Software for the intelligent operation of the lighting of public spaces

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ABSTRACT

The main purpose of this paper is to build the software based an intelligent electronic system and LDR (Light Dependent Resistor) sensor conecting in microcontroller Arduino Uno. A very interesting but also very useful part of this scientific research is the measurement of electrical quantities with high precision as intelligent machines know and can achieve, and one of them in this case is the Arduino Uno microcontroller. These measurements of electrical quantities such as voltage, resistance, and current intensity are used in programmable logic in the microcontroller to decide when to light a light or more and when not to light. Of course, this problem has been solved by using the LDR sensor in the electronic system. Such an electronic and programmable system works perfectly. The work itself contains solutions of electrical circuits in an analytical way, connection of electronic circuits with the Arduino Uno module, communication with the input and output devices of the ATMEGA 328P microcontroller interface and the fusion of the source code - Sketch. This paper will serve as a good basis for further research in determining the moment of ambient darkness to start lighting public spaces. All the measurements of electrical quantities through the Arduino Uno microcontroller have also been confirmed with the measurements made through the universal voltmeter instrument. The results of each measurement are very approximate, of course, many times faster and more accurate than those with a microcontroller.

Keywords: Software, Sensor, Microcontroller, Arduino, Sketch, Voltage, Current, Resistance, LDR, Led

1. INTRODUCTION

Numerous automatic systems in high electronic technologies in all areas of social and economic life today are based on sensors and microcontrollers. This paper presents the system built based on the sensor connected to the microcontroller Arduino Uno ATMEGA 328P [1], [2], [3]. Microcontrollers of different types enable the construction of smart systems, which in most cases are called intelligent systems or even robots. This is made possible by the programmable logical components, respectively software and undoubtedly also the hardware components [8]. Microcontrollers are, in fact, a type of microcomputer that, unlike ordinary computers, electronic devices such as sensors, microswitches, push-buttons and the like can be connected to their input. As long as their outputs can also be connected to electronic devices such as actuators, signal lights such as LEDs (Light-Emitting Diode), contact relays with NO (Normal Open) and NC (Normal Close) contacts, sound and light alarm devices and similar [6] , [9]. In fact, the microcontroller represents a perfect communication interface that enables communication between the input and output devices of the system as a whole. This communication is enabled by the source code according to an algorithm written in the programming language C or C++ within the environment of the Arduino Uno microcontroller in most cases because the possibility of source codes in other programming languages such as Payton, Basic and Pascal is not excluded [10], [19]. The block diagram of the connections of the input and output devices in the microcontroller looks like in Figure 1.
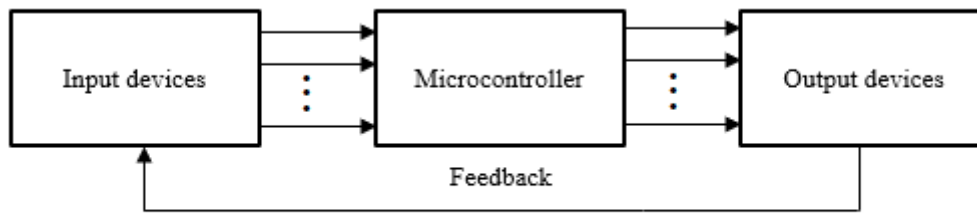
Figure 1. Microcontroller connections to input and output devices

In the specific case of this paper, we are dealing with the electronic system built based on the LDR (Light Dependent Resistor) sensor technology, which is connected to the input of the microcontroller and to the analog pin-port A0 [1], [4], [29], [30]. At the output of the microcontroller, an electromagnetic relay with two contacts NO and NC is connected to the electromagnetic coil 5 [VDC] that enables the lighting system of the spaces, either private or public, with a voltage source of the electrical network of 220 [VAC] [13], [22]. Of course, for the operation of this system built based on the LDR sensor, it is necessary to write the program code in the C++ programming language inside the Arduino Uno environment. The software code works on the basis of the analog input signal brought by the LDR sensor depending on the degree of brightness of the environment where the system is located. Therefore, the analog signal is variable [4], [5]. Depending on the degree of brightness of the environment where the LDR sensor is located, its resistance also changes according to the function given in Figure 2.
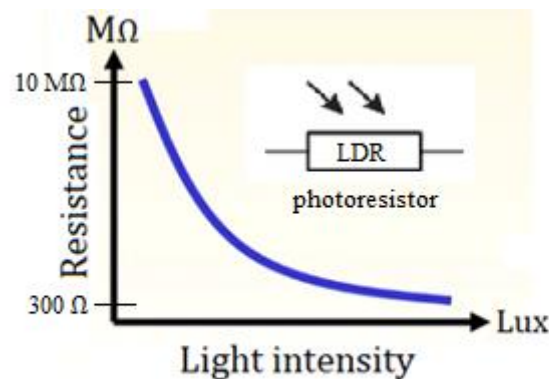

