

# Designing an Automatic Awning System Powered by Solar Energy

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**Abstract:** The automatic awning system provides an option of opening and closing the awning automatically and remotely by using the phone. An awning improves the conditioners efficiency and minimizing the heat gain entering from windows and doors. As well it gives extra protection against rain and wind entering houses and reducing the load on the air conditioners. Many types of research and literatures reviewed have been conducted that show similar principle, but it is used for different projects and anyhow help a lot to simplify the design and working methodology of the project. The project consists of LDR sensor to measure light intensity, Arduino Nano which is the main controller to control the system by reading the inputs and turn it into an output to activate the motor, send commands to LCD and communicate with SIM800L. Also, to drive a stepper motor forward and reverse function with controlling the speed is used motor drive module L298N. Also, GSM module SIM800L is used to send SMS to the user through controlling of Arduino to know the awning position. Solar panel with 15W supplies the rechargeable battery to feed the system by 12V. There are switches used to operate the motor manually in case automatic get to fail. The system is monitored continuously, and any change in awning position observed that the user in charge would receive SMS to know the position status and if system gets intervened by another user. The project is identified and designed as required with circuits schematic, hardware and software implementation. The results demonstrate that automatic awning system was functioning as required and there was a response from the system for any commands given either automatically or manually and as well as remotely through SMS. The test and result analyze conducted after checking the functionality of all the project which will see them in separate chapters. This project can be used for car parking, windows, front of doors or setting areas. It is useful anywhere at home, government buildings, industrial areas, restaurants, swimming pools, car shed and shops.

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## 1. INTRODUCTION

In many situations we as human beings face difficulties to gather family in the home garden during day time because sunrays are strong and cannot sit outside especially in summer. Also, in many restaurants it can be noticed that tables and chairs are kept outside for night time and they cannot use it during day time. The heat transfers through doors and windows that cause uncomfortable conditions inside buildings and air conditioners load will be more due to this heat. So, it is the right time to design a project that will help to overcome these tough situations and can even be used in many applications by making automatic awning systems powered with solar panels to operate the system.

Everyone would like to have automatic awning which will reduce the responsibility to operate it manually. In many situations the awning gets damaged due to strong wind or heavy rain. In addition, if it requires a height truck to enter in the parking area delivering some goods but because the awning level is not possible to bring it inside. So, an automatic awning system removes all these difficulties by opening and closing anytime from anywhere in the world by adding a GSM module which will help more to open and close remotely just by simple SMS.

The project consists of an Arduino Nano board, LCD, GSM module (SIM800L), Motor drive control module and LDR sensor. In addition, it is supported with electronic circuit to be controlled by mobile phone. Solar panel is used as renewable energy to supply the system with required power and saving consumption of electricity bills which are paid monthly. The awning material or fabric suggested to be normal cloth. This project can be used for car parking, windows, front of doors or setting areas. It is useful anywhere at home, government buildings, industrial areas, restaurants, swimming pools, car sheds and shops.

In addition, the researches on the literature reviews said apart from the benefit, An Awning is regulating the amount of sunlight, rain and wind that enters a room thereby protecting the house wares, paints and furniture from premature fading (Alchin, 2008). The outcome from study the researches get some ideas to add a controller which is an Arduino Nano to connect all inputs and outputs in and control the system. GSM module will be added in the system to control the awning remotely. Also, regulated DC power supply is used for system modules. Rechargeable battery gets charging from two sources step down transformer and solar panel that is regulated up to 12V DC.

### **1.1 Motivation of the Research**

With the advancement in technology and our day to day life comfort demands more electric energy. There are many people who need to avoid direct sun radiation to the buildings, doors and windows. Even a garden area during sunny days is not possible to sit outside unless there is a cover sheet to protect them. The heat gain and air conditioners loading are factors that are generated because of the sun. On the other hand, many people do not like to cover some areas all the time as they cannot enjoy night or raining time because of the cover or fix awning. The awning can play as a good solution to recover some of the influences. It can be controlled remotely by using different controls parameters. So, smarter houses and automated system are becoming more significant for today life. Research has been done that 77% of heat is reduced by awnings which is more effective than blinds in summer. Adjustable awnings can be designed to use in summer to reduce heat gain and in winter roll up it by motor to warm up the place to allow the sunlight pass through windows and doors.

