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MECHATRONICAL SYSTEM FOR MEASURING ENVIRONMENTAL PARAMETERS

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Abstract: *Environmental parameters measurement systems are devices that have the ability to measure several parameters, such as temperature, relative humidity, atmospheric pressure, luminosity, noise etc. The paper is aimed at identifying the main parameters that influence the human activity in daily bases and to make a low cost device that might measure the parameters and offer information regarding the limits of exposure. The device is based on an Arduino board along with ten sensors that measure: temperature and humidity, light intensity and noise. The device is intended to be compared to a professional equipment such as TESTO or INNOVA.*
Key words: *Arduino, sensor, temperature, noise, luminosity.*

1. INTRODUCTION

Environmental parameters are need to be measured and interpreted in order to maintain a good environment for every human in his daily activities. Nowadays these parameters are well known and kept under good surveillance with very expensive equipment, by professional staff. Considering the actual development of low cost equipment that involve the use of an Arduino board with various sensors, it lead us to study and make such an equipment that could offer the possibility to measure a number of environmental parameters and further on to test and compare results to a professional equipment that might be found on the market.

In this direction it was done a very critic study regarding the environmental parameters, the electronic boards and the sensors that might be used to obtain the desired results and objectives.

2. DEFINITION OF AMBIENT ENVIRONMENTAL PARAMETERS

Temperature is one of the physical parameters that decisively influence the way of life. The human body has a number of possibilities to adapt to the thermal conditions of the environment, but within certain limits. To correct the thermal variations of the external environment, humans have resorted to creating aids such as clothing and housing, both creating a microclimate that is convenient to the body. Dwelling microclimate means the thermal environment that we create by known means so that the body can spend the rest and restoration of the workforce under comfortable conditions. It has the role of ensuring optimum conditions for the heat exchange between the body and the environment, avoiding the efforts of the thermoregulation. It is known that the human body temperature is constant, oscillating between 36.5 and 36.9 °C. The constant of body temperature is maintained by the thermo-regulation mechanism. Thermoregulation consists of a series of complex processes that interfere with the formation and loss of heat so as to maintain a perfect balance in relation to ambient temperature variations. The body loses heat through the following ways: - convection, 31% (the heat lost by the body for heating the objects it comes into contact with and the ambient air); - irradiation, 44% (the heat the body heats the objects that are some distance away from it); - water evaporation in the skin, 10%; - water evaporation in the lungs, 12%. The higher the air temperature, the body heat loss becomes

insufficient and the more abundant sweat appears. (Fig. 1)

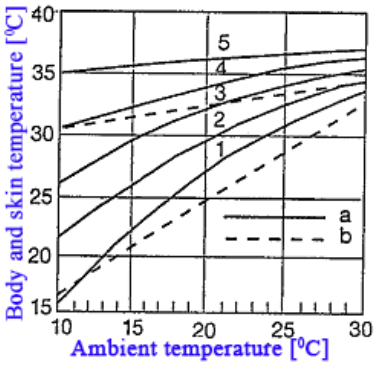


Fig. 1. Body and skin temperature variation according to ambient temperature: average skin temperature (a), mean body surface temperature stripped (b), legs (1), hands (2), torso (3), head (4), rectum (5) [1].

The most favourable relative humidity for the body is between 35-65%. In winter, room air humidity should not drop below 25% as a result of the operation of heating systems, as air dryness has a detrimental effect on mucous membranes. Air humidity in the case of air showers shall not exceed 60%.

At relative humidity less than 30%, the dryness of the skin and the mucous membrane of the airway occurs, and dust formation is favoured, which in contact with the heating bodies burns, producing ammonia and other gases sensed by man. At relative humidity values exceeding 70%, the sensation of stuffiness leads to abundant sweating and the impossibility of evaporating it in a convenient time. During the cold period of the year, the condensation of water vapour in the air of the room also occurs at the contact with cooler surfaces, favouring the appearance of unpleasant smells and mould.

