BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi" din Iaşi
Volumul 66 (70), Numărul 3, 2020
Secţia
ELECTROTEHNICĂ. ENERGETICĂ. ELECTRONICĂ

HOME SAFETY SYSTEM: A DEVICE USED FOR PREVENTING DISASTERS BY MONITORING GAS LEAKAGES, AMBIENTAL TEMPERATURE AND HUMIDITY, EARTHQUAKES AND THEFT SITUATIONS

BY

SERGIU-LEONARD TULBURE, OVIDIU URSARU and CRISTIAN AGHION*

"Gheorghe Asachi" Technical University of Iaşi, Romania
Faculty of Electronics, Telecommunications and Information Technology

Received: October 10, 2020
Accepted for publication: December 12, 2020

Abstract. Safety is a requirement wanted more and more in our days, desired for our cars, offices, homes and other places where we spend our time. As our home is becoming a place where we are spending most of our time, replacing offices, restaurants and other places, the chance for a tragic event to happen at home is increasing. Therefore, it is natural to increase the safety measures, so these events can be detected in time, and avoid a potential disaster. There are many devices that can monitor temperature, gas leaks, earthquakes, movement, etc., but none of them is capable to monitor all these parameter at the same time. The advantage of having a device to monitor several parameters is clear: a higher level of safety with only one device.

Keywords: sensors; monitoring; Bluetooth; alarm; safety; microcontroller.

1. Introduction

*Corresponding author; *e-mail*: aghion@etti.tuiasi.ro

In the following paper, is presented the design of a device which can perform monitoring for different parameters, ensuring safety inside a room (*e.g.*: in a house) and sending to the user via visual/audio interfaces data regarding the temperature and humidity, detection of potential gas leakages, detection of vibration in case of an earthquake (Bruce, 2021), light monitoring and movement detection, transmitted via Bluetooth communication to the user's mobile phone (Sherali *et al*., 2019).

The necessity is obvious: nature is unpredictable and equipment which makes humans life easier is not immune to fails. If alarms are sent before disaster strikes, some lives can be spared. All people have a natural need for safety.

Nowadays exist different devices with functions that our proposed Home Safety System will include. As example there, are gas detectors at only 30$ that can monitor the concentration of combustible gas as an easy-to-read percentage from 0% to 20% of LE, having audible siren sounds when gas level reaches 5% of Lower Explosive Limit (LEL). (Amazon Website, 2017) The main disadvantage is the power supply that is dependent on the electricity provided by the power outlet. This gas detector example is shown in Fig. 1:

Fig. 1 – Example of gas detector device existing on market (Amazon Website, 2017a).

There are temperature and humidity monitoring devices with the inside thermometer of high accuracy of ±2~3%RH and ±1°F for a cost of around 12$ (Amazon Website, 2017b), shown in Fig. 2.

Fig. 2 – Example of temperature and humidity monitoring device existing on market (Amazon Website, 2017b).

Indisputable, there are many devices that can detect and monitor various parameters, each with advantages and disadvantages, with different precision, accuracy, and construction. In the end the function that they hold is the most important.

2. Functional Diagram and System Architecture

The proposed device will work following the functional diagram presented in Fig. 3:

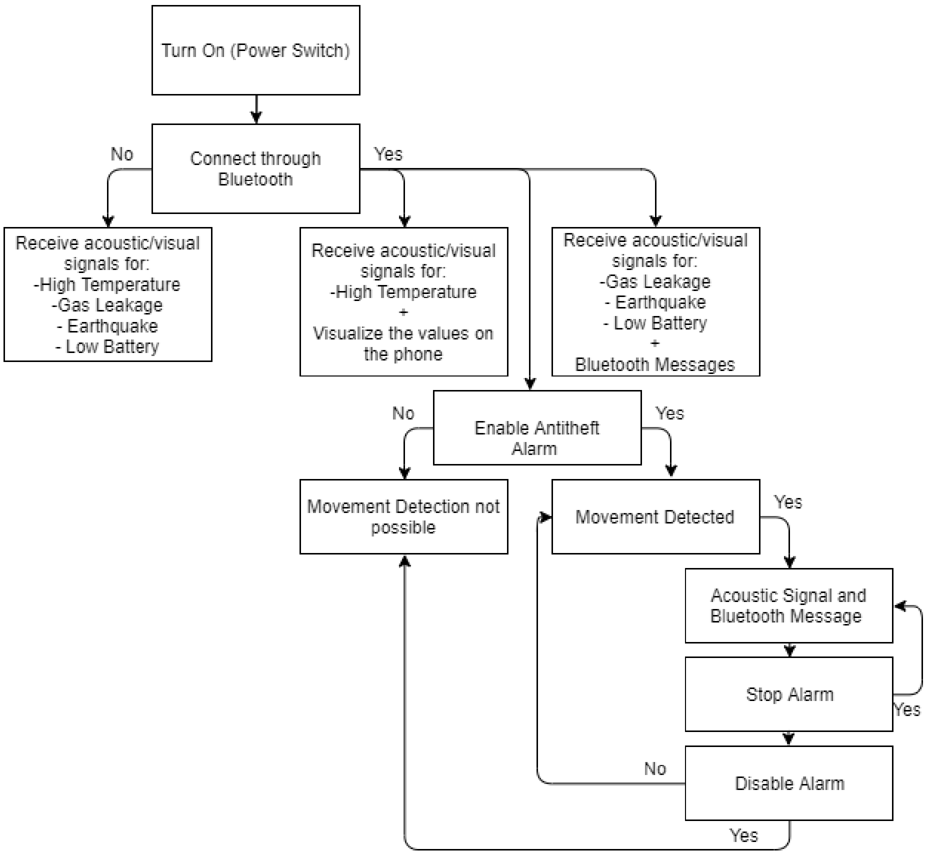

Fig. 3 – Functional diagram of the proposed system.

To be able to perform the functions presented in the diagram given in Fig. 3, the HW and SW will be designed, using carefully chosen parts.

The system architecture given in Fig. 4 shows the main modules and their connection for a proper operation.

