PROTOTYPE OF SMART TENT FOR ALGERIAN SAHARA DESERT NOMADS USING ARDUINO AND PV SYSTEMS

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Abstract - In Sahrawi society the term Khaïma (Sahara tent) also refers to the notion of family, home, or even the tribe. The most traditional ones are made from a weave of camel or sheep's hair. They are of a pyramidal shape with floor mats and sometimes decorated walls. However, this traditional construction of the tent provides lot of problems especially for the Nomads; the missing of sufficient lighting, the absence of permanent source of energy, the heat of the summer, sandstorms and others affect highly their daily life and make it hard. Hence, we propose in this paper the conception and the study of a smart tent that offers a completely new and unique experience for Nomads. These tents can be stand-alone powered using PV panels and batteries. With just a few in installations into place using Arduino and smart sensors, this smart tent giving more time to just relax and makes life easy.

Index Terms - Arduino, PV systems, Sensors; Smart tent

I. INTRODUCTION

As deserts is a known to lack rain, they usually get less amounts of rain during the year. Deserts are characterized by a general shortage of water. Where they have dry soil, little or no water, and high evaporation rate. The deserts are so dry that sometimes the rain evaporates before reaching the ground.

Because the deserts are very dry and the humidity in them is very low, they do not have a cover that helps to isolate the earth. As a result, the desert becomes very hot during the day, but the deserts do not retain heat during the night. Many deserts can become very cold at night. Some deserts can reach more than 50 ° C during the day and fall below zero during the night.

The Sahara is the largest desert in the world. It is a dry and arid desert stretching north and central Africa; known for its high temperature to record highs and the scarcity of rain and the Sahara is rich in precious mineral resources [1]-[2].

The Sahara extends from the shores of the Atlantic Ocean westward to the Red Sea border, while its borders from the south to the north are latitude 30 and 35. Its length is 4800 km and its width is 1800 km, with a total area of about nine and a half million square kilometres [1],[3].

The populations of the Sahara (called Saharan nomads or Bedouin) have adapted to the largest desert of the globe. They learned to use an extremely discontinuous natural vegetation and to feed their flocks. They also knew how to move in the Sahara and ensure their own transport and those of others thanks to a detailed knowledge of this immense country. But, mobility is their most notorious character [4].

The Bedouins knew that they could not enjoy the luxury of living in the fertile areas of their arid land. They could not store surplus food or become rich, so their lives were characterized by simplicity and they had to rely on what was available in nature in broad generosity. And in narrow scarcity of another[5]-[6].

The Bedouin dwelling in the desert is called the house of poetry, because it is woven from the black comforter and in some parts of the hair of the comforter and the camel's hair together, in addition to other materials necessary to build the house such as wood and shrubs [7].

Several conditions must be available at the Desert House which are[8]-[9] :

- House can be folded (bundled) and transported from place to place easily, resistant to shock / road shakes, and can be carried over the camel. That is an appropriate for the life of traveling.
- A house suitable for climatic conditions in the desert in winter and summer, at night and during the day.
- A house that can be built from materials available in the desert and within the reach of the Bedouin.
- A house that can be built and maintained easily without any difficulties and great costs, and the daughters of the family can do so.

There are certain laws adopted by the nomads when they choose the site of poetry in different seasons and this is done by moving to topographic areas appropriate [10]-[11].

In the winter, the house of poetry is located in the eastern slopes and not far from the nearby ravine. To protect the house from the strong winds that may fall home sometimes. The Bedouins also chose to set up their tents high up the course of the valley so as not to sweep the tent and its contents in the flood waters that hit those areas in the winter.

In the summer, the tents were built sporadically in high and flat areas. This was due to the need to avoid crowding and stacking, as well as to enjoy the pleasant winds.

Even so, nowadays the Bedouin life are become a little modern. Using trucks, the water can be brought to the camps. They are no longer depend on their animals for

survival. They can watch television or use cell phones powered by batteries. However, until today, their life is still difficult and need some improvements [12]-[14]. The tents are not so comfortable and the Bedouins suffer every day.

Based on the stat of the art, we can find quite some research has been done in the material of the Tents [15]-[17], but we cannot find lot of researches in the field of Sahara tent and especially the smart tent. Hence, in this paper we will develop a smart tent that makes their life as simple and comfortable.

The concept of smart buildings is studied widely in several papers [18]–[20]. Based on them the prototype of the proposed tent is made.