In this project, an automatic retractable awning system opening and closing automatically that will solve many of the issues is proposed. Additionally, the awning system is powered by a solar panel to reduce the dependency on electric power availability.

### **1.2 Problem Description**

The heat gain and inefficiency of the cooling system inside buildings are main factors forcing people to do cover sheets to protect the building during summer time. Restaurants and hotel or commercial buildings need to install automatic awning systems that open and close automatically and remotely without interfering with the system. Designing an automatic awning system which is controlled by an Arduino is the best solution that increases the comfortability.

### **1.3 Objectives of the Research**

- i. Literature survey to review the similar automatic awning system powered with solar
- ii. To identify the components needed for the project.
- iii. To design a circuit of the awning system.
- iv. To implement and program the designed circuit.
- v. To test the performance characteristics of the design system in real time.

### **1.4 Scope**

The place of this study covers residents, commercials and government buildings that required a solution to reduce heat gain, increase the AC load efficiency and use an automatic system to operate such of this project awning or shade system. Specially in gulf countries during summer time cannot enjoy setting outside due to heat gain. Also, it will help to enhance the efficiency life period of cooling system. An automatic awning system will have an advantage over the system that are available as it works with LDR sensor so, it will be controlled automatically, and no need human intervene. In addition, it can be controlled and monitored by GSM remotely that will increase the comfortability. The project will be controlled by Arduino Nano which programmed according to the requirements. The designing, implementation and testing will be conducted by stages and at the end results will be finalized and concluded.

### **1.5 Feasibility Study**

In order to fulfil the objective of designing an automatic awning system powered with solar, researches have been done on many components that are required to be purchased such as hardware components that includes Arduino, GSM module, LCD, motor drive control module, stepper motor, stepdown transformer, LDR sensor, switches and small components required to complete the circuits. All required materials are purchased to start the design and implementation immediately by designing the system using Protel software. Furthermore, implementing of hardware stage started after designing the system in software and by supporting of literatures reviewed and researches about projects in the same field, it helped to

simplify the topic and idea of implementation and open a guideline for starting the project. The programming of Arduino is implemented after making sure all the components are connected properly and working fine to do a test after programming.

### 1.6 Benefits of the Research to the Society

1. Electric energy saving
2. Reduce manpower
3. Easy to Control
4. Reduce the effort

### 1.7 Project Cost Analysis

The cost of the project is calculated according to purchase of the components. Cost of each one is mentioned below in table 1.1 that show all the prices and the total is added end of the table and most of cost is hardware and software is free.

**Table 1.1 Project cost (Self, 2018).**

No	Unit	Price (OR)
1	Arduino Nano	2
2	GSM Module SIM800L	3
3	Relay	1
4	Rechargeable battery	3
5	Solar Panel	9
6	PCB	1
7	LCD	2
8	Stepper motor drive control module	1
9	Voltage regulators	1
10	Push Button switches	1.5
11	Potentiometer top adjust	0.800
12	Limit Switch	0.500
13	Electrolytic capacitors	1.5
14	Carbon film resistors	1
15	Ceramic disc capacitor	0.100
16	Rectified Diodes	0.200
17	Transistors	0.100
18	Connector plugs male female	1
19	Stepper Motor	7
	<b>Total</b>	<b>36.7 OR</b>

### 1.8 Challenges

It is of sure the project will not success without facing difficulties and challenges during making it either during researching or implementation. Identifying the right idea to start the project take a period to stabilize and understand the project clearly. Moreover, studying and researching how to program the Arduino and search the right codes to be used to run the system. In addition, Designing the complete circuits which required to use in the system and select the specific component for each circuit consume a lot of time by searching from market and internet. Soldering the components in the PCB needs hand skill to be done perfectly. Furthermore, the challenge was during testing activity need to find the best way to test the components. Completing the project and report were the challenge to submit on time

### 1.9 Summary

The chapter includes the general overview and information about the project. It contains identification of the need, problem description, objectives, scope, value and importance of the research, feasibility study, project cost and challenges. The project works are explained briefly in the methodology that how the project is working. In the next chapter comprehensive literature review is provided.

