Development and Implementation of Electronic Applications based on Arduino Platform for a First Basic Course

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Abstract—This paper shows a learning guide about the use of Arduino platform and the different utilities that can be implemented based on this platform for a first basic course. The paper can be useful as a guide for someone who wants to start in the world of microcontroller programming, with examples to consolidate the knowledge learned.
Some students of the School of Industrial Engineering of the University of Malaga (Degree in Industrial Design) approach the study of an engineering career with little knowledge of electronics. This degree contains basic skills on learning electronics and the use of the Arduino platform and its development possibilities can offer students an interesting view of electronics, making better use of classes.
The work is based on both theoretical (to make the components known) and practical (using real assemblies) development to consolidate the knowledge learned.
Therefore, once the basic components necessary to carry out various practices have been explained, the theoretical performance and the programming of Arduino is explained and the various practices that will be set up in the laboratory are presented, as an application of Arduino for different uses.
All applications are accompanied by information about the components used, an assembly guide illustrated with Fritzing schematics and a photo of the actual assembly, as well as an explanation of the instructions used to program the microcontroller illustrated with an image of the code used.
The main idea of this work is to replace the traditional laboratory practices that require more advanced knowledge in electronics with a set of simple practices carried out in Arduino that allow students to have an approximate idea of basic electronics with little knowledge.
After three years of carrying out this new methodology for this first basic electronic course, the surveys demonstrate a better adaptation of the students to the study of electronics. In addition, the marks obtained have improved considerably and the students have the sensation of learning electronics in a simple and fun way.

Keywords—ICT, Educational innovation, Arduino, Basic Electronics, Industrial Design

1 Introduction and context

Electronics is defined as the branch of physics and engineering specialization, which studies and employs systems whose operation is based on the conduction and control of the microscopic flow of electrons in various media (gases, vacuum, semiconductors...) subjected to

the action of electric and magnetic fields [1]. Therefore, it also studies devices linked to electrons, such as diodes, valves, transistors or integrated circuits and is responsible for the design and application of electronic circuits whose operation depends on the flow of electrons to generate, transmit, receive, exchange or store information contained in electrical signals [2]. There is an enormous diversity of electronic circuits with different functionalities such as, for example, wave generation, signal amplification or attenuation, or the control and modulation of these and their logical operations.

The subject "Electronics and Product Automation", located in the third year is the only contact with this discipline for students studying the Degree in Engineering in Industrial Design and Product Development. Therefore, easy access to technology is pursued without requiring great technical knowledge. Both the recent development platforms for electronics (digital and analogue) and the recent developments of open software and hardware, such as Arduino or Processing [3], have made it possible to carry out this objective, revolutionising the way engineers work and extending its scope to other fields, such as digital art, for example. Thanks to the development of diverse electronic practices, of ascending difficulty, it is possible to deepen in the diverse explained electronic elements, as well as to reuse them in practices of greater difficulty, combining the acquired knowledge in the first implemented practices.

Finally, a teaching and learning guide is developed to learn about the different utilities of the Arduino development system.

2 Method and purpose

The work is based on both theoretical (to make the components known) and practical (using real assemblies) development to acquire and strengthen the various knowledge generated during the teaching of the subject.

To this end, a brief description of the development system chosen for the implementation of the different electronic practices is given, followed by the presentation and proposal of various designs, increasing their complexity as the subject progresses, combining the components used in the less difficult practices. These more difficult practices will also require a certain amount of programming.

Arduino is an open microcontroller development platform coupled with an intuitive programming language that allows development using the integrated development environment [4]. By linking Arduino to different components, such as sensors, leds, buzzers, complementary modules, and other integrated circuits, different control systems can be achieved [5]. In the market you can find different models of Arduino boards [6], which differ between them depending on the physical size, the number of pins, the microcontroller model that incorporates, and so on. The different plates integrate similar microcontrollers, developed and manufactured by the Atmel brand.

As for the programming base, the software that it presents is free, free and multiplatform, allowing to program in the own microcontroller of the board what is wanted to execute. This transmission of information between the computer and the board is carried out by means of a USB cable connected to the Arduino.

The use of Arduino is becoming increasingly popular due to the fact that its programming is quite intuitive, not at all complex and, in addition, it offers an infinite number

of possibilities for the realization of projects that include sensors, actuators and other electronic components.

3 Results

The different electronic designs proposed are shown in Table 1. Each includes the following documentation: information about the components used; an illustrated assembly guide with circuit schematics; photographs of the actual assembly and measurements, if applicable; and an explanation of the instructions used to carry out the programming necessary for that design, including the code used.

