Air Dehumidifier Controlled by Arduino Using Peltier

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Abstract. Currently, the water crisis is not only visible in Brazil but almost everywhere and it arises where water scarcity becomes a global challenge or environmental concerns about the shortage of drinking water. The need to have water available for consumption is critical, since, in turn, it is the main source for life on Earth. Despite all of Earth's water found, only 2.5% of it is freshwater. From this smallest part, 70% of it is used in agriculture, 23% by industries and 7% for human consumption. This paper presents an embedded system prototype for air dehumidifying which has the main purpose of obtaining water (by means of condensation). Others benefits include low cost, low size, portability and an Internet of Things application approach. The dehumidifier uses an aluminum plate around 36 cm^2 and about 0.5 mm thickness, a thermoelectric Peltier tablet, a breadboard UNO R3 arduino, wires jumper, transistors TIP122 and 1 KΩ (Ohm) resistors. Within the initial results, we verified the condensed water in the aluminum and the formation of water repeatedly and controlled.

Keywords: Air dehumidifier · Water scarcity-shortage-crisis · Embedded system · Peltier · Open-hardware · Internet of Things (IoT) application

1 Introduction

The importance of water for the survival of life on earth, in general, is indisputable, since it is used for food production, energy generation, human consumption, animal husbandry and others.

According to Coimbra (1999, cited Henker, 2012, p. 13) and NASA (1993, cited Shiklomanov) [1, 2], the total of 100% of water throughout the world, approximately 97.5% is inappropriate for human consumption, it is salty, but the remaining is appropriate, 2.5%, and labeled freshwater. However, from this small percentage, the small part again, less than one-third (1.2% at the surface and 30.1% on the ground), of this is really "practical purpose" water. The full distribution is sketched in Fig. 1.

According still to Coinbra [1], esteemed that 100% of freshwater water consumed in the whole world, 70% is used in agriculture (through irrigation), 23% are used by industries and only 7% by human consumption as shown in Fig. 2.

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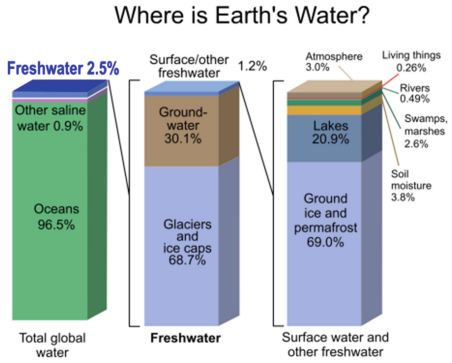

Fig. 1. Distribution of Earth's water. (source: NASA and Shiklomanov, 1993)

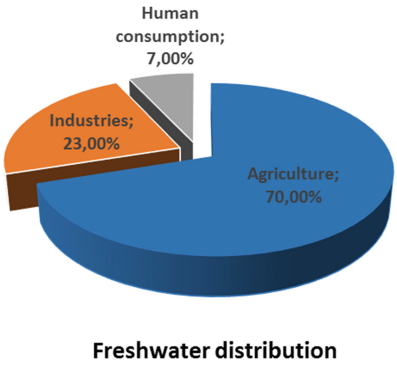

Fig. 2. Consumer's freshwater in the world.

According to the Local Ministry of Environment, the Brazilian territory holds more than 13% of the fresh of all water on Earth. Although Brazil is a privileged territory, there are bad distributions of this water in it and a high rate waste one [3].

The Brazil wastes approximately 37% of the treated water that it produces. On the other hand, in countries such as Germany, Japan and Israel reaches less than 10%, proving that the waste rate is highest in Brazil [4].

Besides Internet of Thing (IoT) perception – according to Chen et al. [5], that it's regarded as a technology and economic wave in the global information industry after the Internet, they listed two relevant, among others, capabilities of the IoT applications: (a) Environment Sensing; and (b) Remote Controlling. These are closely related with others similar app fields like Smart Cities (Environment monitoring, Smart agriculture, etc.), Industry (production process control, energy saving, pollution control, etc.) and E-health (monitoring, home care, etc.). Its applicability is directed connected with water quality monitoring, air quality monitoring, environmental information network and its information platforms.

Due to limited availability of water in relation to the general percentage for the population and the big waste of treated water produced, we thought in a dehumidifier

air, embedded system device, in order to remove water in the air through the condensation. We were also considered cheaper and smart devices or components also including Internet of Things (IoT) resources and its potential researches and further developments – like Arduino [5, 6] or other open-hardware platforms.