At first place, the main needs of a Bedouin family are treated. Then, for each need, a full smart system is proposed based on real time. The concept of smart sensors is studied using Arduino card. Arduino is a freeboard printed circuit board on which a microcontroller is located. It can be programmed to analyse and produce electrical signals, in order to perform a wide variety of tasks, such as home automation (control of domestic appliances - lighting, heating, etc.), control of a robot, etc [21]–[23].

At second place, a stand-alone photovoltaic (PV) system is studied in order to power the tent. PV systems are devices that convert solar energy into DC electric power using solar cells. Theirs market is growing year after year because of its low cost and their reliability [24]–[26]. In addition, the motivation of using this kind of systems is, first; Algeria has a considerable amount of sunshine hours over the year [27] (more than 3500hours/year) and second; the support of the Algerian government and the free price of offering these systems for the Bedouins. Moreover, a power back up system is added using batteries to ensure the continuity of the power for the tent. Finally, a realization of the project of smart tent is reached.

The rest of the paper is organized as follows; section II will present the characterisation of the used location for the creation of the tent. Section III, will show the prototype of the proposed smart tent. Section IV, will give an overview of the all used materials and sensors in the tent. Section V, will present the results of the proposed PV system sizing method and the last section will devoted to the conclusion and future perspectives.

II. CARACTERISATION OF THE LOCATION

Laghouat province (coordinates: 33°48 ´ 10″N 2°52 30″E) is southern Algerian city . Its elevation from sea level is 750 m on the southern slopes of the Desert Atlas. It is built on the banks of the Wadi Mzi, which flows eastwards from the Amour Mountains and is one of a large number of seasonal streams.

It is now called the Northern Oasis, and the other is located in the south. It is called the Southern Oasis and extends outside the two palaces, which were used for grain farming. The first name is called the Southern Valley. Each time the rain subsided, the area was flooded with Wadi Musaed, which is flooded with water,

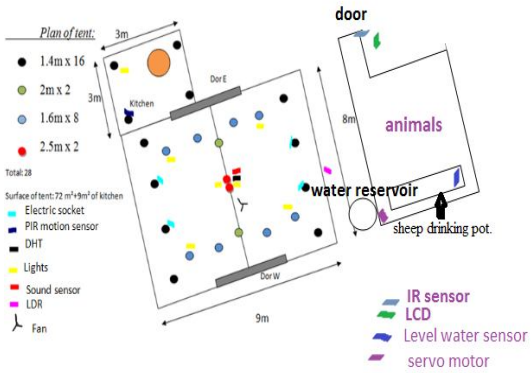


Fig.1 Prototype of the smart tent .

Laghouat has a desert climate during the year, there is no actual rainfall in Laghouat. The average annual temperature is 17.4 ° C per year, with an average precipitation of 176 ml.

III. PROTOTYPE OF THE SMART TENT

In the proposed tent, we control the lights, the temperature, level water and the counting of sheep. Based on this, we have chosen the right location of tent and the right location of the circuits.

We have put the tent in higher place for avoid the streams of water resulting from rain. The direct of tent is East-West in the summer the two doors of tent are open. To ventilate more and in the winter just the east door open. For the circuit (sensors; lights …etc.), Fig. 1 shows their location.

IV. MATERIALS AND SENSORS

In this part, we will present the used materials inside and outside the tent as well as their characteristics:

A.Inside of tent

A.1 Lighting

In our tent we control the lights with Arduino and smart sensors for make it more simple and economic for energy. They are threes sensors used for control the lights: LDR (Light Dependent Resistor), sound sensor, PIR motion.

(Light Dependent Resistor(LDR) sensor the LDR is similar to the human eye . It contains two cadmium sulphide (cds) photoconductive cells . The cell resistance falls with increasing light intensity. This sensor can be used for different applications such as light control, burglar alarm and smock detection . In the tent, the LDR sensor is used in the tent to control the ON/OFF of lights so in the dark the light will be ON and in when sunshine the lights will be OFF. For making this condition we realise this circuit (Fig.2).

Sound sensor is used to detect any intensity variation of sounds. It contains a microphone that used as an amplifier, peak detector or a buffer of the input sounds

. A microcontroller is necessary for the processing the comings signals . This sensors can be used for security and monitoring applications [29].

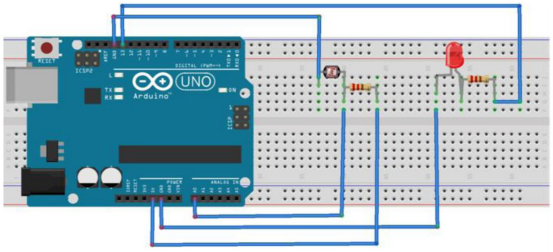


Fig.2 Circuit of LDR ON/OFF light using Arduino Uno.