## 2. LITERATURE REVIEW

Many researches have been done related to the retractable awning system and benefits of installing it in the building or anywhere. Also, the controllers are used to move the awning smoothly and remotely.

Ajao, Yahaya and Kolawole in 2017 found that more of the heat energy is transferred through doors and windows with approximately 20 percent of air conditioner load, from solar radiation through doors and windows.

Karmakar, Chattopadhyay and Xiao in 2017 proposed dynamically controlling exterior and interior window coverings through IOT for environmentally friendly smart homes. As per their study awnings are more effective for reducing heat gain and consumption cooling energy especially in the global warming that affects the human and animals' live comfortability.

Sathish et al in 2017 about design and experimental study on automatic cloth retrieval and drying systems that many people go to work on daily from morning till evening which require them to dry clothes outside on sunny days. The weather changes frequently at the same time from sunny to rainy that cause the clothes drying is not completed.

SAAD, FARIJ, SALAH, ABDALJALIL in 2015 about automatic street light control system using microcontroller the new system is designed mainly for the streetlight to reduce consumption of the electricity and large areas of illumination with high intensity of light. Lighting the street is costing the countries a lot of money around 10-38% of the total energy. Street light is significant to the public, economic and social stability.

Kadiyam, Rajasekhar, and Pravin in 2015 showing advanced technology tools and equipment provide us comfortable life and make our jobs done in easy ways. Mobile phones can be used to service our life simply and in a short time. By using this smart gadget, we can control our home smartly. There are many components available in the market that allow home appliances to be controlled automatically through the internet, Bluetooth, RFID, GSM and Wifi technology. But the security and limitation of connectivity range is still lacking currently.

## 3. METHODOLOGY

The project is controlled by an Arduino Nano which all the components and devices are connected to it. Furthermore, Arduino is programmed by Arduino IDE to setup and configure each components and work as same as designed. This project works on when the power supply is applied by rechargeable battery after get charging from solar panel or AC 12V power supply. The system switches ON after connecting it with battery. In the LCD will show connecting message till message sent from system to mobile that indicating system ON. Then LCD indicates battery and LDR or light intensity value rate. At this status the system is in auto mode waiting two conditions if battery set point below 11V or LDR set point below 30% then shade will get close. And if LDR sensor more than 30%, shade will get open. At auto mode system depend on LDR sensor. During opening and closing the shade the system sends message to mobile as SMS to alert the user about shade position.