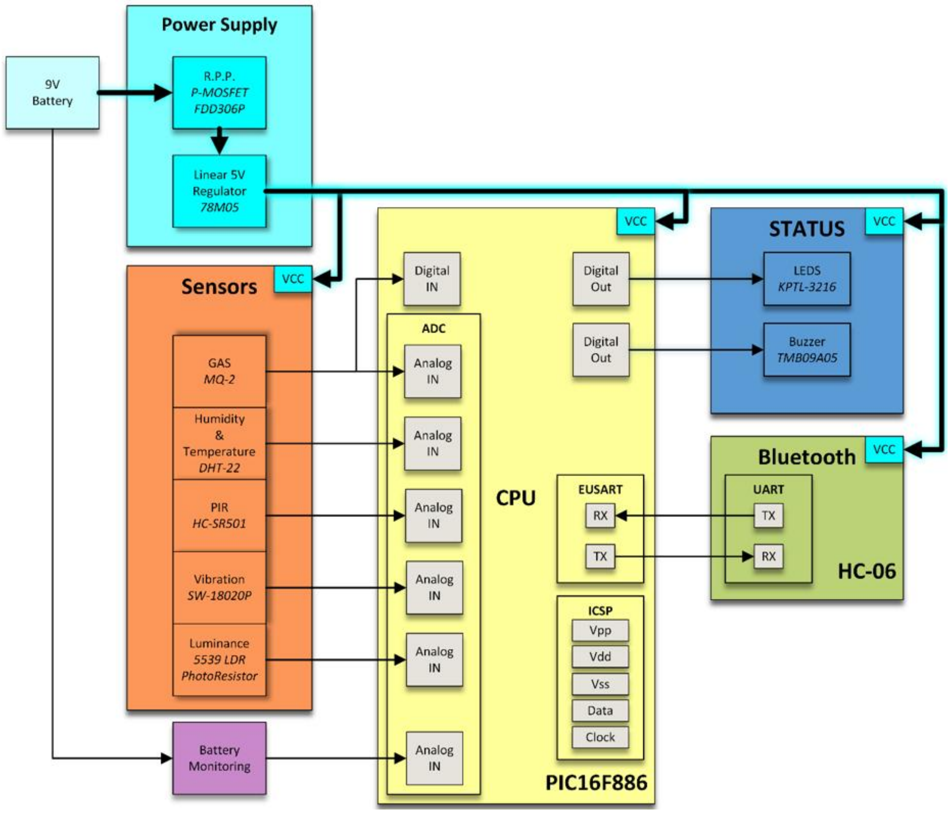

Fig. 4 – System architecture of the proposed system.

The Power Supply module is needed to supply the system parts with the correct voltage, and is consisting of a reverse voltage protection in case the battery will ever be set in the opposed way and a voltage regulator that stabilize the voltage at 5V, that is the voltage that all the parts will work with.

Sensors Module is the interface sensing the external factors that influence the system. As stated before, the system will detect gas, human presence (movement) vibration and light and will measure humidity and temperature. Besides this, supply voltage is monitored to keep track of the battery life.

The Central Processing Unit (CPU), the brain of the system, is a microcontroller from PIC16 family (Microchip, 2007) that is able to convert all the received signals at its ports, process the data and send information to the Status Module or through Bluetooth, to alert the user.

3. Power Supply Module Design

The diagram for the power supply module is presented in Fig. 5.

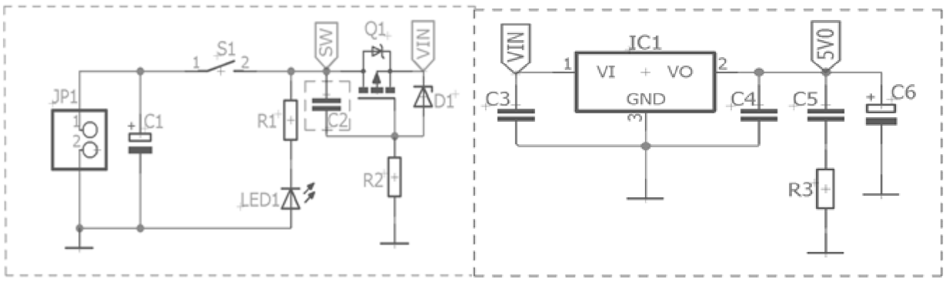

Fig. 5 – Power supply diagram.

JP1 Connector will be used for 9V battery connection. Capacitor C_1 is an electrolytic capacitor meant to be a buffer for the supply voltage, in case of a sudden drop, to give enough time for the MCU to send a short message that the battery fell off.

To calculate this time, formulas for capacitors will come in handy. Capacitor charge is proportional with capacity and voltage: (OpenStax, 2020)

$$Q = C*V \tag{1}$$

To calculate the minimum Capacitance value necessary for the capacitor to hold the voltage at a safe level of functioning for a time long enough for the MCU to run the number of instructions necessary to transmit the message via Bluetooth, the following formula can be used:

$$C= t/(\ln(V_c/V)*(V/I)) \tag{2}$$

where: V – Battery voltage; V_c – Voltage that capacitor is charged; I – Circuit current consumption; C – Capacitance; t – Discharge time.

Knowing the MCU working frequency and the numbers of instructions it executes at a time, the necessary time until the messages are send can be well calculated.

A value of 2 ms is considered more than enough to execute the instructions. Using the formula (2), the capacitance necessary for such job will be around 200 µF, so a capacitor with nominal capacitance value of 220 µF and tolerance of 20% is suitable.

The switch has to withstand a continuous current of a value compared to the maximum value necessary when all the consumers are active in the circuit.

LED1 will be used to warn the user when the battery is placed with reversed polarity and to function, it will need resistor R_1 to limit the current, which is explained with following formulas:

$$V_{R1} + V_{LED1} = V_{battery} \tag{3}$$

$$V_{R1} = I_{LED1} * R_1 \tag{4}$$

$$R_1 = (V_{battery} - V_{LED1})/I_{LED} \ [\Omega] \tag{5}$$

The power necessary for the resistor to withstand will be given by formula:

$$P_{R1} = V_{R1} * I_{R1} \ [\mathrm{W}] \tag{6}$$

Capacitor C_2 is not populated as the P-MOSFET Q_1, used for reverse polarity protection, will not work on switching thus a control of precise switching time is not necessary.

Diode D_1 is a Zenner diode, used to limit the VGS voltage at safe values for the MOSFET.

Voltage stabilization is done by a Linear Low Dropout Voltage Regulator (Texas Instruments, 1999), I_{C1} in schematic, having the following most important parameters to characterize it:

- Dropout Voltage
- Quiescent Current
- Efficiency
- Dissipated Power
- Stability

The dropout voltage is the difference in voltage from input to output at which the circuit fails to stabilize according to the necessary voltage, and it is represented in Fig. 6 across the input and output pins of Voltage Regulator (STMicroelectronics, 2018), placed in typical circuit topology. This usually happens when the input voltage is close to (as value) Output Voltage. The element that gives this limit is a simple resistor of a specific value R_{on}.

$$V_{dropout} = I_o * R_{on} \tag{7}$$

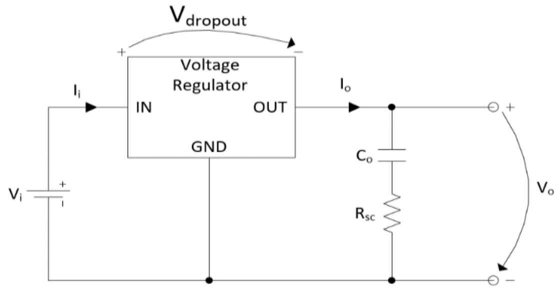

Fig. 6 – Typical circuit configuration for linear voltage regulators.