Table 1. Proposals for electronic designs based on Arduino

Practice Number	Description of practice
1	Control of one LED with one push-button
2	Step-by-step motor control with one push-button
3	Reading a potentiometer
4	Reading an optical sensor
5	Dimmer of an LED with a potentiometer
6	Speed regulator of a direct current motor with a potentiometer
7	Buzzer activated by an ultrasonic sensor
8	Development of a theremin
9	Temperature and humidity meter
10	Distance Meter

These applications that the students must carry out suppose a time not superior to 45 minutes for the most complex system (distance meter). With all this, the students can be convinced of how simple it can be to carry out different electronic applications knowing the basics (speed regulator of a motor, buzzer activated by a sensor, measurement of temperature and humidity, etc.).

As an example, one of the practices proposed is detailed below, namely that relating to the development of a theremin (practice number 8). A theremin is a musical instrument that has a pair of metallic antennas that, when approaching or moving away from them, allow to control the volume and frequency of the note emitted. In this assembly, Figure 1, an LDR (resistance dependent on the intensity of the incident light) will be used, which makes the function of these antennas, as a close movement detector (when bringing the hand closer, for example, the intensity of the light decreases and its resistance increases) and the piezoelectric buzzer as a sound emitter when receiving current.

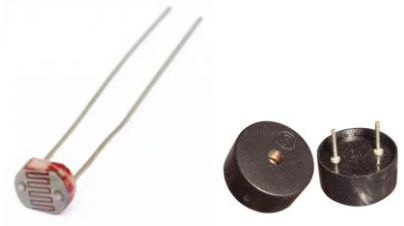

Fig. 1. Sample of used LDR and piezoelectric buzzer

For mounting, therefore, the two components described above are needed, as well as some extra components (basically resistors), to adapt the connections of the Arduino board.

One LDR terminal is connected to the 5 volt voltage source directly, and the other terminal is connected to ground (0 volts) via a 1 kΩ resistor and the Arduino analog "0" pin. To connect to the buzzer, one terminal is connected directly to ground, and the other terminal is connected to the digital pin "8" on the Arduino board via a 220 Ω resistor. Figure 2 shows the various schematics. Figure 3 shows the real mounting.