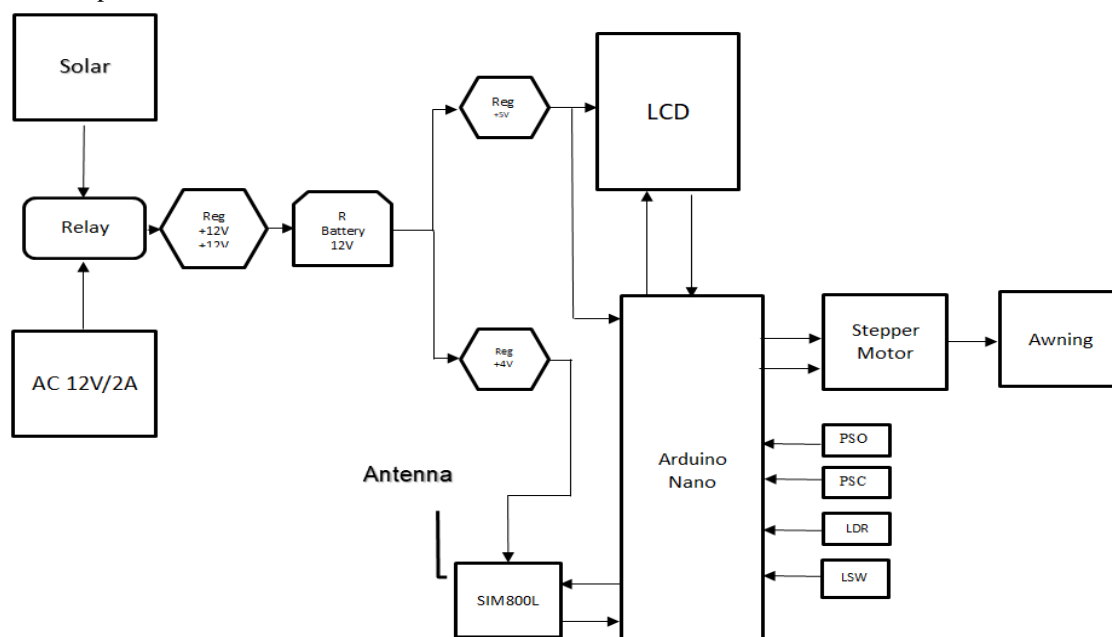


Figure 3.1 Block diagram of the Project

#### 4. MAIN PROJECT COMPONENTS

here are many components used in the project such as Arduino LDR, Stepper motor, Motor drive module, SIM800L, Solar Panel, LCD, Rechargeable battery and Relay below will give more information about each one.

##### i) Arduino Nano

As shown below figure 3.1 the Arduino Nano is a complete, compact and bread-board friendly microcontroller board. The weight of Nano board around 7 grams with length of 4.5 cm and width is 1.8 cm. It has similar functionality like Duemilanove and different in package compare to Arduino UNO. Also, Nano has feature which is inbuilt with ATmega328P microcontroller, same what have seen in Arduino UNO. Nano consists.