The quiescent current, I_q, or the current "leakage" for the voltage regulator is the difference between input and output current. Quiescent current has to be small to reduce power losses and maximize efficiency, given by formula (9) and shown in Fig. 7.

$$I_q = I_i - I_o \tag{8}$$

$$Efficiency = (V_o*V_i)/((I_o+I_q) * V_i) * 100 \tag{9}$$

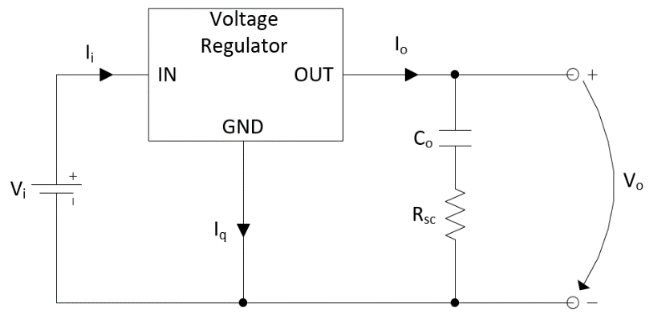

Fig. 7 – Circuit for quiescent current illustration at voltage regulators

Also, the power that is dissipated by the voltage regulator is also a measure of efficiency:

$$PD = (V_i - V_o) * I_o \tag{10}$$

The capacitors values and types to be used with voltage regulators are usually recommended in the datasheet of the voltage regulator, for stability and line compensation.

Additional to the two recommended capacitors, other capacitors can be used to filter a wider band of noise frequency, also a resistor can be used if the ESR value is too low, to set the regulator in the stable region.

4. Sensors Module Design

The Sensors Module contains the following submodules:

- Gas Detection,
- Temperature and Humidity Monitoring,
- Presence/Movement Detection,
- Vibration Detection,
- Light Detection,
- Battery voltage Monitoring.

Each of the submodules has to detect the corresponding phenomenon and generate the signal which can be monitored by MCU.

Gas detection is done with a gas sensor capable of detecting most of flammable and asphyxiating gasses with most important being methane, CH4, widely used as energy source in different environment, including homes.

The MQ-2 gas sensor can detect the presence of liquefied petroleum gas (LPG) which contains mainly propane and butane, the presence of methane, alcohol, smoke, etc. Its cost is low and is suitable for various applications.

The sensing material for MQ-2 is SnO_2 (Zhengzhou, 2015), which has a low conductivity in fresh air. When there is combustible gas in the air, the conductivity of the sensing material increases as the gas concentration increases. Therefore, using a simple circuit, the intensity of the conducted current will be converted into that of the output signal for the gas concentration. So, the higher the gas concentration, the higher the output signal voltage.

The sensor has the following properties: good sensitivity for a wide range of combustible gases, high sensitivity to LPG, propane and hydrogen, long life and low cost and simple interfacing circuit.

The MQ series of gas sensors intrinsically use a small heater (H pins) with an electrochemical sensor. It best measures the gases inside and at room temperature (A and B pins, shown if Fig. 8 representing the pinout of the sensor). By connecting a variable load resistor, the detection sensitivity of the sensor can be adjusted.

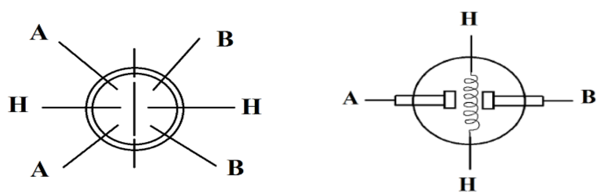

Fig. 8 – MQ-2 Sensor Pinout.

In Fig. 9 is presented the schematic of MQ gas sensor used for Digital and Analog detection.

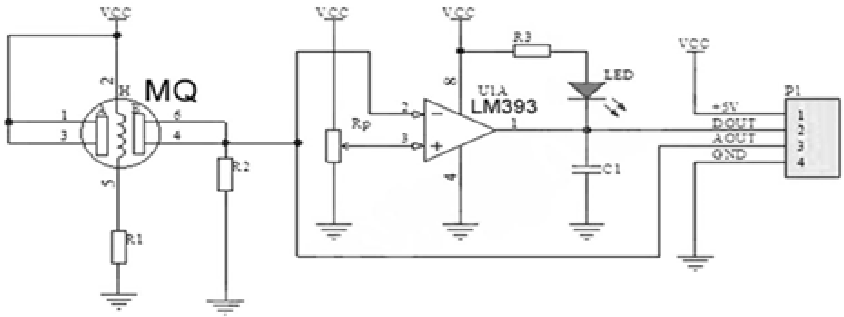

Fig. 9 – MQ-2 Gas Detection Module Schematic.

The detection circuit for the MQ-2 sensor consists of the sensor itself, properly connected. This sensor not only allows a binary indication of the presence of the gas but also allows the analog measurement of its concentration.

The temperature and humidity sensing part is based on the DHT22 (Digital Humidity and Temperature) sensor (Thomas, DHT22 datasheet) (Zahid, 2019), which consists of a thermistor to measure temperature and a capacitive humidity sensor to measure humidity (Thomas, 2004), shown in Fig. 10 along with the pinout.

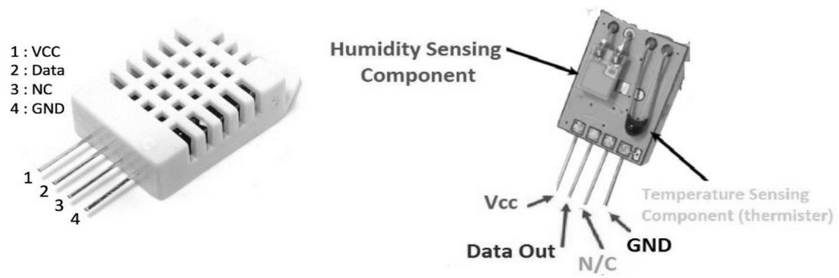

Fig. 10 – DHT22 Pinout.

For temperature measurement is used a sensor that has a negative temperature coefficient (NTC - Negative Temperature Coefficient) also called a thermistor (Dejan, 2016). A thermistor is a variable resistor that changes its resistance value as the temperature changes. For NTC thermistors the resistance varies inversely with the temperature: if the temperature increases, the resistance decreases.