2 Theory and Materials

According to Silva and Souza (2009, cited Henker, 2012, p 14) [1] one square meter for water production rate of chilled area for the conditions of semi-arid regions of Northeast Brazil was investigated, the results established amounts to approximately 1.23 L/m^3 with a power consumption 0.75 kWh. However, to remove water from the air, the relative humidity must be at least reasonably high, the relative humidity is the ratio between the amount of water vapor the air contains and what it would contain if it were saturated. To avoid damage to the health of people the humidity must be around at least 30% if it is smaller than that affect human health. According Sultan (2004, cited Henker, 2012, p. 21) [1] "The water extraction may be performed atmospheric air cooling a surface below the dew point, where moisture is condensed." Therefore, for obtaining water by condensing dehumidifier is necessary that the surface is at a lower temperature than the ambient so that, in turn, condensation occurs.

The Peltier thermoelectric chip is a small unit that uses a condensed matter technology to operate as a heat pump. Its thickness is only a few millimeters and its shape is square, it being 4 × 40 × 40 mm, the chip contains small cubes of Bi2Te3 (bismuth telluride) [7]. Figure 3 shows a thermoelectric Peltier chip.

Fig. 3. Peltier thermoelectric chip.

The Peltier effect was discovered in 1834, the Peltier effect thermoelectric chips typically uses the semiconductor material, which is proportional to create semiconductor P-type and N-type, therefore, when there is supply of electric current of the materials are replaced ease and another to receive electrons to donate electrons easily, resulting in heating one side of the peltier and cooling in the opposite side of the insert.

According to Moura, (2010, p. 100) [9], the Peltier effect may be calculated as follows when there is a loss of electrons of a metal by means of electrical current, one side of the metal will be heated (TQ) and the other cold (TF) depending on the current direction for this purpose is defined coefficient peltier π_{ab}, that is:

$$q = \pi_{ab} I \tag{1}$$

According to Moura (2010, p. 100) in Eq. 1, q is the heat is pumped through the junction, when traversed by the current I that π_{ab} case is positive if the metal junction warms and the metallic junction "b" cools when current flows from "a" to "b". Again this effect in metallic joints are masked by the Joule heating effect, the use of semiconductor materials allows have this effect so as to enable its use in devices for cooling, as shown in Fig. 4.

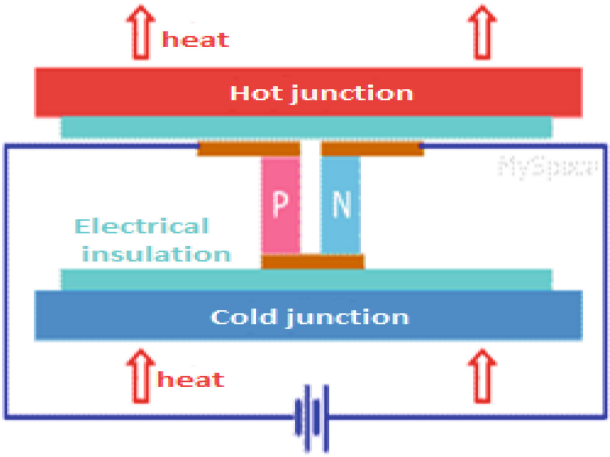

Fig. 4. Peltier effect.

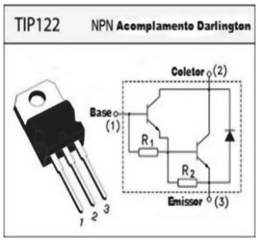

Fig. 5. Transistor TIP 122 with coupling Darlington.

The use of thermoelectric Peltier chip to perform the Peltier effect can be used as a dehumidifier, it being low cost, small size and reduced risk. Considering that the use of the peltier dehumidifier is effective due to its ability to maintain the low temperature side compared with the environment.

The TIP122 is a transistor high gain power transistor, that is, it receives a very weak signal at the input (base) and turns it into a signal high-powered in the output (collector or emitter). The TIP 122 is formed by two transistors in a structure known as coupling Darlington, as shown in Fig. 5:

Resistors are components that can be used to function as a regulator or [8] set the current flow traversing them. They are selected by colors found on their surface, for prototype was used a resistor of 1 KΩ, as shown in Fig. 6.

Fig. 6. Resistor of 1 KΩ.

2.1 Arduino

The Arduino is an open source prototyping platform based on hardware and software created in 2005 by Italian Massimo and other employees, with the help of order in electronics education for design students and artists. Initially the main objective was to develop a low-cost platform so that students could develop their projects at the lowest possible cost, the Arduino has a ATMEL AVR microcontroller with input and output support [6], Arduino uses a standard programming which has Wiring origin, and it is essentially the C/C++. The instructions are programmed using the Arduino software called IDE, which works as follows: the programming language is modeled from the Wiring language when pressed FDI the Upload button, the code is translated into C and language transmitted to the avr-gcc compiler, which performs the translation of language commands into a line that can be understood by the microcontroller. Figure 7 shows a UNO R3 Arduino.