To make the ON and OFF of lights very simple, we have used this sensor to control the lights by clapping; that meaning when the Bedouin wont OFF the lights just make two clapping, and do the same thing for ON the lights. For making this condition we realise this circuit as show in Fig.3.
All these circuits are used inside the tent. However, for the kitchen we have used another sensor to control the light using the PIR motion sensor.

A.2 PIR motion sensor

PIR sensors is used to detect any movement. It contains two slots with an infra-red sensitive material. It detects the radiated amount from the room, walls, or outdoors. Moreover, any warm body like a human or animal passes the PIR can simply sense. In the reverse operation where the warm body leaves the sensing are, the sensor will generate negative differential change and stop the detection [30]. This sensor has been used in the kitchen to sense when a person enters inside, the lights turned on and when he exits, the lights turned off automatically. Fig.4 shows its proposed diagram circuit.

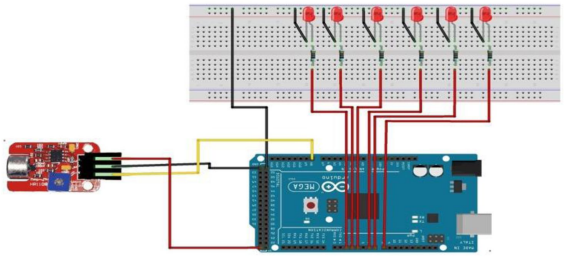


Fig.3 Circuit diagram of sound sensor ON/OFF light using Arduino Mega.

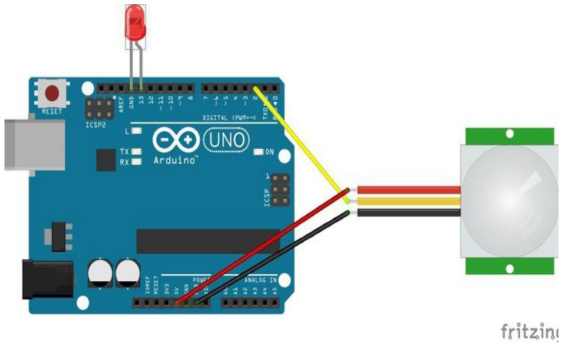


Fig.4 Circuit diagram of control LED with PIR motion sensor.

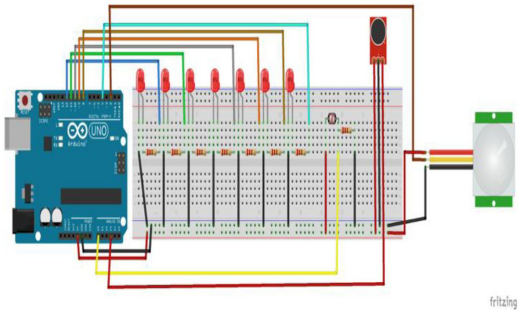


Fig.5 Circuit diagram of control LEDs with smart sensors and Arduino.

The final circuit of lighting with all the smart sensors and Arduino is shown in Fig.5 .

A.3 The temperature

We will monitor the temperature inside the tent and adjust it, if it is not favorable. The used sensor is the DHT 11 sensor. DHT11 used to sense the temperature and the humidity. It contains a resistive sense of wet components and NTC temperature measurement devices, and connected with a high-performance microcontroller [31].
This circuit is a standalone automatic fan speed controller that controls the speed of an electric fan according to the requirement. Is very compact and uses a few components only. The project will help save energy/electricity. The schematic of the Automatic Fan Speed Controller is shown in Fig.6.

B. Outside of the tent

In outside of the tent, we will help the Bedouin to count the sheep's because is very difficult task to do and because it is important; and we control the level of water in the sheep drinking pot.

B.1 Counting sheep's

The circuit is based on the interfacing of some components such as sensors. With Arduino microcontroller. This counter can count sheep's in both directions. This circuit can be used to count the number of sheep's entering a Sheep Corral in the entrance gate. The used sensor is IR sensor and counting is displayed on a 16x2 LCD through the controller.