To measure humidity, a component is used that has two electrodes with a substrate that retains moisture between them.

When the humidity changes, so does the conductivity of the substrate, or the resistance between the electrodes. Resistance change is measured, processed, and read by the microcontroller. Fig. 11 shows both the temperature and humidity sensors construction.

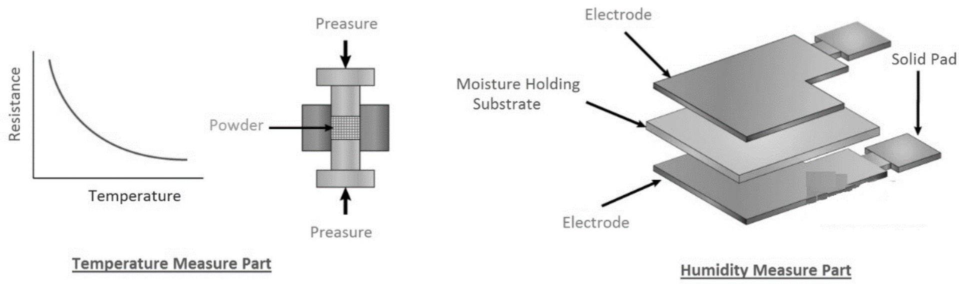

Fig. 11 – DHT22 Functioning Principle (Dejan, 2016).

Both temperature and humidity changes are processed by an integrated circuit placed on the other side of the device. It calculates the values of the two parameters and transmits them to the microcontroller using a single data line, through a serial protocol (Duma, 2004).

The datasheet suggests using a pull-up resistor to ensure the logic level when the pins change from input to output, to have a relevant data reading and to be able to validate the communication between the sensor and the microcontroller, shown in schematic diagram from Fig. 12.

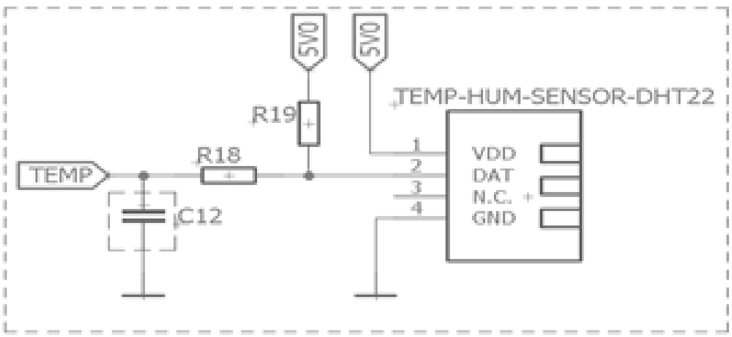

Fig. 12 – DHT12 Sensor used in schematic.

The motion detection part is made with the help of a PIR sensor (Passive Infrared or Pyroelectric), integrated in HC-SR501 module (DataSheet4U, HC-SR501). The term "passive" indicates that the sensor does not take an active part in the process, which means that it does not emit the infrared signal by itself, but rather passively detects infrared radiation from the environment.

These types of sensors are made of pyroelectric sensors (Emin, 2009), which detect the level of infrared radiation. Every thing emits a certain level of radiation, and the warmer that thing is, the more radiation it emits.

Infrared light is invisible to the human eye, although longer infrared waves can be perceived as heat. However, they share some characteristics of visible light such as: it can be focused, reflected and polarized.

A Fresnel lens is used to increase the range of detection of the sensor, capturing more infrared radiation and focusing it into a small point.

These lenses have been constructed translucently allowing only the passage of infrared radiation without being influenced by other radiation in the visible spectrum.

The pyroelectric sensor is actually divided into two halves. The reason for this was the desire to detect movement, changes in infrared levels and not just radiation levels. When the sensor is inactive both sides detect the same level of radiation in the environment, the two parts being connected so as to cancel each other out.

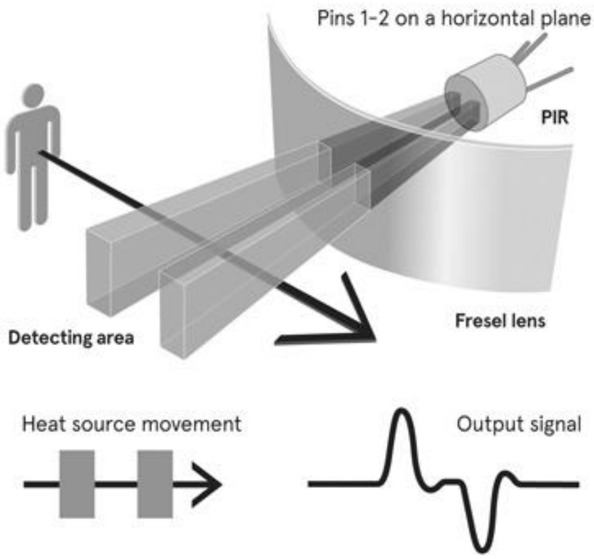

Fig. 13 – PIR sensor working principle (Emin, 2009).

When a warm body, such as a human or animal, passes in front of the sensor, it first intercepts one of the halves of the sensor, causing a positive differential change between the two halves. When a warm body leaves the detection area, the reverse happens, the sensor, generating a negative differential change, shown in Fig. 13. These pulses generated by differential changes are what the sensor detects as motion.

The circuit for the PIR HC-SR501 sensor allows an adjustment with the help of potentiometers for sensitivity, which regulates the maximum distance from which motion can be detected (ranging normally between 3 and 7 meters), and for the delay time, which regulates the amount of time for which the output will be active (from a minimum of 3 seconds to a maximum of 300 seconds).

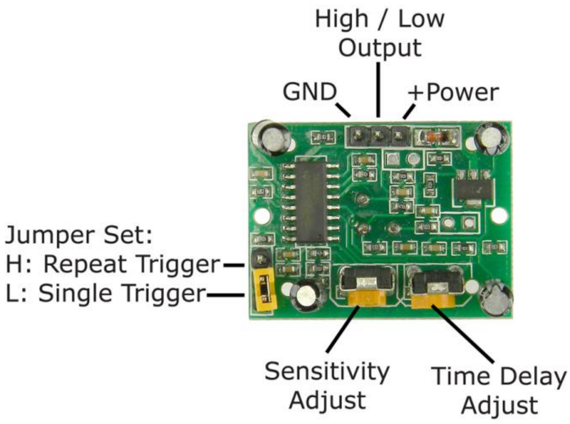

Fig. 14 – HC-SR501 PIR module construction (Datasheet HC-SR501).