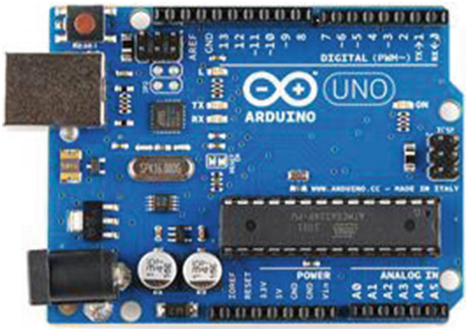

Fig. 7. Arduino UNO R3.

The ATMEL AVR microcontroller is 8-bit microcontroller, developed under the tecnologiaRISC – Reduced Instruction Set Computer (Computer with Reduced Instruction Set) architecture separates the data memory of program memory. Thus an AVR microcontroller has a bus for data and one for the program. This separation of buses

enables greater speed in the processing of data and program. Figure 8 shows an Atmel AVR microcontroller.

Fig. 8. Atmel AVR microcontroller.

To control the Peltier cooler and the power supply was used the Arduino PWM and a schedule was set up in the equipment itself IDE. Digital control is used to create a square wave, a signal switched between on and off. The standard on-off can simulate the tensions between linked in (5 V) and off (0 V). As shown below:

```
int peltier = 3; //The N-Channel MOSFET is on digital pin 3
int power = 0; //Power level fro 0 to 99%
int peltier_level = map(power, 0, 99, 0, 255); //This is a value from
0 to 255 that actually controls the MOSFET

void setup(){
Serial.begin(9600);

//pinMode(peltier, OUTPUT);
}

void loop(){
char option;

if(Serial.available() > 0)
{
option = Serial.read();
if(option == 'a')
power += 5;
else if(option == 'z')
power -= 5;

if(power > 99) power = 99;
if(power < 0) power = 0;

peltier_level = map(power, 0, 99, 0, 255);
}

Serial.print("Power=");
Serial.print(power);
Serial.print(" PLevel=");
Serial.println(peltier_level);

analogWrite(peltier, peltier_level); //Write this new value out to
the port

delay;

}
```

Programming work follows after performed the upload, open to the type field of the serial monitor and then the character insertion “a” will increase the POWER 5 and for performing the reverse procedure just increment the character “z”. By increasing “a”

will increase the current supplied to Peltier tablet for the cooler, by increasing the current in the tablet, is remarkable the increase of the heating at one side of the wafer and cooling in the other, as well as the cooler trigger for cooling the same. Therefore, as an increase in the supply of current to Peltier causing thus further warming, the cooler will increase your speed so you can keep refrigerated tablet, so it is not damaged. Then, after the development of the schedule is performed uploading same Arduino, can be seen through the serial monitor IDE device, the control voltage supplied to the peltier and cooler, which ranges from 0 to 255. 0 means that 0% of supplied voltage is 99 to 255%.

3 Results

The dehumidifier uses an aluminum of approximately 36 cm^2, with a thickness of around 0.5 mm, a thermoelectric Peltier chip TEC1-12706 4 cm^2, a heat sink, a cooler, an Arduino Uno R3, protoboard 800 pins, jumper wires, three transistors TIP 122 and three resistors 1 KΩ, as shown in Fig. 9.

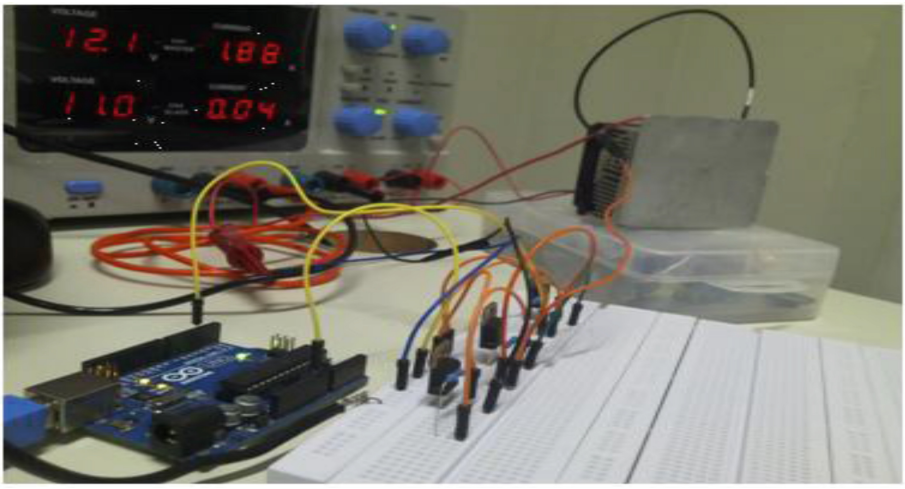

Fig. 9. Prototype of dehumidifier.