Figure 2. Variations in resistance to change in light intensity

For any value of the change in the resistance of the LDR sensor under the influence of light, be it natural within 24 hours or the influence of an artificial light caused by alternative electrical sources, the measurements are performed and at the same time, through the program code loaded in the Arduino Uno module, it is ordered to turn on or off the contact relay so that the system based on the LDR sensor works [7], [11], [14]. The essential purpose of this paper is to measure not only the change in resistance but also the voltage and current intensity in the LDR sensor circuit within every second if we want that too without completely disconnecting the electrical circuit in the system. These measurements serve us for certain values to activate the electrical circuit of the 220 [VAC] network in order to illuminate the darkened environment or in special cases it can also be used in medicine to determine the wavelength of light which affects in the human eye. This will be the subject of the study of the next paper in collaboration with health professionals and optical physics [12], [15], [16].
The block diagram of the connection system for public lighting based on the sensor consists of various electronic elements and programmable technology, respectively microcontroller, and is presented as in Figure 3.
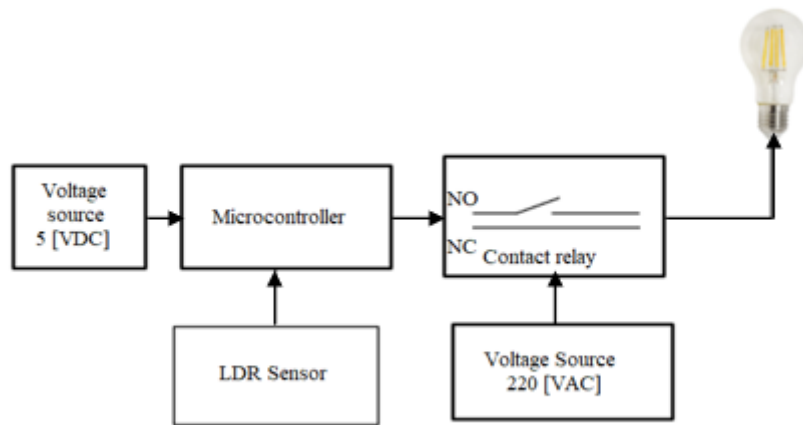
Figure 3. Block diagram of lighting system connections

2. METHOD

The method of measuring electrical quantities, the intensity of the electric current in the established circuit of the LDR sensor, the voltage between the two ends of the sensor and its resistance, always taking into account during the working regime of the electronic system based on the LDR sensor is mainly experimental. The measurement of the voltage between the two ends of the LDR sensor is also performed with a universal instrument or voltmeter [23]. The numerical values of the voltage measured with the Arduino Uno module, respectively the Atmega 328P microcontroller, completely match the measurements made through the voltmeter. Of particular importance is the fact that the measurement of these three electrical quantities is performed during the working mode of the electronic system and without disconnecting the electrical circuit [25]. First, we connect the LDR sensor to the analog port A0 of the Arduino Uno module as shown in Figure 4.
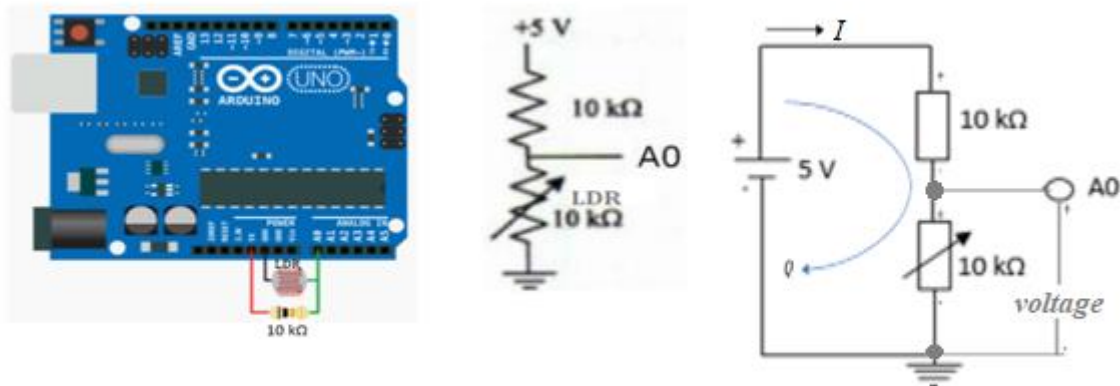