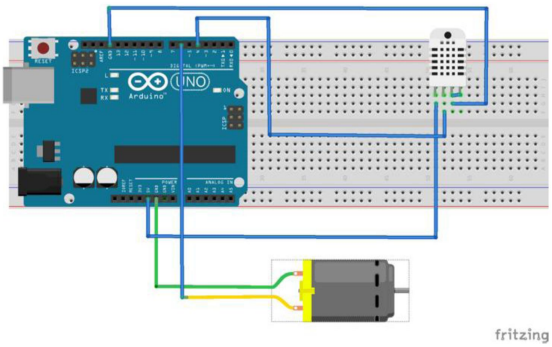


Fig.6 Schematic of the Automatic Fan Speed Controller.

Infrared Obstacle Avoidance Proximity Sensors has built-in IR transmitter and IR receiver that sends out IR energy and looks for reflected IR energy to detect presence of any obstacle in front of the sensor module. The module has on board potentiometer that lets user adjust detection range. The sensor has very good and stable response even in ambient light or in complete darkness [32]. The schematic of this circuit I shown in Fig. 7. Level water sensor is used for saving the water in drinking pot for sheep's and save the water tank; it's simple circuit based on a level water sensor and servo motor use for open the valve when the water in pot low. Water level sensor is used for high / drop of water amount . It is based on series of parallel wires exposed traces measured droplets/water volume in order to determine the water level [32]. In the tent , water level sensor is used to control the movement of the valve of water tank and by the way resulting its opening/closing (using servomotor) depending on the amount of water. The schematic of this circuit is shown in Fig. 8: Finally, Fig.9 shows the steps for making the prototype of the smart tent. This can be applied to a real tent with same sensors.

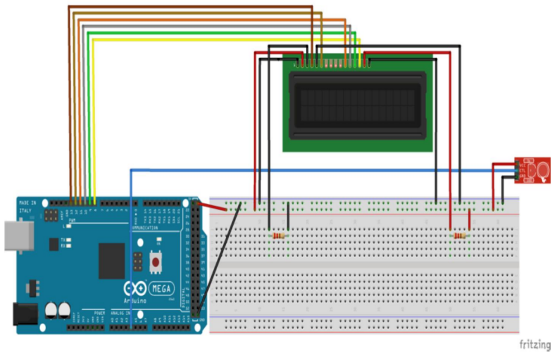


Fig.7 Circuit diagram of counting circuit.

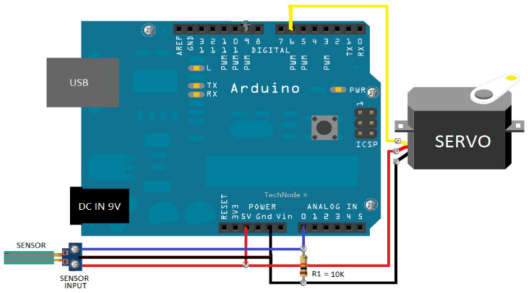


Fig.8 Controlling servomotor with level water sensor and Arduino Uno.



Fig.9 The setup of component on the tent.

C. Powering the Smart tent

In this part, to power the smart tent , we have used two sources ; a main power source consists of PV panels and auxiliary power source that is batteries, which is used in the case of absence of the Sun.

Hence , we begin first with the sizing of the stand alone PV systems that consists of finding the best compromise between panels and batteries for optimal power supply of the tent is studied. The used methodology is based on the following steps.

Firstly : Calculate the energy consumed by the device in kWh per day.The results are expressed in Table 1.

Table 1. Consumed energy per day (in KWh).

Nbr	device	Nbr of devices	Device wattage (w)	Working hours per day	Energy (kwh/day)
1	Ventilator : C10G40	1	55	8	0.44
2	Mini Fridge	1	22	24	0.528
3	Lamps	7	11	6	0.462
4	TV: Condor LED 32"	1	50	8	0.4
5	Satellite receiver	1	25	8	0.2
6	Brushless Servomotor	1	247	2	0.494
7	Other devices	1	30	2	0.06
TOTAL		13	440		2.584

From Table 1, we can see that the required power to run all the devices in the day is: 2.584 kwh/day.

Secondly: Calculate the number of panels and batteries

In this part, the loss of load probability (LLP) method is applied to get the optimum number of panels and batteries to assure the load at any moment. The used method is the same one presented in our previous published paper [33] . It consists of determining the PV generator capacity (the number of loads fed only by the PV array) and the battery storage capacity indicates the number of days (hours) where the load is supplied only by the batteries and not from the PV array [33].

The summary of the algorithm as well as all the parameters and their definitions are taken from [33] given as follows:

Step 1: Initialization of the data;

$LLP \leftarrow 0.01$, $L_t \leftarrow$ Load at time t , $Err \leftarrow 10^{-4}$, $\eta_t \leftarrow$ the $LLP_s \leftarrow 0.01$ panels' efficiency, $H_{g\beta_i} \leftarrow$ the monthly mean solar radiation data on an inclined surface (data of the lowest average solar radiation month), $C_S \leftarrow 1$.