The sensor can also be set in one of the two modes, using the Trigger Selection Jumper. H (Hold) is the mode in which the HC-SR501 will output a logical "1" signal as long as motion is detected. In L mode only the alarm will be triggered and the output will be in logical "1" for the time period set with the potentiometer. In most cases the H mode is used, being implicitly connected in the circuit. This information can be seen in Fig. 14 as well as in the PIR module construction.

For vibration detection of a potential earthquake, an SW-520D (BAILIN SW-520, datasheet) tilt sensor is used. Its operation is simple, as it acts like a switch. The sensor is built of an insulated, sealed cylindrical housing. At one end of the housing are the pins that conduct current when they are short-circuited by the mass inside that makes contact with them. The mass inside that connects the pins between them consists of two balls made of very good and sensitive conductive materials, shown in Fig. 15.

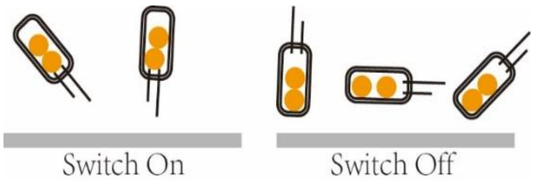

Fig. 15 – Tilt Sensor working principle (SW-520 Datasheet).

To use it as a vibration sensor, software processing is needed, in order to determine with precision the periods between each interruption of contact (reduce transient signals by using debouncing). Further on, the MCU will decide if the vibration type is coming from a possible earthquake.

Brightness detection is done with a photoresistor, which is also known as a photoconductor, photocell, or LDR (Kevin, 2014), shown in Fig. 16 schematic as PH1. This is a type of resistor whose resistance decreases with increasing light intensity, in other words, the higher the light intensity, the higher the intensity of the electric current through it. In the absence of light, the photoresistor acts as a material with high resistance, and in its presence, it behaves as a material with low resistance.

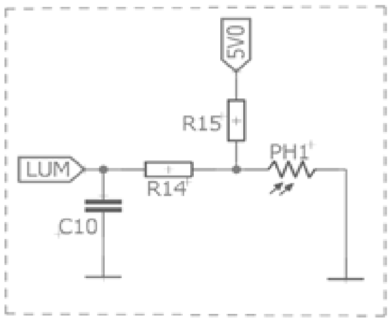

Fig. 16 – Schematic of photoresistor light monitoring system.

The battery monitoring, shown in Fig. 17, is done by dividing the voltage of 9 V of the battery marked with “SW”, representing the voltage from the switch output, to 5 V through a resistive divider formed by resistors R_7 and R_{11}, giving the signal to be monitored, and subsequently processed by software. The Zener D_2 diode has a protective role for the microcontroller, in the case of an overvoltage. The overvoltage applied to the divider will be blocked at its Zener voltage level, bearable for the microcontroller pin.

Resistor R_{12} together with capacitor C_8 has the role of filtering the signal from the voltage divider for better measurement accuracy.

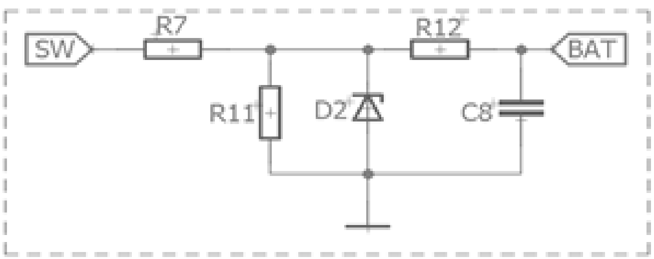

Fig. 17 – Battery Voltage Monitoring Schematic.

5. Communication and Status Module Design

Bluetooth communication is done using the HC-06 Bluetooth module (Erich, 2013; Aman, 2020) presented in Fig. 18 (or any other from HC family that can be plug and play). It can only be used as a slave (it cannot initiate and control communication but only responds to commands) and uses serial communication. Once connected, it transmits to the microcontroller only what it receives via Bluetooth, and whatever it receives from the microcontroller is transmitted to the connected device (Duma, 2001).

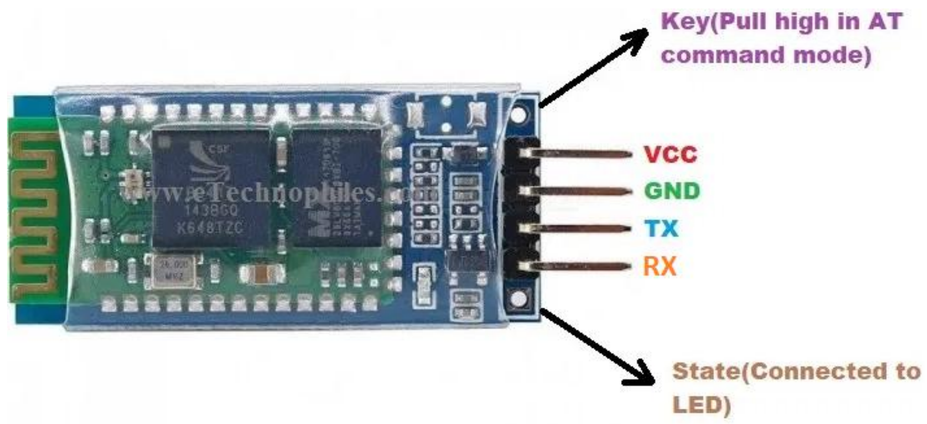

Fig. 18 – HC-06 Bluetooth module pinout.

Finally, the Status Module, shown in Fig. 19, is built from two parts: the part responsible for the light warning and the part responsible for the audio signals that can be received by the user.

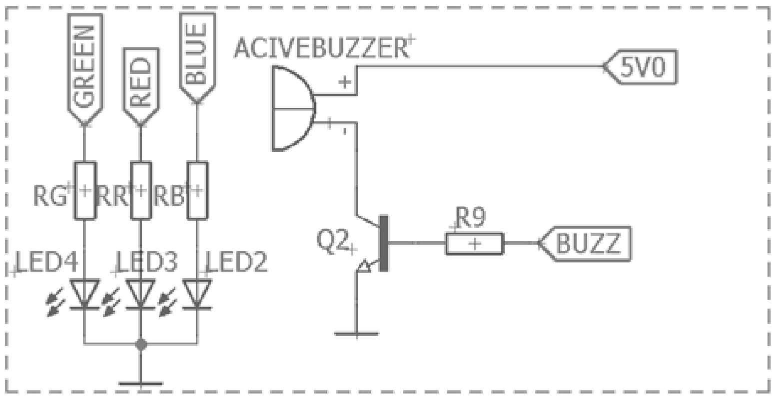

Fig. 19 – Status Module Schematic.

The light warning consists of 3 LEDs signaling certain conditions and modes, which are connected to the output pins of the microcontroller through resistors.