Figure 4. connecting the LDR sensor to port A0 of the Arduino Uno module

The indicated resistance of the LDR sensor of 10 [kΩ] belongs to a working regime at a certain degree of brightness, while the other resistor with resistance also 10 [kΩ] is connected for the purpose of voltage division to protect the LDR sensor and the port A0 and with this even the microcontroller from destruction. If we do not connect the resistor of 10 [kΩ] for dividing the voltage at the moment when the luminance is maximum, then the resistance of the LDR sensor will decrease to a few ohms and an unacceptable current intensity will flow for the sensor, port A0 and the Arduino Uno module itself. to cause destruction of the programmable electronic device [18], [26]. The variable analog signals that the sensors receive in this case are the light rays, sometimes with more expressed intensity and sometimes weakened. Due to the fact that the LDR sensor is continuously exposed to light, these light beams produce analog signals because the luminance intensity changes from moment to moment. These signals are returned (converted) to digital signals in the corresponding A/D-converter devices located at the input of the Arduino Uno module, in order to achieve their processing in the microcontroller [27]. The read values of the analog signal are in the range *[0.1023],* because the resolution of the A/D (Analog to Digital Converter) converter is 10 bits ($2^{10} = 1024$,

this means that the microcontroller processor is 10 bits per supply voltage of 5 [VDC]). Therefore, it is necessary to determine the formula for the return of digital read values at each moment of time in voltage [21], [17], [3].

$$voltage = value \cdot \frac{5\,[V]}{1023} \tag{1}$$

$voltage-$ variable representing the voltage measured on pin A0 of the Arduino Uno module
$value -$ variable which represents the reference analog value read in port A0 by the LDR sensor but converted to digital in the range [0, 1023] through the A/D converter so that the microcontroller processor can process them.
Based on the electronic connections in Figure 4 and equation (1) we can now write the program code in C++ inside the Arduino Uno environment, namely the sketch through which the voltage in the sensor is measured and that in every second of the time and the results are displayed in the Serial Monitor window [2], [6], [20].

```
void setup()
{
  Serial.begin(9600); //microcontroller communication with computer
}
void loop()
{
  int value=analogRead(A0); //reading the analog values of the signal in the LDR sensor
  float voltage=value*5.0/1023.0; //calculation of voltage in LDR sensor
  Serial.print("The value read by the sensor:\t");
  Serial.print(value); //print analog values read but converted to digital
  Serial.print("\t");
  Serial.print("Voltage in Volts:\t");
  Serial.print(voltage);//printing the calculated voltage value in Volts
  Serial.println("V");
  delay(1000); //one second dead loop time delay
}
```

After uploading this program code to the Arduino Uno Atmega 328P microcontroller and opening the Serial Monitor window, simultaneously illuminating the LDR sensor with different luminance intensities in the form of artificial lighting, we will have this result [4], [24], [28]:

```
The value read by the sensor:    1008    Voltage in Volts:    4.93 V
The value read by the sensor:    445     Voltage in Volts:    2.17 V
The value read by the sensor:    380     Voltage in Volts:    1.86 V
The value read by the sensor:    22      Voltage in Volts:    0.11 V
The value read by the sensor:    6       Voltage in Volts:    0.03 V
```

Figure 5. The Serial Monitor window for presentation of the measurements performed by the microcontroller

Now to calculate the resistance of the LDR sensor, when it is illuminated at maximum brightness then the sensor resistance of 10 [MΩ] drops drastically. Since the voltage is measured with a voltmeter at point A0, respectively at the two ends of the LDR sensor, and that voltage is 0.08 [V] when the photosensor is illuminated by a light source, the resistance of the LDR sensor under high brightness conditions must be calculated! From the electronic circuit given above, it can be seen that between the two ends of the LDR sensor the voltage is 0.08 [VDC] which is measured by a voltmeter, then for this part of the electronic circuit we derive the simplified electrical scheme Figure 6 as follows:
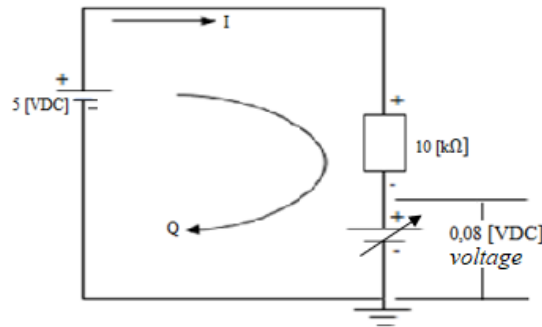
Figure 6. The electrical circuit when the sensor is maxmimally illuminated