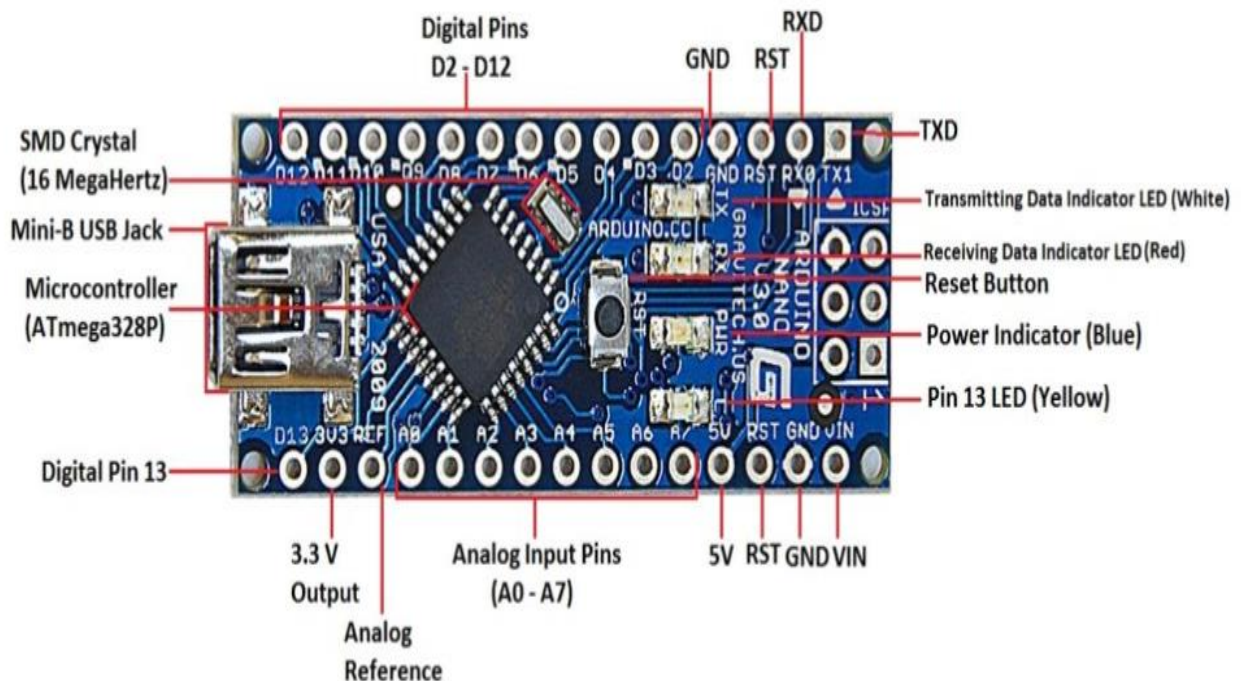
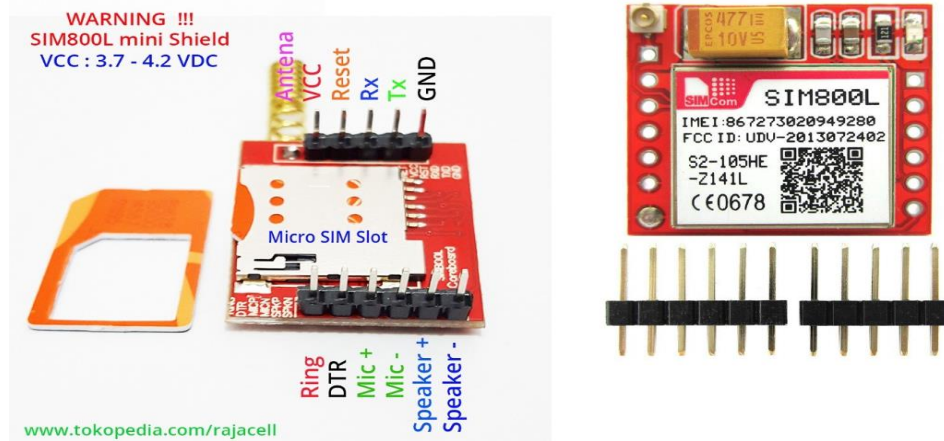


Figure 3. 1 Arduino Nano

Total of 36 pins available in TQFP (plastic quad flat pack). Each pin has its function. 14 digital I/O pins which are used either input or output. Pins are working with maximum 5V voltage. A DC power jack does not available in Nano board like other Arduino boards so, instead of that a mini USB port is occur. The programming and serial monitoring are configured through USB port as mentioned in below figure. Pins are used for different purpose such as serial communication, PWM Pulse Width Modulation, External interrupts, Serial Peripheral Interface, LED, Arduino Nano analog, I2C, Analog Reference, Reset, In Circuit Serial Programming and power. Arduino Nano is used in many applications and in different projects like car speed detector, water level indicator and home automation using IR remote control etc. This module requires software to be programmed to control the operations. Arduino Nano control all the system and all programs all implemented in to make the system communicating among each other of the components (John, 2018).

##### ii) SIM800L Module

The SIM800L board is named as a cellular communication module which has the capability to make send SMS texts, send email, make calls and can be connected to internet. It is a GSM GPRS quad band module. It can function like a mobile phone just need external peripherals to operate in proper way. This module can communicate with Arduino easily. The power supply should not exceed 4.3V because 5V can damage the SIM800L module so, power range is from 3.4V to 4.3V. 3.3V is not enough to operate the module. The module size is 2.5 cm x 2.3 cm as in figure 3.2. The SIM800L can be used in many applications such as in automotive, industrials, personal tracking and so on. Micro SIM Card can be inserted in. It is available with antenna to get the required signals and frequencies. Also, there is a serial monitor used to enable the communication with Arduino and can be used to check status of the device.