After the dehumidifier be connected to the digital power supply, 12.0 V output voltage (Volts) being 12 V and insert Peltier cooler is performed for a control of the current flow through PWM, tests were performed with a temperature of approximately 23 °C. The voltage of the dehumidifier was controlled by serial monitor when activated to the maximum, a rapid condensation on the aluminum plate was noticed, as shown in Fig. 10.

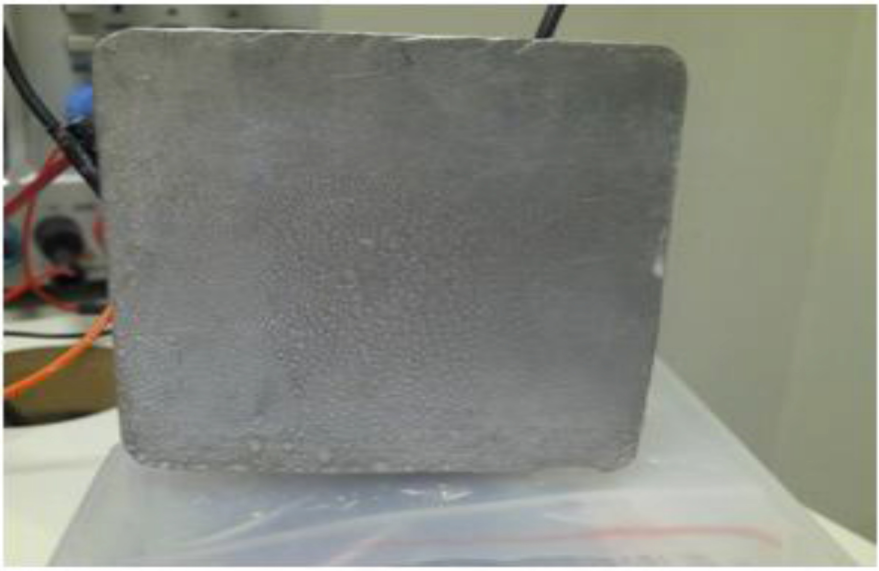

Fig. 10. Condensation on aluminum plate.

After a few minutes with the condensed water concentration of the aluminum plate was the formation of several drops, as shown in Fig. 11.

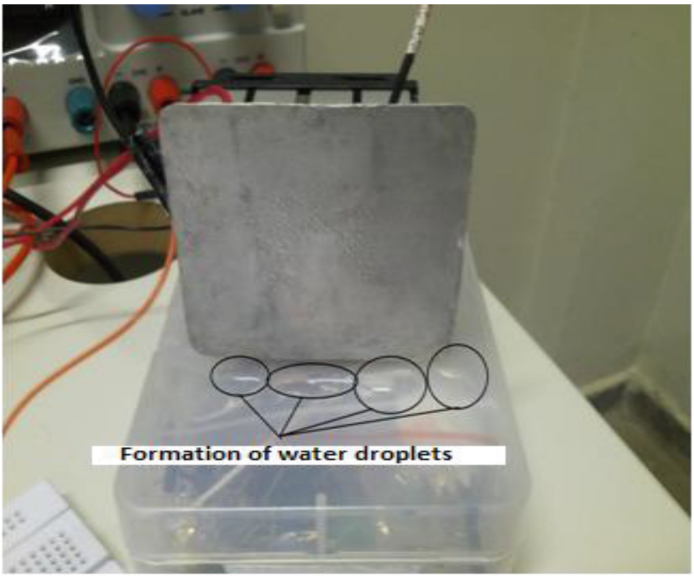

Fig. 11. Condensation of water droplets.

Condensation on the aluminum plate Besides being able to perform temperature control of the Peltier through the voltage supplied controlled by PWM, the cooler can be controlled to insert cooling, that is, rotates as the temperature thereof, thus, when the insert is more heated the cooler will turn faster and when there is little heat, will rotate with less speed, with a control not only of the need for peltier, but also in spending power consumption for the operation of the cooler.

4 Conclusion and Further Work

Thus, it is clear that the dehumidifier is effective, catching the drops of water into the vapor form into the air, with a higher concentration of micro drops in aluminum foil through condensation, when compared with the first prototype, and noted the difference from Figs. 10 and 11, which can be perceived in a high water concentration in the current prototype, thereafter, forming water droplets, in addition to having the wafer temperature control and cooler speed. The water removal of the air can be stored in a container such as a PET bottle or the quartz tube.

However, since it is a prototype on stage level, obtaining water is known "limited", due to condensation be restricted by the size of the flame of aluminum, but that does not stop be expanded in future projects, towards its more effective in producing water through condensation.

On the further studies, we could address: energy harvesting (get the necessary energy to produce local autonomy—or very close to this), self-adapted water production (based on the existent humidity and its local water condensed), modular aggregation to get scalability on inner water production – among others.

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