To calculate the resistance of the sensor according to Ohm's Law we have:

$$R = \frac{0,08\ V}{I} \tag{2}$$

when at its ends the voltage is 0.08 [V] first we need to calculate the current in the electric circuit. The equation according to Kirhoff's second law in the assumed Q contour as in Figure 6 above is defined as follows:

$$5\ [V] - 10\ [k\Omega] \cdot I - 0,08\ [V] = 0 \tag{3}$$

From this it follows that the current intensity *I* is: $I = 0,49\ [mA]$. The resistance of the LDR sensor can now be calculated according to Ohm's law. $I = 0,49\ [mA]$

$$R = \frac{0,08\ V}{I} = \frac{0,08\ [VDC]}{0,49 \cdot 10^{-3}[A]} = 163\ [\Omega] \tag{4}$$

From this it can be seen that with high brightness the LDR sensor from its resistance in the dark of 10 [MΩ] is reduced to the resistance of 163 [Ω]. In variable light intensity, the resistance of the LDR sensor will also be variable! To measure, respectively, the resistance of the sensor is calculated in certain moments of time, we start from equation (1) and circuit Q in Figure 6 to which electric circuit we write the equation according to Kirhoff's second Law for voltages as follows:

$$5\ [V] - voltage - 10[k\Omega] \cdot I = 0 \tag{5}$$

From equation (5) we derive the following equation for calculating the current intensity:

$$I = \frac{5\ [V] - voltage\ [V]}{10 \cdot 10^3[\Omega]} \tag{6}$$

Finally, starting from Ohm's Law, we calculate the resistance value R of the LDR sensor:

$$R = \frac{U}{I} = \frac{voltage\ [V]}{\frac{5\ [V] - voltage\ [V]}{10 \cdot 10^3[\Omega]}} = \frac{voltage\ [V] \cdot 10 \cdot 10^3[\Omega]}{5\ [V] - voltage\ [V]} = \frac{10000 \cdot voltage\ [V] \cdot [\Omega]}{5\ [V] - voltage\ [V]} = \frac{10000 \cdot voltage}{5 - voltage}\ [\Omega] \tag{7}$$

The variable voltage variable in the LDR sensor that depends on the intensity of illumination 24 hours a day is calculated according to equation (1) $voltage\ [V]$.

Now the program code for measuring the voltage and resistance of the LDR sensor will be:

```
void setup()
{
 Serial.begin(9600); //microcontroller communication with computer
}
void loop()
{
 int value=analogRead(A0); //reading the analog values of the signal in the LDR sensor
 float voltage=value*5.0/1023.0; //calculation of voltage in LDR sensor
 float resistance=10000*voltage/(5-voltage); //calculation of LDR sensor resistance
 Serial.print("The value read by the sensor: ");
 Serial.print(value); //print analog values read but converted to digital
 Serial.print(" ");
 Serial.print("Voltage in Volts: ");
```

```
Serial.print(voltage); //print the calculated voltage value in Volts
Serial.print("V");
Serial.print(" Resistance in Ohm: ");
Serial.print(resistance); //print the calculated resistance value in Ohms
Serial.println("Ω");
delay(1000);
}
```

After uploading this program code to the Arduino Uno Atmega 328P microcontroller and opening the Serial Monitor window, simultaneously illuminating the LDR sensor with different luminance intensities in the form of artificial lighting, we will have this result [4], [5], [8]:

```
The value read by the sensor: 1009  Voltage in Volts: 4.93 V  Resistance in Ohm:  720715.00 Ω
The value read by the sensor: 480  Voltage in Volts: 2.35 V  Resistance in Ohm:  8839.78 Ω
The value read by the sensor: 407  Voltage in Volts: 1.99 V  Resistance in Ohm:  6607.14 Ω
The value read by the sensor: 3  Voltage in Volts: 0.01 V  Resistance in Ohm:  29.41 Ω
```