**Figure 3. 2 SIM800L GPRS GSM Module Micro Card Board Quad-band Port Antenna.**

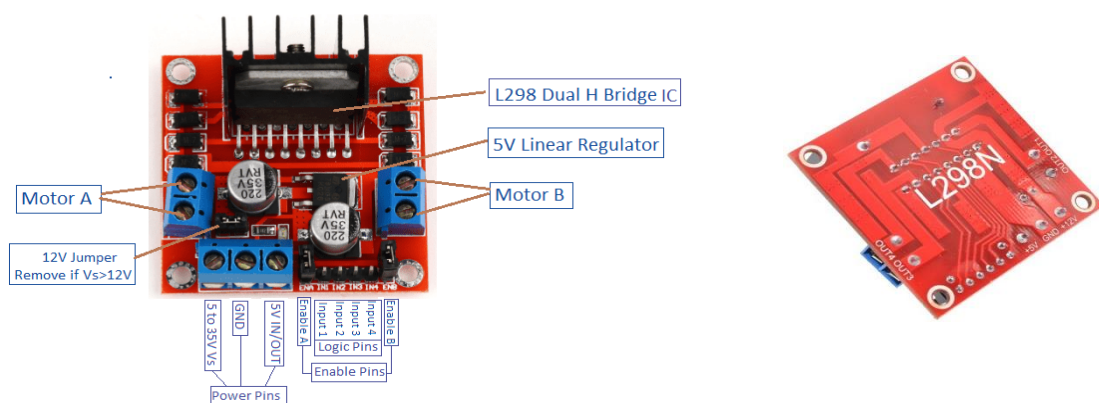
Below table 3.4 shows pin connections of SIM800L that are used to connect with Arduino to communicate between each other.

**Table 3. 1 Pin connections:**

SIM800L	Arduino
GND	GND
SIM_TXD	D8
SIM_RXD	D7

### iii) Stepper motor drive control module

Stepper motor drive control module is a small board used to control and drive the speed and the direction of DC motors. It can drive two 3-30V DC motors and supply output interface of 5V. It is supporting 3.3VMCU control. It needs 5V to work. The size of this board is 43mm x 43mm and the weight is 33g and full internal descriptions are mentioned in figure 3.3 Motor Drive control module. The cost of this module is inexpensive and size with weight is small. It is reducing prototype errors and this module This module is perfect to build robots and land moving projects like toy car.



**Figure 3.3 Motor Drive Control Module**

### iv) Stepper motor

The stepper motor is an electromechanical device converting the electrical pulses into a discrete mechanical movement. The spindle or shaft is rotating in discrete step increments at time of electrical commands applied to it in sequence. Due to the input pulses are applied to the motors rotation that will give several direct relationships. So, the relation will be directly proportional between each other. When frequency input pulses increase the speed of motor shaft rotation will

increase accordingly. There are different sizes of stepper motors as below figure 3.4. It uses high torque to rotate the shaft at precise positions and hold in any step you need without any sensors. It needs 12V to work perfectly. The degrees of stepper motor are 1.8 per step which is 200 steps per revolution. Nowadays stepper motors are used all around us in many applications such as printers, watches, clock, factory automation and machinery and disk drives. It is low cost, high torque with low speed and simple, strong construction can work in different environment and has high reliability. The positive supply is wired to the center taps of the winding and there are two ends of each winding are connected to ground in the drive circuit to function as reverse direction of the field given by same winding.



Figure 3. 4 Stepper motor sizes and wiring diagrams.