The audible warning activates a buzzer, in a certain way, when a certain alarm is desired. This buzzer is of the active type, with an oscillating circuit inside, so that when it is powered by a direct current, it will produce sound without the need for a power supply as an alternating voltage to create the sound.

The application used to communicate with HC Bluetooth module is free (on Google App Store) and easy to use, and with some short instructions, anyone can download and use it, as presented in Fig. 20.

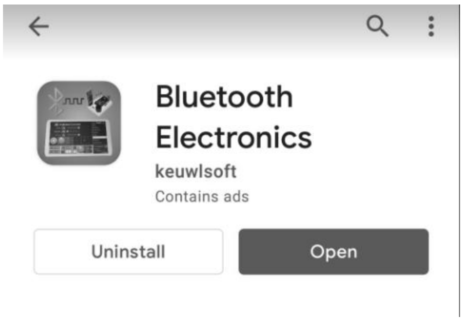

Fig. 20 –Application used for Bluetooth Communication for HC-06 module.

This application allows the user to select one of the already existing panels, for example the one for Temperature and Humidity sensor, in Fig. 21.

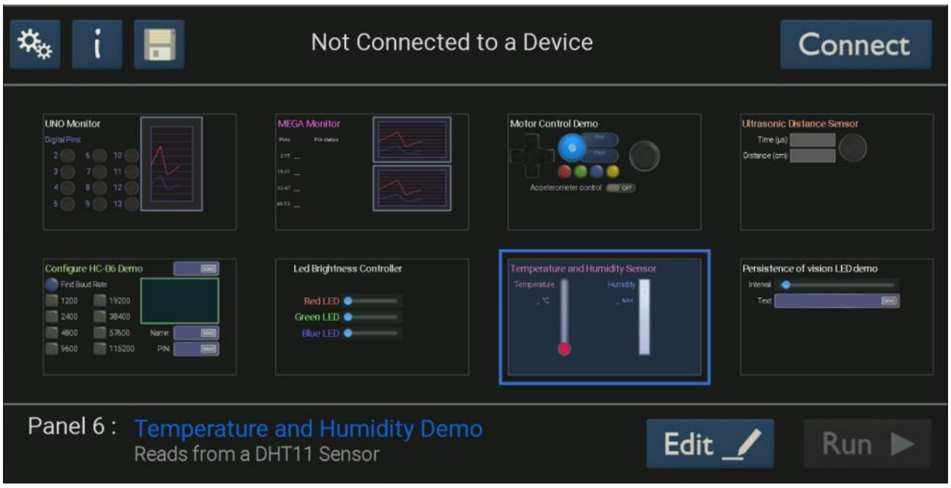

Fig. 21 – Interface for Bluetooth application.

Any user can create a new panel by adding different user controls such as indicators, buttons, etc., and edit the values that have to be received or transmitted through Bluetooth so the action can take place.

6. Device Testing

Several tests have been performed with the device, to validate the functioning from component point of view and from system point of view.

The PCB (Clarke, 2008) of the device is double layered, as it can be seen in Fig. 22 with parts assembled.

The device robustness has been tested with overvoltage (Fig. 23) and undervoltage (Fig. 24) tests, continuously for several seconds, to test the voltage regulator stability. The voltage regulator was tested and is capable of stabilizing the output at 5 V from a range of 7-12 V at input.

Fig. 22 – Device Under Test.

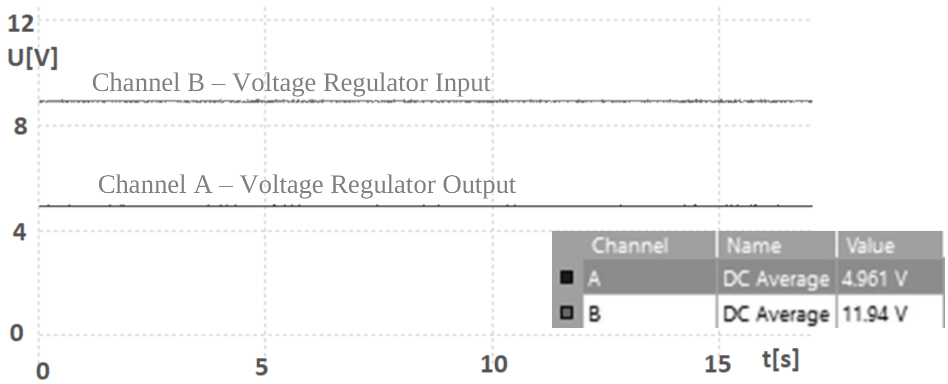

Fig. 23 – Stabilization from 12 V to 5 V from Power Supply Module (Overvoltage).

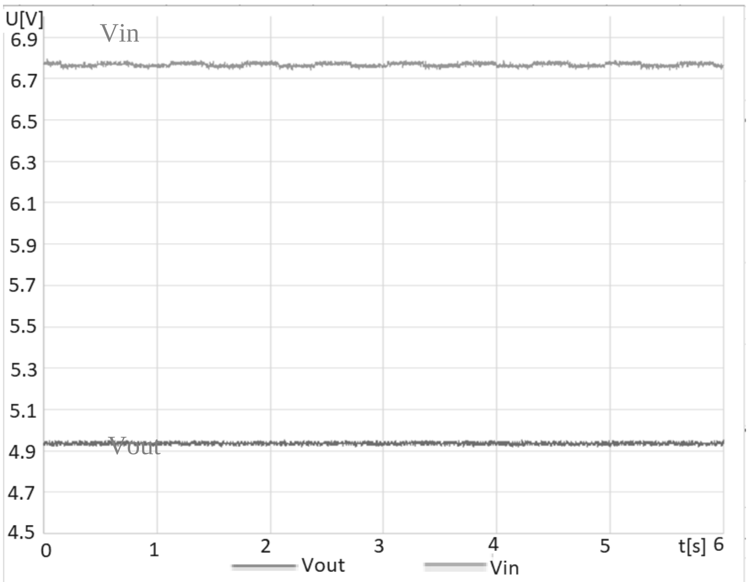

Fig. 24 – Stabilization from 7 V to 5 V from Power Supply Module (Undervoltage).

The current drawn by the circuit can be seen on the Voltage Source display, in Fig. 25 from Voltage Measurement setup, at around of 0.20 A maximum.