Step 2: Calculate the useful PV array area A_G and the maximum useful battery capacity C_U ;

$$SOC \leftarrow 0\ ,\ E^{Aux} \leftarrow 0\ ,\ A_G = \frac{C_A L_t}{\eta_t H_{g\beta_i}}\ ,\ C_U = C_S L_t \qquad (1)$$

Step 3: calculate the state of the charge of the battery at the time t,

$$SOC_t = \min\left(SOC_{t-1} + \frac{\eta_t A_G H_{g\beta_i}}{C_U}; 1 \right) \qquad (2)$$

The energy supplied by the auxiliary generator E^{Aux} , keep the battery fully charged if the load requirements are bigger than the energy stored in the batteries, that

$$SOC_t \geq \frac{1}{C_S} \Rightarrow E_t^{Aux} = 0$$

$$SOC_t \leq \frac{1}{C_S} \Rightarrow E_t^{Aux} = (1 - SOC_t).L_t.C_S \quad \text{And} \quad SOC_t = 1 \qquad (3)$$

The LLP value is calculated over the number of available hours by the following equation,

$$LLP = \frac{\sum_{t=1}^{N_t} E_t^{Aux}}{\sum_{t=1}^{N_t} L_t} \qquad (4)$$

Step 4: if $LLP > LLP_s$ then $C_A \leftarrow C_A + 0.05$ and go to step 5; Otherwise $C_A \leftarrow C_A - 0.05$ and go to step 5

Step 5: if $(ABS(LLP - LLP_s)) > Err$ go to step 3; else, go to the next step.

Step 6: saving pairs C_A, C_S .

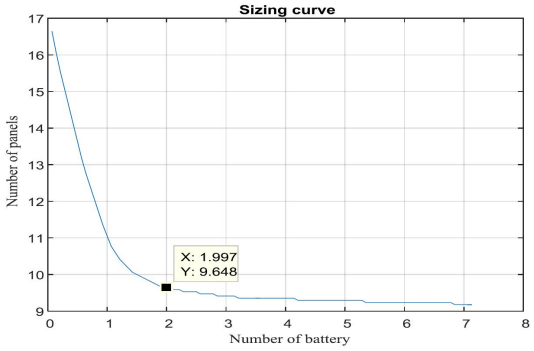


Fig.10 Sizing curve (number of panels against batteries number) using LLP method..

Step 7: if the values of C_A, C_S are changes go to step 2; otherwise stop.

The results of the application of this method taking into consideration the month of January as the lowest solar radiation month of the year and a daily estimated load for the tent equals to 2.584 are shown in Fig.10 . In the simulation we have used ZJP-260W solar panel with a 13.4 efficiency and 12 V Trojan J305G battery with a nominal capacity of 315Ah.

We can see clearly that the use of 10 panels with 2 batteries ensure the load at any time.

CONCLUSION

Bedouins lifestyle is a big challenge, their tents are made from goat's hair that do not protect them from rain. They live hard conditions with summer hot days

and freezing winter nights. Nowadays, the tents are used so often and are moved day by day that we changed the material and style to be more proper for our guests. But they still not offering the Bedouin comfort and atmosphere.

Hence, in this paper, we interested to create a hall concept of smart tent to make their life as comfortable as possible. We have based on the use of Arduino card that is a powerful microprocessor based card that makes the interaction between inputs and outputs simple. Sensors are used to ensure the best experience for these Bedouin in their tents. Lighting, temperature control, water management and even sheep's counting is taken into consideration using simple and cheap sensors.

In addition, ensuring the optimal power with the minimal cost is also studied. Using stand-alone PV systems that is given free from the Algerian government encourage the use of such green energy systems.

Finally, and as a conclusion, we can confirm clearly the proposed prototype using low cost sensors and materials that helps really the nomads in their life's. The obtained results make a revolution and considered as a first step in the desert camping technologies that can help lot of people in desert areas.

Future works can add more sensors and more developed systems as replacing Arduino with ATmega pic only, using the huge range of the available sensors that makes the experiences more reliable and effective for the Bedouin life style.

APPENDIX

All the used Arduino sketches for the proposed smart tent circuits can be free downloaded from the following link :

https://drive.google.com/drive/folders/1ssvUzhCGuqHT2FJpXxDc8iviR35Skup0?usp=sharing

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