#### v) Rechargeable Battery

Sealed maintenance free rechargeable battery is used to provide 12V DC voltage which the same one I used to power the project as you see in figure 3.5 It has capacity 3.3Ah which stay 20 hrs. The dimensions of battery are length 134 mm, width 68 mm and height 62 mm with weight of 1.25kg. It can operate under ambient temperature from -20 to +50 °C. The cycle life of battery is extremely high and life performance, high reliability. It is characterized by low self-discharge. The battery get charge continuously through direct regulated power supply 12V or solar cells in the absent of direct power supply. Battery output is supplying the circuit with 12V but there are regulators that regulate the power depend on the boards used in the project some of them need +4VDC and some +5V DC. Rechargeable battery uses in different applications such as uninterruptable power supply UPS system, Emergency lighting, Emergency backup power supply, DC power supply and electronic apparatus and equipment etc. Self-discharging is less than 3% per month of the capacity at temperature 25°C.



Figure 3. 5 Rechargeable battery.

#### LIQUID CRYSTAL DISPLAY

The Liquid Crystal Display (LCD) which shown below in figure 3.10 is the most display applied type in generality applications. It can display a 16 set of characters in one bar and this display features a paired line that can show a total of 32 characters. In addition, the display has an adjustable backlighting which possible to turn ON or OFF and to be cleared with a single command. The LCD is used in the project to display status of battery rate, light intensity of LDR and condition of opening and closing the awning. Also, display status of system while communicating with Arduino (Codebender, 2015).



Figure 3. 6 LCD Display.

## 5. RESULTS AND DISCUSSIONS

This chapter will focus on the output results which are observed during project process activities. LDR sensor and battery rate output will be analyzed according to the codes written by Arduino software and applied in Arduino Nano. There are five main parameters indicating the performance of the project and according to them the results will be discussed. Beginning with the Arduino is the main controller in the project and all others are connected in. Furthermore, LDR sensor is the second significant parameter which the system depends on when auto mode activation is implemented, so the opening and closing position is waiting for the LDR signal. If light intensity is less than 30% then awning will close and if above will open. Third parameter is the stepper motor has the power to drive the fabric in open or in close position with the help of a drive control module to control the speed and the direction. Finally, Sending SMS to the person or user who is in charge to receive shade position feedback or operate the system remotely through SMS.

### *Result and analysis of the source code*

From figure 6.1 displays the source code header starts to include all libraries required in the system by implementing asynchronous serial communication on the Arduino to allow communicating with other serial devices. Also, the digital I/O pins on the Arduino configured by creating a serial connection with the help of software serial. EEPROM library is a memory which all values are kept in that allow it to recall after the board turns off and enable the user to write and read those bytes (Arduino, 2018). The last library used is the liquid crystal which allows the Arduino to control LCD display to indicate the required reading in the display (Arduino, 2018). In the project every step in the codes was showing exactly in the display. Number of motor rotation and speed of shaft is defined in the code and a test is conducted by changing the speed from 1 to 5 and shows that at 1 is the maximum speed and 5 is minimum speed. Many changes are done in the speed to adjust the right speed to use in the project as you see below two examples of the test in figure 6.2 and got different results during motor rotation.

## 6. CONCLUSION

Finally, in conclusion, an automatic awning system powered by the solar project was designed, implemented, tested and analyzed perfectly. Many types of research are reviewed to find out the suitable components to be used and how to connect them to the project. Also, they help to gain more knowledge about procedures for designing a project and what are the requirements taken to care before proceeding the activities. Implementation of the project was divided into two sections hardware and software which help a lot to complete the connection of components and programming the Arduino to get the required outputs. The project will improve the cooling system and minimize the heat in the houses and even in commercial buildings such as hotels, restaurant and shops. The project will reduce following opening and closing of the awning frequently and increase the comfortability to the owner to operate it remotely just by sending SMS to the system.