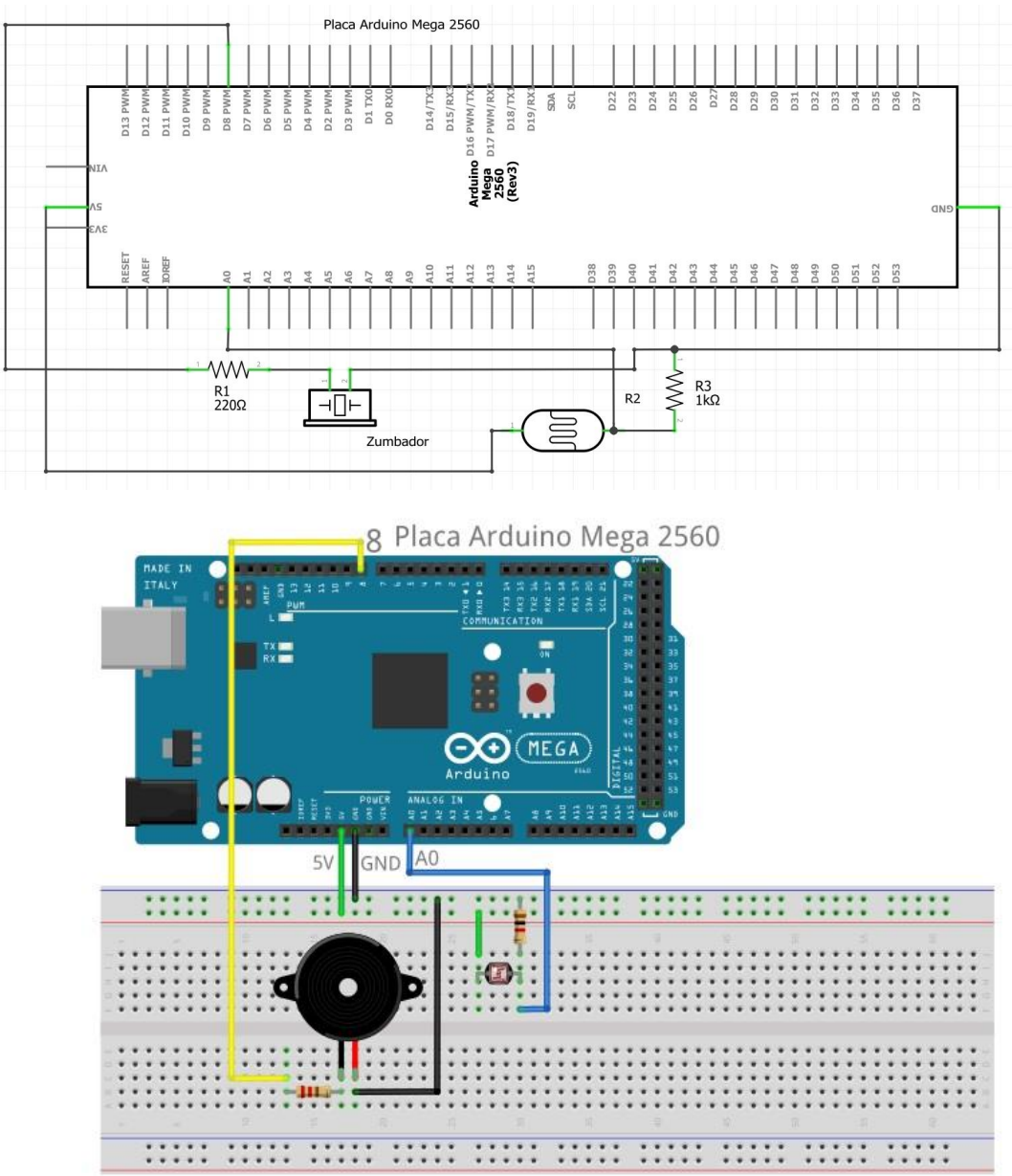

Fig. 2. Schematics of the assembly of a theremin

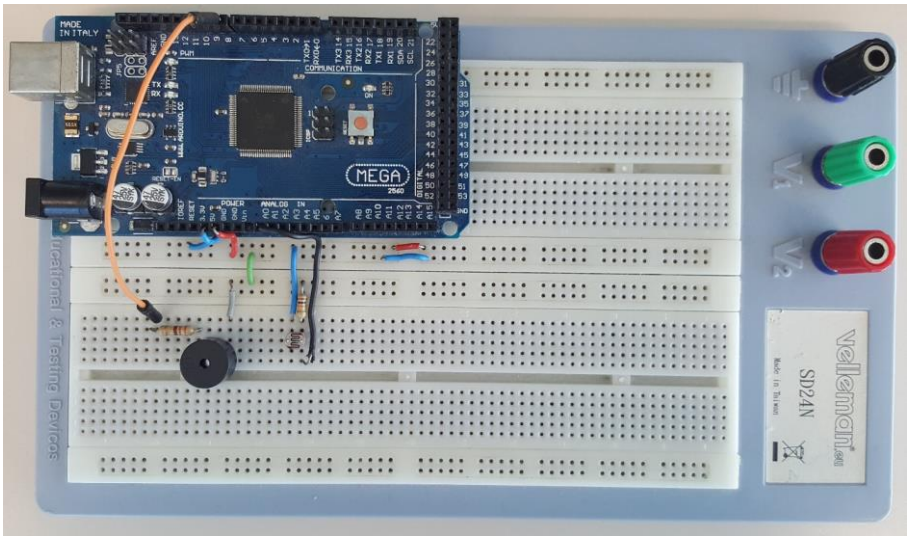

Fig. 3. Real assembly of a theremin

Finally, as far as programming is concerned, the buzzer has been configured as output, the LDR as input (although it is not necessary) and the serial port has been initialized at 9,600 bauds. As programming language, the instruction "analogRead ()" has been used to read the value of the LDR; the instruction "Serial.println ()" has been used to show this value by the serial monitor; the instruction "map ()" has been used to transform the value obtained from the LDR to a frequency value for the buzzer. In addition, a specific instruction called "tone ()" has been used to play back tones with the buzzer. The result is shown in Figure 4.

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```
//THEREMIN

int zumb = 8;
int ldr = 0;
int val;
int frec;

void setup() {

  pinMode(zumb, OUTPUT);                //Se configura el zumbador como salida
  pinMode(ldr, INPUT);                  //Se configura la ldr como entrada
  Serial.begin(9600);

}

void loop() {

  val = analogRead(ldr);
  Serial.println(val);
  frec = map(val, 0, 1023, 0, 1500);    //Se transforma el valor leído de la LDR
                                        //en un valor correspondiente a la frecuencia del zumbador
  tone(zumb, frec, 10);                 //Se hace sonar el zumbador con la frecuencia resultante
  delay(1);
}
```

Fig. 4. Code developed for theremin assembly

In the same way as the detailed one for this practice, it is possible to follow the different instructions to implement the rest of the proposed electronic practices.

4 Conclusions and future works

The results and the surveys carried out by the students show that the knowledge acquired is strengthened by the visit to the laboratory and the work carried out on the Arduino platform, thanks to the detailed guide to the various basic circuit proposals.

Also, thanks to the development of this detailed guide, it is possible to have a better use of time in the laboratory, improving skills and knowledge of students.

The work presented is open to future modifications in order to further improve the teaching/learning process. By way of example, several suggestions are proposed to extend the guide:

- Development of new assemblies deepening in the used components.
- Use of new programming instructions to achieve more advanced assemblies.
- Development of new assemblies using Arduino "Shields" to work with network communication.

5 References

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