PRESSURE

Sensitive low-cost altimeter for schools

In 1648 Pascal and his brother-in-law Perrier showed that the level of mercury in the Torricelli barometer, measured at the top of the 1000 m high Puy de Dome Mountain in France, was over 3 inches lower than at its foot. Recent measurements show that the atmospheric pressure close to the Earth's surface decreases quasi-linearly with the altitude at the rate of 0.12 hPa/m.

Today, thanks to microelectronics, the fact that atmospheric pressure depends on altitude may be easily demonstrated in the classroom. Below we describe a simple and low-cost device (an altimeter) that may be assembled even by a schoolmaster or collegian. Its structure is shown in figure 1.

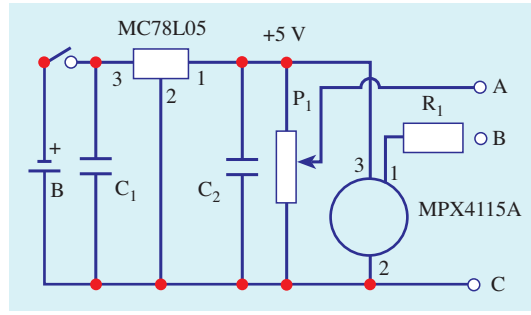

Figure 1. *Scheme of the altimeter. MPX 4115A is a pressure sensor. MC 78L05 is a 5 V voltage regulator. B is a battery 9 V type 6LR61. C_1 = 0.33 µF; C_2 = 0.01 µF; P_1 = 10 turns potentiometer 20 kΩ 0.5 W; R_1 = protecting resistor 750 Ω/0.1 W.*

Detecting pressure changes

The apparatus is based on an integrated pressure sensor (IPS) of the type MPX 4115A (Motorola) [1]. It's a piezoresistive transducer integrated with a well-compensated operational amplifier. It is characterized by high output signal and pressure sensitivity equal to 4.59 mV/hPa. Using the simplest digital multimeter with resolution of 0.1 mV, we can detect pressure changes of about 0.02 hPa, or corresponding altitude changes of about 0.6 mV/m. For example, when we lift the altimeter 2 m up, the output signal changes by 1.2 mV! To ensure such sensitivity and a good reliability the IPS requires a well-stabilized 5 V voltage, provided by the stabilizer type MC78L05 [2].

The applied IPS is designed for pressure measurements in the range from 150 hPa to 1150 hPa. In this range the output voltage varies from 0.5 V to 5 V. In our experiments we want to measure only pressure changes close to atmospheric pressure, so to take advantage of the full sensitivity of the sensor at this pressure, we can compensate the output voltage of IPS (measured at the clamp B) by the reference voltage regulated by the potentiometer P1 (measured at the clamp A).

Then, if the altimeter is lifted to a new level, the voltage between the clamps A and B changes from zero to a new value corresponding to a new level. The change in height may be calculated by dividing this value expressed in mV by a factor of 0.6. For more precise measurements it is necessary to calibrate the altimeter using objects that have a known height.

Altimeter specifications

This altimeter may be used in experiments in classrooms, high buildings, geographic excursions and so on. The total cost of the elements used to assemble it is less than $30 (£17). The cost of a simple digital multimeter with a range of 200 mV and resolution of 0.1 mV is about $10. The altimeter consumes 8 mA from the 9 V batteries.

It should be noted that due to a short response time of the pressure sensor (1 ms) the device can be connected to a digital oscilloscope and may be used to record and analyse the infrasonic pressure oscillations during storms and winds. It is known that such oscillations have a negative influence on human mental activity [3].

References

[1] www.freescale.com/files/sensors/doc/data_sheet/MPX4115A.pdf
[2] www.onsemi.com/pub/Collateral/MC78L00A-D.PDF
[3] Delyukov A and Didyk L 1999 *Int. J. Biometeorol.* **43** 31–7

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