Figure 7. Serial Monitor window for measuring the voltage and resistance of the LDR sensor when it is illuminated with different luminance expressed in Lux

The intensity of the electric current in the LDR sensor based on the electric circuit in Figure 6 is also the current of the electric circuit alone. Therefore, starting from equation (5) and (6), we have the following equation for calculating the intensity of the electric current:

$$I = \frac{5\,[V] - voltage\,[V]}{10\,[\Omega]} \cdot 10^{-3} = \frac{5 - voltage}{10}\,[mA] \tag{8}$$

The intensity of the electric current is expressed in the unit [mA] because even then it is not possible to achieve a higher intensity since measures were taken in time with the selection of the resistor from the single electric circuit where the LDR sensor is located. This is also a preventive measure to protect the A0 port of the Arduino Uno module and with it the ATMEGA 328P microcontroller itself, because according to the technical characteristics of the Arduino Uno module given in references [2], [3] and [21] the maximum current of allowed on a module port is 20 [mA]. $10\,[k\Omega]$

Finally, we get the program code written in the C++ programming language under the Arduino Uno IDE environment, which is called Sketch and which calculates the voltage, resistance and current intensity of the LDR sensor as follows:

```
void setup()
{
  Serial.begin(9600); //microcontroller communication with computer

}
void loop()
{
  int value=analogRead(A0); //reading the analog values of the signal in the LDR sensor
  float voltage=value*5.0/1023.0; //calculate the voltage in volts [V] of the LDR sensor
  float resistance=10000*voltage/(5-voltage); //calculate the resistance in Ohm[Ω] of the LDR sensor
  float I=(5-voltage)/10; //calculate the current intensity in [mA] of the LDR sensor
  Serial.print("Analog value: "); //analog value read on the sensor converted to digital,
                          //through A/D converter within range [0, 1023]
  Serial.print(value);//print the read value
  Serial.print("\t");
  Serial.print("Voltage=");
  Serial.print(voltage);//print the calculated voltage value in volts
  Serial.print("[V]");
  Serial.print("\t\ ");
  Serial.print("R=");
  Serial.print(resistance); //print the calculated resistance value in ohms
  Serial.print("[Ω]");
  Serial.print("\t");
  Serial.print("I=");
  Serial.print(I); //print the calculated value of current intensity in milliamperes
```

```
  Serial.println("[mA]");
  delay(1000);
}
```

After uploading this program code to the Arduino Uno Atmega 328P microcontroller and opening the Serial Monitor window, simultaneously illuminating the LDR sensor with different luminance intensity in the form of artificial lighting, we will have this result [4], [25], [26], [27]:

```
Analog value: 1011      Voltage=4.94[V]      R=842500.87[Ω]    I=0.01[mA]
Analog value: 480       Voltage=2.35[V]      R=8839.78[Ω]      I=0.27[mA]
Analog value: 64        Voltage=0.31[V]      R=667.36[Ω]       I=0.47[mA]
Analog value: 4         Voltage=0.02[V]      R=39.25[Ω]        I=0.50[mA]
```

Figure 8. Serial Monitor window with measured voltage, resistance and current results in the LDR sensor