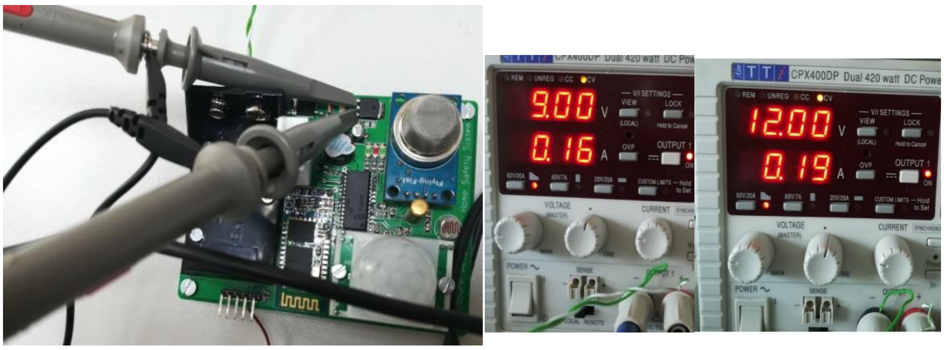

Fig. 25 – Setup for Voltage Measurement from
IN and OUT pins of voltage regulator.

Next test is performed to verify the robustness of the supply module when its input is submitted to sudden and fast voltage changes, presented in Fig. 26.

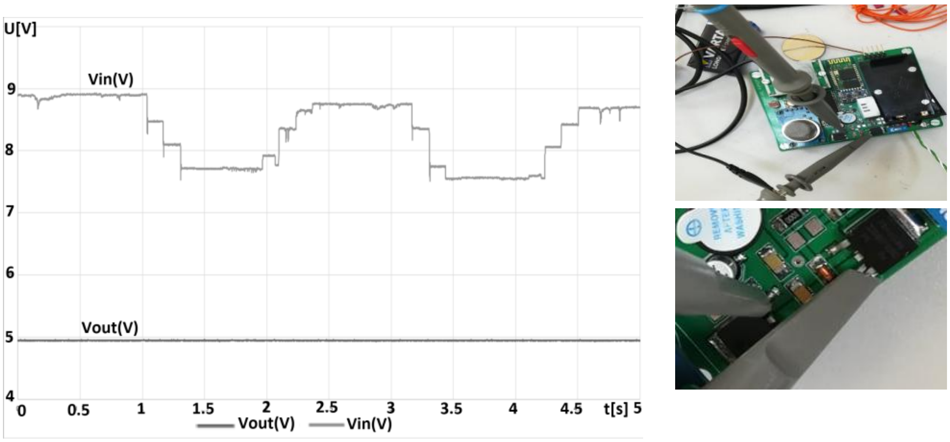

Fig. 26 – Input Voltage Changes robustness test.

For movement detection, the output of the PIR sensor module was connected to oscilloscope probe.

The H (Hold) mode is the mode in which the HC-SR501 PIR sensor module will output a logical “1” signal as long as motion that is detected. The voltage level for logical “1” is 3.5 V, as shown in Fig. 27.

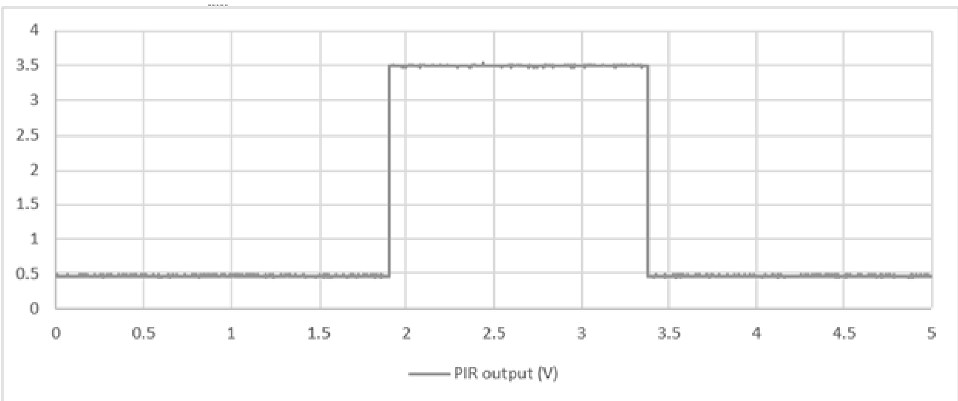

Fig. 27 – Movement detection with PIR sensor on Hold mode.

The device is also capable of detecting the light intensity and announce when it is night (it is getting dark). When the threshold value encoded for the signal taken from the photoresistor is exceeded, the microcontroller places the LED pin to high level (logical “1”) lighting the LED up, also visible in Fig. 28.

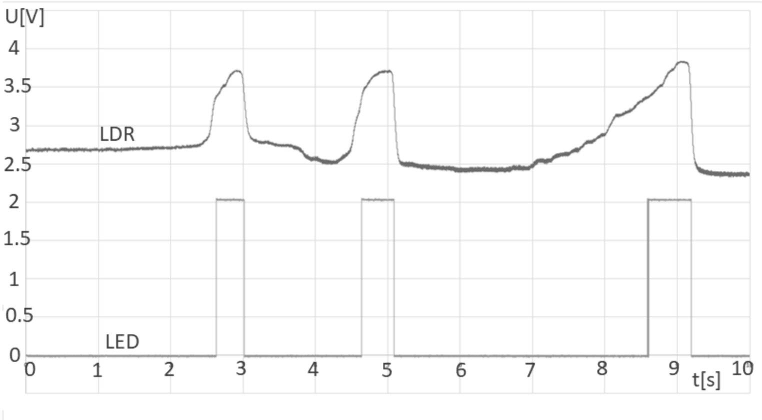

Fig. 28 – Light Monitoring.

When it is getting dark, the current through the device will decrease, and the voltage on the pin will increase, being more influenced by the power supply through the pull-up. When the analog-to-digital converter receives a voltage of approximately 3.2 V, the LED will turn on.

Gas is monitored by an MQ-2 sensor which provides an analog output signal (Honeywell, 11296_Gas Book). Knowing that this sensor has a maximum sensitivity to methane gas for the concentration of 1%, we can create the detection threshold lower than half the number of values allowed by the analog to digital converter. So, for 10-bit AD converter where there are 1024 values, the threshold of 500 is used. Therefore, when the gas concentration is reached (the appropriate threshold exceeded), the buzzer will ring for 2 seconds, and this can be seen in Fig. 29.

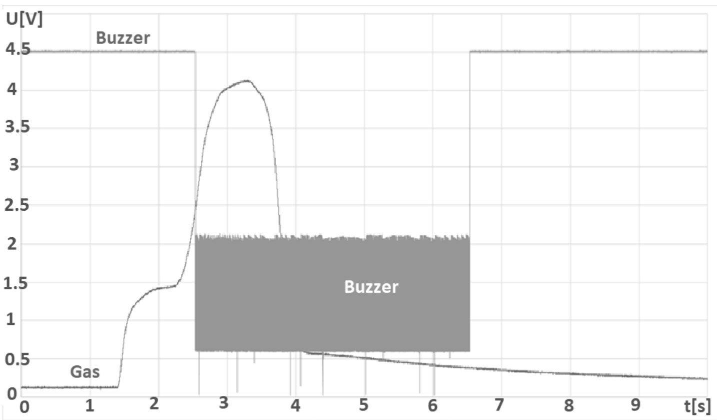

Fig. 29 – Gas Monitoring.