The light used in the dwelling is of two kind, natural or artificial. Natural light is the one we receive from the sun, it can be: direct; diffuse or reflected. Solar radiation includes rays: light; caloric and ultraviolet. In the dwelling, with direct natural light, the ultraviolet rays penetrate. Solar rays are of special value through their bactericidal and biological action.

Among the conditions that the home has to provide is the peace of rest and sleep, as well as activities that take place within it. Noise has an unfavourable influence on health. Noise that exceeds a certain intensity and which repeatedly irritates the nervous system, disturbs rest and sleep, resulting in lower labour efficiency, especially intellectual. Noise in the home may come from the outside or from the inside. Noise is considered to be a mechanical wave in space.

The maximum permissible limit for noise at workplaces with normal attention is 90 dB (A) continuous equivalent acoustic level per week of work. The continuous equivalent acoustic level is defined as the acoustic level in dB (A) of constant noise and operating continuously throughout the working week has an auditory effect similar to the effect of the measured real-time noise at work. There are tables that indicate the time of exposure to various levels of noise.

Besides these parameters there are others such as: pollutant agents, air dust, air currents, air pressure, contact surface etc.

3. MEASURING SYSTEMS OF ENVIRONMENTAL PARAMETERS

Environmental parameter measurement systems are devices that have the ability to measure several parameters, such as: temperature, relative humidity, atmospheric pressure, luminosity, noise. Two testers, Testo 435 and Innova 1221, are shown below. Testo 435 is a specialized instrument for measuring the air quality and the parameters of the ventilation systems. Innova 1221 is a device that allows you to check the thermal comfort and indoor air quality.

TESTO 435 is a multifunctional instrument for measuring the air quality and the parameters of the ventilation systems in order to optimize the ambient conditions.

The device can measure: air temperature; air humidity; air velocity (draft); flow, temperature, humidity in pipes; surface temperature; carbon dioxide; absolute pressure; differential pressure; the luminous intensity. (Fig. 2)

In developed countries, people spend more than 90% of their lives in their rooms. Numerous studies show that there are massive complaints about the poor inner environment, discomfort in buildings and cars, having a negative effect on both people's well-being and productivity. To avoid negative effects, it is essential that buildings and vehicles be designed to meet the

fundamental human requirements. After construction of buildings, cars in many cases require an internal environment check to ensure that the specifications have been met. Later, measurements are made to check systems to ensure optimal performance or to identify problems.

a)

b)

Fig. 2. Testo 435 (a) and the related probes (b) [2].

Innova AirTech Instruments provides tools and solutions to measure, analyse a wide range of parameters to check for thermal comfort, ventilation systems and indoor air quality. Innova AirTech Instruments offers devices that measure indoor climate with a large variety of transducers without using another measuring instrument, this device (Fig. 3) is called Innova 1221 (Confort Data Logger).

Fig. 3. Innova 1221 and the related probes.

Eight types of transducers, probes, can be used: temperature transducer for air; surface temperature transducer; transducer for measurement of asymmetric thermal radiation; humidity transducer; transducer for air velocity measurement: operative temperature transducer; WBGT transducer, Transducer for measuring dry heat losses.

Both of these professional equipment have evolved a lot in the last years in comparison to the ones described here but the companies and transducers are mainly the same.

4. MECHATRONIC SYSTEM FOR MEASURING THE ENVIRONMENTAL PARAMETERS

Component parts of the mechatronic system for measuring the environmental parameters (Fig. 4) are:

- Arduino Duemilanove development board with ATmega 328 microcontroller;
- plate with sensors and actuator connectors;
- 32-character LCD display on 2 lines;
- temperature and humidity sensor SHT1x;
- four DS1820 temperature sensors;
- four BPW 34 photodiode light sensors;
- noise sensor consisting of a capacitive microphone CZN-15E and an MCP 601 I/P.