3. RESULTS AND DISCUSSION

All this current analysis related to the calculation of electrical quantities such as the voltage between the ends of the LDR sensor, its resistance and the intensity of the current that passes through the electrical circuit where the LDR sensor is connected serve us for the construction of various electronic controlled systems with relevant software. In this regard, it is worth noting that the Arduino Uno module in this case turns into an excellent measuring instrument and many times more accurate, faster, more flexible and more convenient than any other universal instrument. On the other hand, all measurements of electrical quantities in this case are performed without completely disconnecting the electrical circuit. What is more interesting is the measurement of the variable resistance of the LDR sensor, resistance which changes depending on the intensity of the light falling on the LDR sensor. The material of this sensor is semiconductor, therefore the properties of semiconductors in this electronic system are very suitable for study. There is no doubt that measuring the resistance of the LDR sensor but also any other resistor within the time when the electronic system is in working mode is impossible. With the help of the sketch-program code uploaded to the Arduino Uno ATMEGA 328P module, the voltage, resistance and current measurements are performed every second, maybe they can be performed in intervals even smaller than seconds, which manually an engineer would not be able to do. I perform them in the traditional way with a universal standard instrument. The microcontroller performs the measurements of the aforementioned electrical quantities such as voltage, resistance and current intensity of the LDR sensor simultaneously, which with a universal instrument of the standard manual form would never be achieved! During the realization of this work, the measurements of the voltage and current passing through the LDR sensor during the working regime of the system with the universal instrument voltmeter and ammeter have been compared, which results have always been correct and identical, and many times more reliable than those of the microcontroller than measurements with a universal instrument because the microcontroller can provide values with more digits after the decimal point, which the universal instrument does not reach! In the following we will present an excellent practical example of where the read values of the electrical quantities discussed above can be used and what the practical effect is. Undoubtedly, thanks to this, **a public lighting system has been built through the LDR sensor and "2 Relay Module" Relay Contact type:** JQ-3FF-SZ, through which a lamp that is supplied by an external electrical source is switched on. of the city network voltage of 220 [VAC] shown in Figure 1. The same system can be used to connect more lights to illuminate streets, squares, parks or other spaces in a city. In order for the system built and based on the LDR sensor to work perfectly, the calculated voltage values are used, the resistance or intensity of the electric current is understood in the LDR sensor every second of the time within the 24-hour day and performs their comparison with an appropriate value depending on the geographic location of the globe where this electronic system is used, which enables the system to turn on the lights (when it rains) at a voltage of 220 [AC] and at the next moment (when it dawns) to cut off the electricity supply to the lights from the city network. This electronic system based on the LDR sensor is shown in Figure 9.
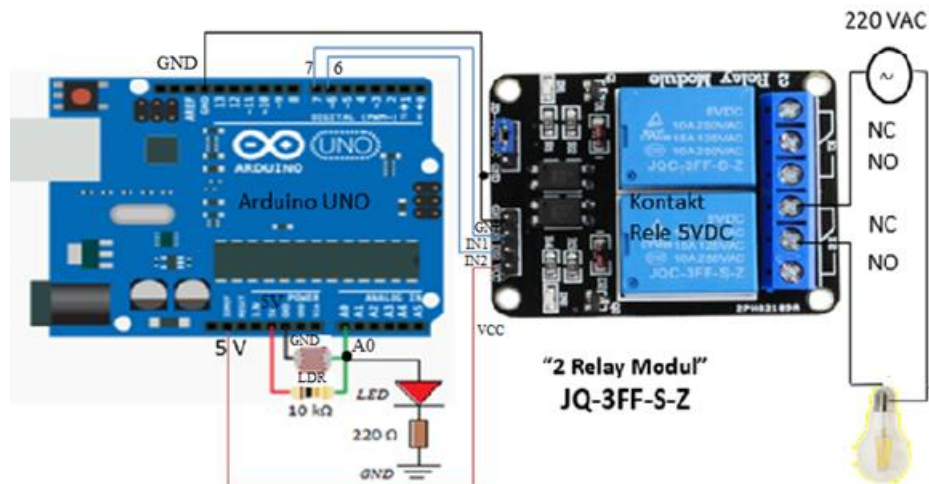
Figure 9. Public lighting system through the LDR sensor as well as "2 Relay Module" Relay Contact type: JQ-3FF-S-Z

Electrical connections in the system have the following meaning:

1. The common-ground (GND) connection point that connects to the Arduino UNO on either the input or output pins

2. Also the common-ground (GND) connection point that connects to the Arduino UNO either on the input or output pins

3. IN1 – input signal 1 (Input 1) that comes from output pin 7 of the Arduino Uno module. It is usually a voltage from 0 to 5 [VDC]. This input signal depends directly on the analog signal on the A0 input pin of the Arduino Uno module.

When the intensity of the light falling on the LDR sensor connected to pin A0 of the Arduino Uno module is large and creates a voltage according to the condition in the programming code of less than 1 VDC, then the light turns off - the public lighting is interrupted. This means that there is enough natural lighting from sunlight. From this, according to the condition in the program code, output pin 7 will have a LOW voltage value, which actually activates the contact K1 (switch K1) and disconnects (opens) the contact K1 (NC) and prevents the existence of the 220 VAC voltage, which supplies one and more many lights up to the permitted limit of the current flow through the contact maximum 10 A in the specific case!

At the next moment when the light falls, the light rays are absent on the surface of the LDR sensor, then the values read on pin A0 will form a greater voltage than when the sensor is illuminated and if according to the program condition the voltage is greater than 1 then in bit 1 or the HIGH voltage is sent to pin 7 of the Arduino Uno module, which means the closing of the K1 contact, which enables the closing of the 220 VAC alternating electrical circuit that supplies one or more lights up to the maximum allowable limit of current flow through the contact 10 And in this case!