Certain vibrations can be detected by the device using the tilt sensor and software that detects some profiles corresponding to earthquake's first waves, P-waves (Primary waves). P-waves are pressure waves that travel through the earth faster than other waves, being the waves that arrive first at seismograph stations.

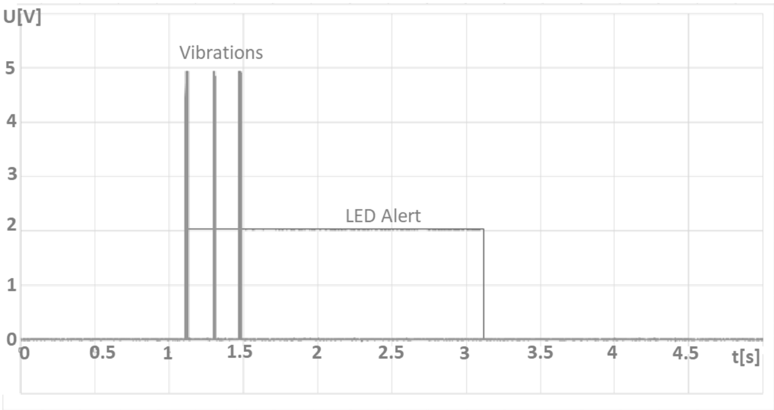

Fig. 30 – Vibration Monitoring.

The device was tested for this feature for some random vibration pattern to be sure it reacts and that the alarm goes off. In Fig. 30 can be seen the 3 voltage peaks corresponding to the vibration signal (more peaks are present in each line).

7. Conclusions

In the vast field of "ambient factors" monitoring techniques and devices, users will choose the ones that ensure best safety and reliability features. Monitoring more than a single parameter at a time, the device becomes multifunctional thus incorporating extra safety dimensions. Implementing a robust and user friendly design, combined with low cost and low maintenance, the Home Safety System can bring a significant improvement in every person's life.

REFERENCES

Aman Negi, *HC-06 Pinout, Specifications, Datasheet and Arduino Connection*, eTechnophiles website, October 12, 2020.

Bruce A. Bolt, *Earthquake*, Encyclopaedia Britannica, Earth Sciences, Last Update: Feb 1, 2021.

Clarke T., *The EAGLE Schematic & PCB Layout Editor - A Guide* © Imperial College London, 2005, 2006, 2007, 2008
Dejan, *DHT11 & DHT22 Sensors Temperature and Humidity Tutorial Using Arduino, Howtomechatronics Website, 2016*
Duma P., *Microcontrolerul INTEL 8051. Aplicaţii*, Ed. TEHNOPRESS, Iaşi, 2004.
Duma P., *Arhitectura sistemelor cu microprocesor. Microcontrolere*, Ed. Univ. Tehnice Gh. Asachi, Iaşi, 2001.
Emin Birey Soyer, *Pyroelectric Infrared (PIR) Sensor Based Event Detection*, Department of Electrical and Electronics Engineering and the Institute of Engineering and Sciences of Bilkent University, July 2009.
Erich Styger, *Using the HC-06 Bluetooth Module*, Instructables Website, June 19, 2013.
Kevin Spurr, *How an LDR (Light Dependent Resistor) Work*, Kitronik, 14 Jan 2014.
Sherali Zeadally, Farhan Siddiqui, Zubair Baig, *25 Years of Bluetooth Technology*, Future Internet, 9 September 2019.
Thomas Liu, *Digital-Output Relative Humidity & Temperature Sensor/Module DHT22 (DHT22 Also Named as AM2302)*, Aosong Electronics Co.
Thomas L. Floyd, *Electronics Fundamentals*, 6e, Chapter 9, Copyright ©2004 by Pearson Education, Inc. Upper Saddle River, New Jersey.
Zahid Ali, *Introduction to DHT22*, Blog Electronic Components, February 24, 2019.
Zhengzhou Winsen Electronics Technology, *Flammable Gas Sensor Model: MQ-2 Manual*, Version: 1.4 Valid from: 2015-03-10.
*** Amazon Website, Gas Detectors & Alarms, *Propane-Natural-Detector-Combustible-Explosive*, November 30, 2017.
*** Amazon Website, *ThermoPro-TP50-Digital-Thermometer-Temperature, 2017.*
*** BAILIN ELECTRONICS CO, *SW-520 Roll Ball Switch Datasheet.*
*** DataSheet4U, *HC-SR501 PIR MOTION DETECTOR*, Product Description.
*** Honeywell, *Honeywell Gas Detection. 11296_Gas Book*_V5_0413_LR_EN.
*** Microchip, *PIC16F882/883/884/886/887Data Sheet*, DS41291D, Microchip Technology Inc., 2007.
*** OpenStax, *RC Circuits*, LibreTexts, University Physics, Nov 5, 2020.
*** STMicroelectronics, *L78 Datasheet, Positive Voltage Regulator ICs*, DS0422 - Rev 36 - September 2018.
*** Texas Instruments, *Technical Review of Low Dropout Voltage Regulator Operation and Performance*, Application Report, August 1999.

SISTEM DE SIGURANȚĂ PENTRU ACASĂ: DISPOZITIV UTILIZAT PENTRU PREVENIREA CATASTROFELOR PRIN MONITORIZAREA SCURGERILOR DE GAZ, A TEMPERATURII ȘI UMIDITĂȚII AMBIENTALE, PENTRU DETECTAREA CUTREMURELOR ȘI A SITUAȚIILOR DE EFRACȚIE

(Rezumat)

Siguranța este din ce în ce mai mult dorită în zilele noastre, inclusiv în mașini, birouri, case și alte locuri în care petrecem timpul. Pe măsură ce casele noastre devin un loc în care petrecem cea mai mare parte a timpului, înlocuind birouri, restaurante și alte

locuri, șansa ca un eveniment tragic să se întâmple acasă crește. Prin urmare, este firesc să se mărească și măsurile de siguranță pentru ca aceste evenimente să fie detectate la timp și să se evite un potențial dezastru. Există multe dispozitive care pot monitoriza temperatura, scurgerile de gaz, cutremurele, mișcările etc., dar niciunul nu face asta, astfel încât să avem monitorizate simultan toate mărimile critice. Avantajul de a avea un dispozitiv pentru a monitoriza mai mulți parametri este clar: un nivel mai ridicat de siguranță obținut cu un singur dispozitiv.