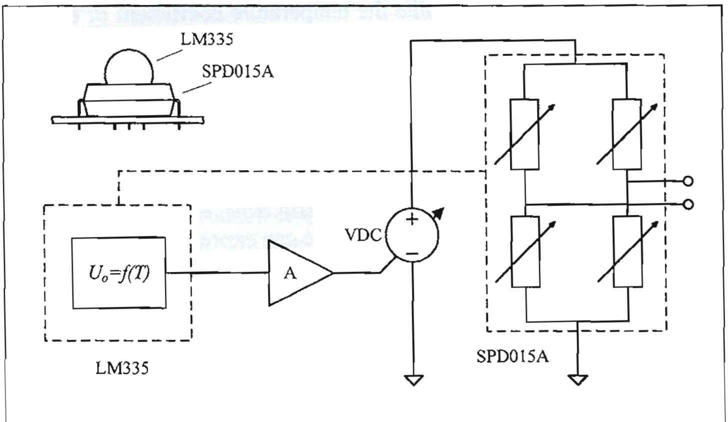

Fig. 4

The realization of the method is represented on figure 4. The pressure sensor is supplied by a thermo compensated voltage source by temperature sensor LM335. The essence of the method is to control the supplying voltage in correlation with the temperature in order to obtain temperature independent output signal.

On figure 5 we have the linear function $U_O = f(U_S) = K_U \,.\, U_S + C$ (P = const, T = const), where U_O is the sensor's output voltage, U_S is the supply voltage, K_U is the supply voltage coefficient, C is free coefficient (fig. 5). Now we have to adjust the temperature coefficient of the controlled voltage source K_{TVDC} , in order to compensate K_T of the pressure sensor: $K_U \,.\, K_{TVDC} = - K_T$. This can be done by simply selecting proper amplification of the amplifier A (fig. 4). On figure 6 we have the results from the hardware compensation. The marked areas show an effect occurring when the temperature changes rapidly. This effect is due to different thermal inertia of both sensors. Although they are placed one on top of the other (fig. 4), the LM335 sensor reacts faster than the pressure sensor and for some period of time the line follows the temperature trend. The effect can be reduced by improving the thermal contact between both sensors and reducing the speed of temperature changes. In spite of this problem the hardware compensation gives satisfactory results.

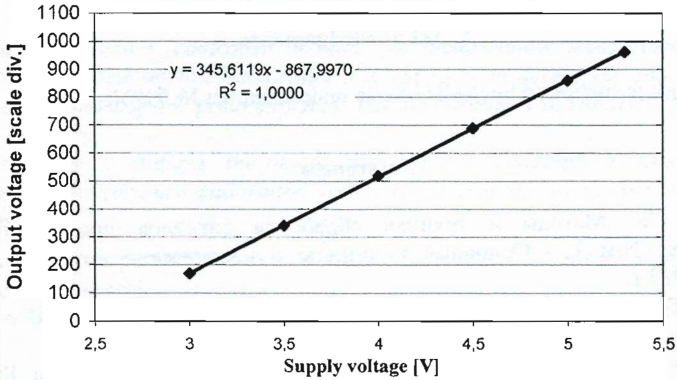

Fig. 5

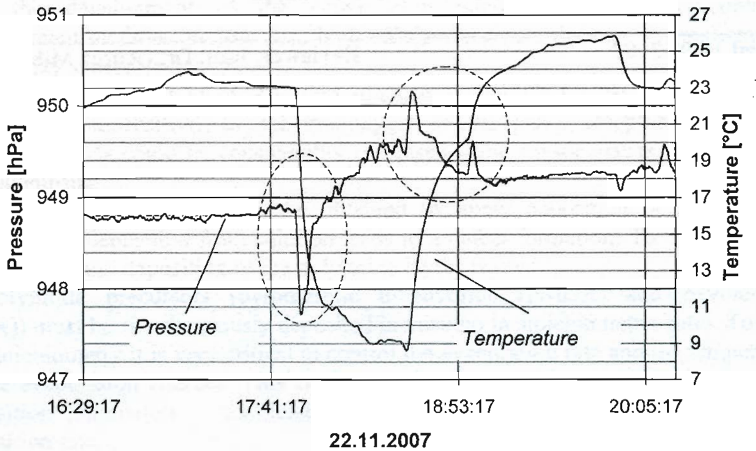

Fig. 6

4. Conclusion

The analysis of the sensor shows that special precautions have to be taken in order to eliminate undesired temperature effects. The described methods can reduce the temperature dependance to acceptable level.

5. Acknowledgements

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