4. IN2 – input signal 2 (Input 2) that comes from the output pin 6 of the Arduino Uno module. It is usually a voltage from 0 to 5 V DC. This signal applies to contact K2 of the relay contact and everything that applies to IN1 simultaneously also applies to the input signal IN2. Also, for contact K1, all that was said above also applies to IN2.

5. VCC the point to which the voltage of 5 VDC is connected and is taken from the 5 V pin of the Arduino Uno module. This tension

enables the operation of the module: **"2 Relay Module"** type: JQ-3FF-SZ

6. Point 6 contactor contactor K1, NC in the 220 VAC alternating voltage network

7. Point 7 contact connector K1, NC in the network of alternating voltage 220 VAC

8. Point 8 of contactor contactor K2, NC in the network of alternating voltage 220 VAC

9. Point 9 of the K2 contactor contact connector, NC in the 220 VAC alternating voltage network

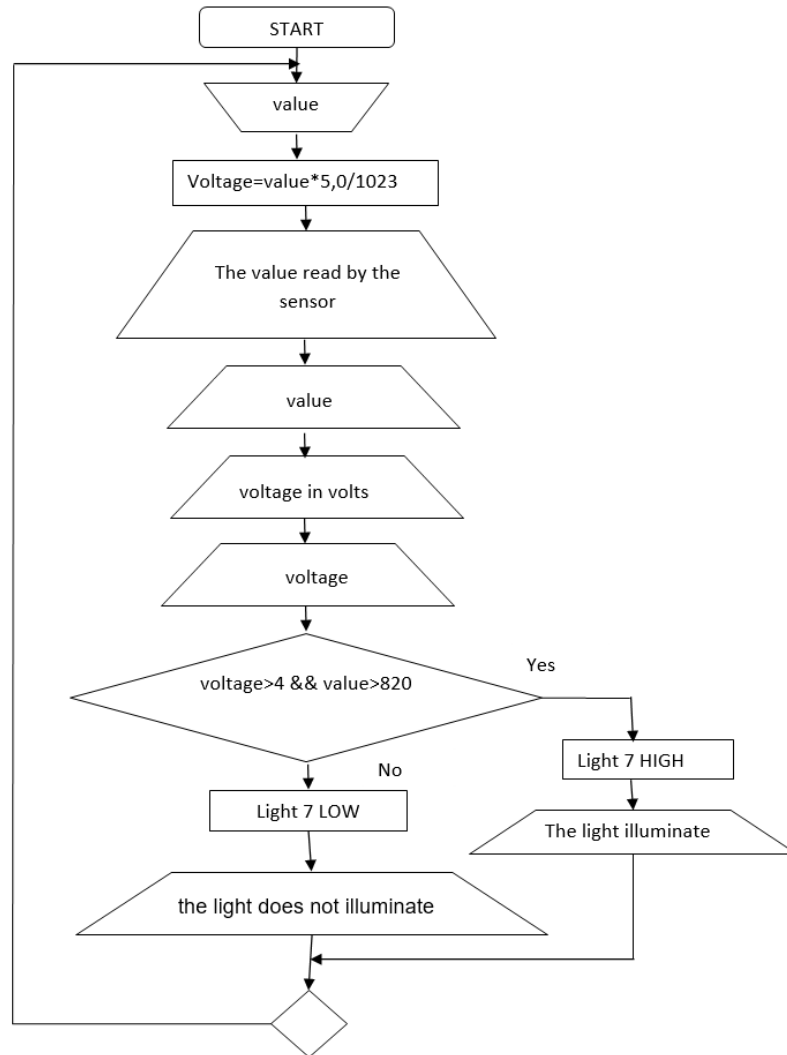The graphic algorithm for switching on or off the public lighting looks like in Figure 10:

Figure 10. The graphic algorithm for switching on or off the public lighting

The program code for the intelligent operation of the lighting of public spaces or any space where people want to implement them looks like the following:

```
int light = 7; //output pin 7 on the Arduino turns on the light and connects to the IN1 pin of the relay
void setup(){
  pinMode(light, OUTPUT); // pin 7 is declared output
  Serial.begin(9600); // microcontroller communication with computer
}
void loop()
{
  int value=analogRead(A0); //read luminance values [0.1023]
  float voltage=(value*5.0)/1023; //voltage calculation
  Serial.print("The value read by the sensor:\t"); //text to Serial Monitor
  Serial.print(value); //print the values read in the range [0,1023]
  Serial.print("\t"); //tab between texts in Serial Monitor
  Serial.print("Voltage in Volts:\t"); //print the text
  Serial.print(voltage);// print calculated voltage values in volts
  if ((voltage > 4)&&(value > 820)) // the condition when for voltage > than 4 volts the light turns on
  {
```

```
  digitalWrite(light, HIGH);// light turns on and illuminates
  Serial.println("\t the light illuminate ");
 }
 otherwise
 {
  digitalWrite(light, LOW);// the light turns off and does not illuminate
  Serial.println("\t the light does not illuminate ");// text in Serial Monitor
 }
 delay(1000);// read analog signals in LDR Sensor every second
}
```

After uploading this program code to the microcontroller Arduino Uno ATMEGA 328P in the Serial Monitor window we will have the read analog values converted through the A/D converter into digital numerical values as well as the voltage values in the LDR sensor depending on the level of ambient brightness as in Figure 11.

```
The value read by the sensor:   26     Voltage in Volts:     0.13     the light does not illuminate
The value read by the sensor:   568    Voltage in Volts:     2.78     the light does not illuminate
The value read by the sensor:   1016   Voltage in Volts:     4.97     the light illuminate
The value read by the sensor:   848    Voltage in Volts:     4.14     the light illuminate
```

Figure 11. Serial Monitor window with measured voltage, and reading the analog signals converted to digital and displaying the information that the 220 [VAC] light is lighting or not

This represents a state of deep darkness of the environment where the LDR sensor is located. This can also be proved mathematically by writing Kirhoff's second Law for voltages based on Figure 12. On the other hand, according to the curve in Figure 2 it is clearly seen that the resistance of the LDR sensor can be about 10 [MΩ] higher in complete darkness of the environment but none fall to the zero value.
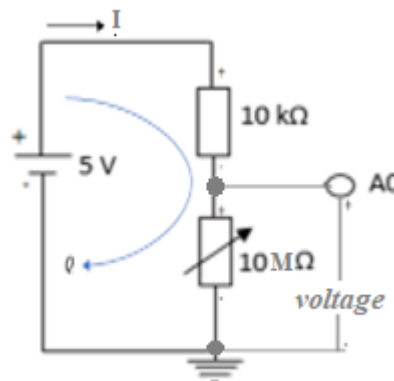

Figure 12. The electrical circuit of the connection of the LDR sensor to pin A0 of the Arduino Uno module, in conditions of complete darkness

$$5\,[VDC] - 10\,[k\Omega] \cdot I - 10\,[M\Omega] \cdot I = 0 \qquad (9)$$

From this equation we can calculate the intensity of the current in the electric circuit Q and then through Ohm's Law we can calculate the voltage in the LDR sensor with resistance when it is in deep darkness.10 [$M\Omega$]

$$I = \frac{5\,[VDC]}{(10\cdot10^3 + 10\cdot10^6)\,[\Omega]} = \frac{5}{10010000}\,[A] = 0{,}0000004995\,[A] = 0{,}4995\,[\mu A] \qquad (10)$$

The voltage on pin A0 in comparison with the ground, namely the voltage between the two ends of the LDR sensor with a resistance of 10 [M will be calculated according to Ohm's Law:Ω]

$$voltage = 10\,[M\Omega] \cdot 0{,}4995[\mu A] = 10 \cdot 10^6[\Omega] \cdot 0{,}4995 \cdot 10^{-6}\,[A] = 4{,}995\,[V] \qquad (11)$$

4. CONCLUSION

This research has to do with the measurement of electronic quantities such as voltage, resistance and intensity of the electric current in an intelligent form through the Arduino Uno Atmega 328P Module in an electronic system based on the LDR (Light Dependent Resistor) sensor for switching and the disconnection of a light that is supplied by the city's mains voltage of 220 [VAC]. The built system works perfectly. Measurements of electrical quantities serve to set the condition in the sketch-program code written in C++ within the Arduino Uno IDE environment. For the condition of when the lights should be switched on, any suitable electrical measured value can be taken that corresponds to the darkened or illuminated environment in the geographical area of the land where it is used. This paper will serve as a good basis for further research in determining the wavelength of light which represents an obstacle for people with vision problems. Of course, the research will be in collaboration with doctors in the relevant field of ophthalmology and optical physics.

ACKNOWLEDGMENTS

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