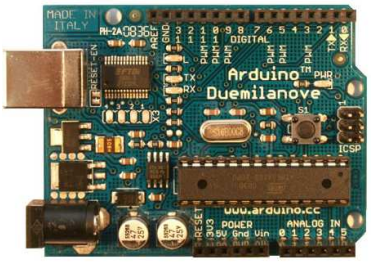
The Arduino Duemilanove board has 14 digital inputs / outputs, of which 6 functions as PWM; 6 analog inputs, a 16MHz oscillator, an ICSP connector, a USB connection and a reset button. The board is powered by USB or by a DC power supply of 7-12V. The main part of the board is the ATmega 328 microcontroller. The microcontroller operates at 5 volts at 16 MHz. It has a 32 KB Flash memory of which 2 KB is busy, 2 KB of SRAM and 1 KB of EEPROM.amplifier.

Arduino Duemilanove has 6 analog inputs, each input has a 10-bit analog-to-digital converter. The converter distinguishes 1024 values from 0 to 5 volts.

The sensor and actuator connector board is used for easy and professional connection of buttons, potentiometers, various sensors, motors, relays, display systems such as LCDs and LEDs. On the Arduino board connect the sensor and actuator connector plate with the pins

on the bottom of the sensor connector plate.

The LCD monitor works with only four wires, two wires (Vcc, GND) and two wires for communication with the Tx, Rx microcontroller on the Arduino board. This is possible with the I2C serial communication module. The communication between the display and the Arduino board is done with an ATmega8-16AU microcontroller, being specially programmed for this mode of operation.



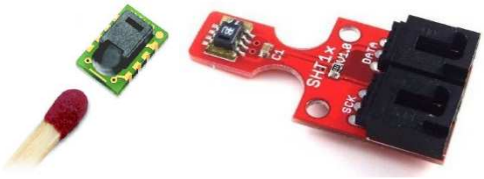
a)

b)

Fig. 4. Connectors and main parts of the Arduino Duemilanove board (a); connector board for sensors and actuators (b).

The serial communication module connects to two digital outputs / inputs supporting serial communication. The display is powered by 5 volts on the Arduino board.

The SH1x sensor (Fig. 5) has two types of sensors embedded in the same housing, a temperature sensor and a relative humidity sensor. The sensor has an SMD housing.



a) b)

Fig. 5. Temperature and humidity sensor SHT1x (a), sensor integrated on the specific board (b)

The DS1820 (Fig. 6) is a calibrated digital sensor that distributes a 9-bit signal and measures temperatures between -55...+125 oC with a resolution of 0.5 oC. The measured temperature is converted into digital signals in 200 ms.

Fig. 6. Temperature sensor DS1820 [3].

The light sensor consists of a BPW 34 photodiode (Fig. 7), a 47KΩ potentiometer (semi-adjustable) and a 3-pin connector. The main element of the sensor is the photodiode. It is suitable for high-speed measurement of light and infra-red radiation with a wavelength in the range of 400-1100 nm. It has a highly transparent epoxy plastic case for this reason it becomes much cheaper than photodiodes with TO-5 carcasses made of metal. Due to the large active area, the sensor has a high sensitivity at a large angle. The sensitive area is 7.5 mm^2. At the angle $\varphi = \pm 65$ °, the photodiode's sensitivity decreases by half and decreases as the angle increases. His answer is 20 ns.

Fig. 7. Photodiode BPW 34 [4].

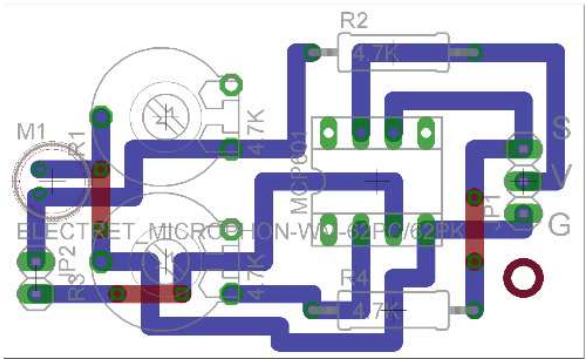
The noise sensor consists of a capacitive microphone CZN-15E (Fig. 8), an operational amplifier MCP 601 I/P, two semi-adjustable resistors of 4.7 KΩ, two 4.7 KΩ resistors and a three-pin connector. The capacitive microphone has a sensitivity of -46...-34 dB (0dB = 1V/pa, 1 KHz) and a low impedance of 2.2 kΩ. It is omnidirectional, it operates in the frequency range of 20-16,000Hz.