## REFERENCES

- [1] Ajao, K, R .&Yahaya, T.& Kolawole, M,Y.& Aweda,J,O., 2017. Design, Fabrication and Performance Evaluation of Awning/Canopy for Thermal Comfortability. *FUOYE Journal of Engineering and Technology*, 2(1), pp. 135-138.
- [2] Cunningham, C., 2014. *What is a capacitor?* [Online]. Available from: <https://learn.adafruit.com/circuit-playground-c-is-for-capacitor/what-is-a-capacitor>. [Accessed: 08<sup>th</sup> April 2020]
- [3] Codebender, 2015. *How to use an LCD display*. [Online]. Available from: <http://www.instructables.com/id/How-to-use-an-LCD-displays-Arduino-Tutorial/>. [Accessed: 10<sup>th</sup> April 2020]
- [4] Doe, J., 2017. *All About IC 7805 Voltage Regulator*. [Online]. Available from: <https://electronicsforu.com/resources/learn-electronics/7805-ic-voltage-regulator>. [Accessed: 10<sup>th</sup> April 2020]



- [5] Electronics Tutorials, 2017. *Variable voltage power supply*. [Online]. Available from: <https://www.electronicstutorials.ws/blog/variable-voltage-power-supply.html>. [Accessed: 10<sup>th</sup> April 2020]
- [6] eBay, 1995. *Power Relay 12v DC Coil Srd-12vdc-sl-c SONGLE PCB Type*. [Online]. Available from: <https://www.ebay.com/p/5pcs-Power-Relay-12v-DC-Coil-Srd-12vdc-sl-c-SONGLE-PCB-Type/875619986?iid=401356066119>. [Accessed: 07<sup>th</sup> April 2020]
- [7] Future Electronics, none. *General Purpose Transistors*. [Online]. Available from: <http://www.futureelectronics.com/en/transistors/general-purpose-transistor.aspx>. [Accessed: 12<sup>th</sup> April 2020]
- [8] Impremedia, 2017. *L298 MOTOR DRIVER TUTORIAL*. [Online]. Available from: <https://impremedia.net/1298-motor-driver-tutorial/>. [Accessed: 09<sup>th</sup> April 2020]
- [9] John., 2018. *Circuits Today*. [Online]. Available from: <http://www.circuitstoday.com/arduino-nano-tutorial-pinout-schematics>. [Accessed: 08<sup>th</sup> April 2020].
- [10] Karmakar,G. & Chattopadhyay, G. & Xiao,Z., 2017. Dynamically Controlling Exterior and Interior Window Coverings through IoT for Environmental Friendly Smart Homes. *Faculty of Science and Technology*, pp. 487-491.
- [11] Kumar,B,S.& Selvaganapathy,M.& Siddhath,S.&Kumaresan,G., 2017. Design and Experimental Study on Automatic Cloth Retrieval and Drying System. *International Journal of Advance Research, Ideas and Innovations in Technology*, 3(2), pp. 49-57.
- [12] Learning Engineering, 2016. *What is the Work of Diode*. [Online Video]. 27<sup>th</sup> September. Available from: <https://www.youtube.com/watch?v=VxVEeNNrcSM>. [Accessed: 10<sup>h</sup> April 2020]
- [13] Papiewski, J., 2018. *How Do Push Button Switches Work in an Electrical Circuit?*. [Online]. Available from: <https://sciencing.com/push-switches-work-electrical-circuit-5030234.html>. [Accessed: 10<sup>h</sup> April 2020]
- [14] Ricafort, Joseph., 2018. *PREDICTABLE DESIGNS. The SIM800 Cellular Module and Arduino: Powerful IoT Combo*. [Online]. Available from: <https://predictabledesigns.com/the-sim800-cellular-module-and-arduino-a-powerful-iot-combo>. [Accessed: 09<sup>h</sup> April 2020]
- [15] Sahu, B. P., 2015. *Light Dependent Resistor*. [Online]. Available from: <https://www.slideshare.net/bibhusahu1/light-dependent-resistor-45449769>. [Accessed: 09<sup>th</sup> April 2020]
- [16] Wikipedia, 2018. *Stepper Motor*. [Online]. Available from: [https://en.wikipedia.org/wiki/Stepper\\_motor](https://en.wikipedia.org/wiki/Stepper_motor). [Accessed: 09<sup>th</sup> May 2020]