Fig. 8. Capacitive microphone CZN-15E [5].

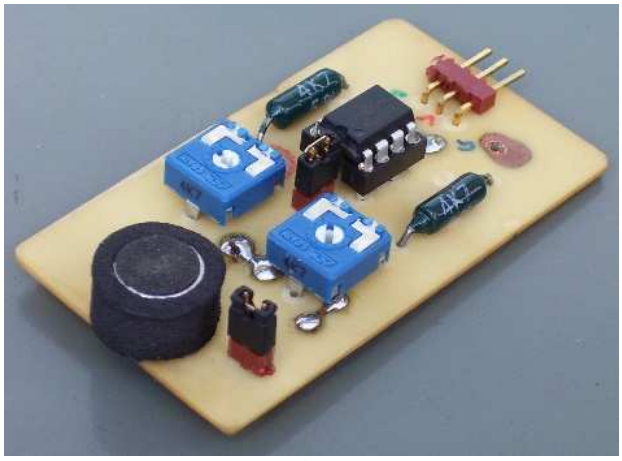
The microphone is powered with a voltage

between 1.5...10V, the standard operating voltage is 4.5 V. The microphone has a maximum consumption of 0.5 mA.

All the above mentioned sensors have been integrated in one device that can be seen in Figures 9, 10 and 11. The results obtained will be compared to those obtained with the TESTO device in a later paper. Other results were obtained and published in a previous paper. [6]

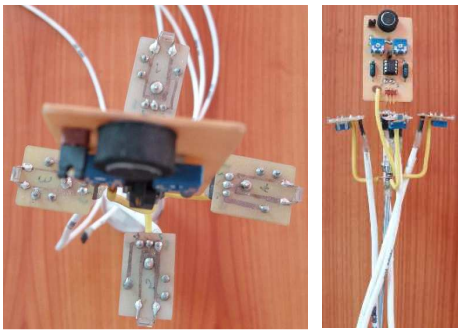


a)



b)

Fig. 9. The printed circuit of the operational amplifier designed in EAGLE (a); finalized noise detector (b).



a) b)

Fig. 10. Sensors mounted on the stand with the cables connected, top view (a) side view (b).

Fig. 11. The whole system for measuring environmental parameters (temperature, luminosity, brightness, noise) [7].

5. CONCLUSION

The device, obtained according to the above explanations, proved to be a good solution, low cost, for measuring environmental parameters. The device does not show the accuracy of professional equipment and has small disadvantages that require further improvement regarding using phototransistors instead of photodiode.

The future of this type of device would be to be supplemented with actuators, such as relays for temperature modulation, air humidity by starting a fan, air conditioning or changing the brightness by lighting a bulb or pulling a curtain with an electric motor.

Nowadays considering the evolution in open access information regarding circuit boards such as Arduino or other ones it could lead to a considerable evolution in various fields such as Mechatronics, Biomedical Engineering, Applied Informatics and Electronics. This could be done by almost anyone that has skills in the above mentioned fields. Social media and networking is considered to be very helpful in this direction.

Acknowledgements

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Sistem mecatronic pentru măsurarea parametrilor mediului înconjurător

Sistemele destinate măsurării parametrilor mediului înconjurător sunt dispozitive ce pot furniza date despre starea ambientului ca: temperatură, umiditate relativă, presiune atmosferică, luminozitate, zgomot etc. lucrarea are ca scop identificarea parametrilor principali ce influențează activitatea umană zilnică de bază și prezentarea unui dispozitiv ieftin ce poate furniza date referitoare la limitele de expunere. Acesta are ca bază o placă de dezvoltare Arduino la care sunt conectați zece senzori ce pot măsura: temperatura și umiditatea, intensitatea luminoasă și zgomotul. Dispozitivul este vizat spre comparare cu echipamente profesionale ca TESTO sau INNOVA.

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