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Arduino based PWM Solar Charge Controller Using IoT:- Hardware Implementation

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***Abstract* -** IoT has numerous applications; in which one of which is solar power tracking and modulating network. Energy- saving mechanisms can be delineated in IoT, which can lessen both energy dissipation and human endeavor necessary to do the task. The proposed system has been rendered to accord the PWM-based solar charge controller and its response by utilizing webservers and laptops/cell phones. This project used specialist equipment to evaluate the voltage and light intensity by using sensors to monitor solar power and then it sends the information to the website after making the process by Arduino chip that was programmed by C language updated information of the development system can be accessed through the mobile application.

Index Terms – IoT, Arduino, Solar, sensor.

I.Introduction

This project aimed to design and implement an embedded system capable of monitoring the flow of voltage and current in solar panels via the internet by embracing the Internet of Things (IoT) technology model.
To determine the requirements needed to design and implement such a system we had to define the following goals:
a. Refining and filtering of the fetched data.
b. Applying needed processes on the data.
c. Showing information on a display peripheral.
d. Sending information over the internet.
e. Plotting the information for visual representation.

II.SYSTEM ARCHITECTURE

A.Hardware requirements:

1. Arduino (ATMEGA328 microcontroller):
Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board [3].
The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, theArduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the microcontroller into a more accessible package [3].

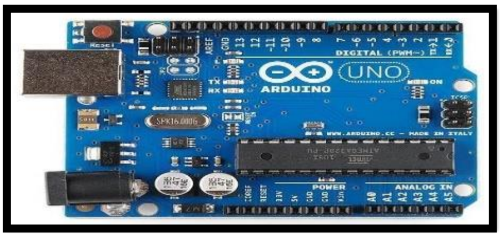

Fig. 1: Arduino

2. Voltage Regulator:

The voltage regulator is not actually something you can (or should) interact with on the Arduino. But it is potentially useful to know that it is there and what it's for. The voltage regulator does exactly what it says – it controls the amount of voltage that is let into the Arduino board. Think of it as a kind of gatekeeper; it will turn away an extra voltage that might harm the circuit. Of course, it has its limits, so don't hook up your Arduino to anything greater than 20 volts [3].

3. LCD (Liquid Crystal Display) 16*2:

LCD (Liquid Crystal Display) screen is an electronic display module and finds a wide range of applications. A 16*2LCD display is a very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi-segment LEDs.The reasons are that LCDs are economical; easilyprogrammable; have no special display & even custom characters (unlike in seven segments), animations so on.

A 16*2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character isdisplayed in a 5*7-pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores thecommand instructions given to the LCD how in. A commandis an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling the display, etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD [2].

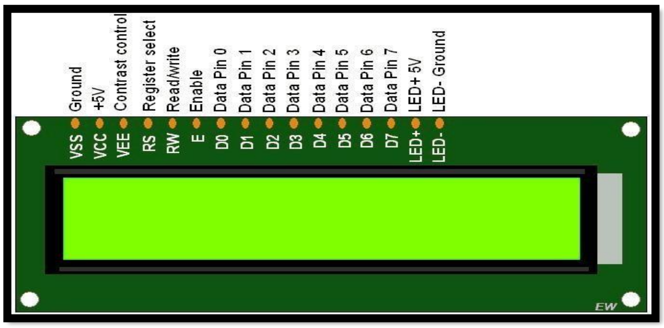

Fig. 2: LCD 16*2

4. Current sensor:

A current sensor is a device that detects electric current in a wire and generates a signal proportional to that current. The generated signal could be analog voltage or current or even a digital output. The generated signal can be then used to display the measured current in an ammeter, can be stored for further analysis in a data acquisition system, or can be used forthe purpose of control [5].

Current sensors based on closed-loop Hall effect technology are electronic transformers. They allow for themeasurement of direct, alternating, and impulse currents, with galvanic insulation between the primary and secondarycircuits.

The primary current IP flowing across the sensor creates aprimary magnetic flux. The magnetic circuit channels this magnetic flux. The Hall probe placed in the air gap of the magnetic circuit provides a voltage proportional to this flux [5].

5. Solar panels:

Solar panels absorb sunlight as a source of energy togenerate electricity or heat.

A photovoltaic (PV) module is a packaged, connect assembly of typically 6x10 photovoltaic solar cells.Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Eachmodule is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 Watts (W). The efficiency of a module determines the area of amodule given the same rated output – an 8% efficient 230 W module will have twice the area of a 16% efficient 230 W module. There are a few commercially available solar modulesthat exceed the efficiency of 22% and reportedly also exceed 24%. A single solar module can produce only a limited amount of power; most installations contain multiple modules.A photovoltaic system typically includes an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism.

6. Wi-Fi module (ESP8266):

The ESP8266 is a low-cost Wi-Fi microchip with a full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espress if Systems.

The chip first came to the attention of western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer, Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and makesimple TCP/IP connections using Hayes-style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted. Thevery low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and software on it, aswell as to translate the Chinese documentation.
The ESP8285 is an ESP8266 with 1 MB of built-in flash, allowing for single-chip devices capable of connecting to Wi- Fi.

Fig. 3: Wi-Fi module(esp8266)

7. Light Sensor:
A Light Sensor is something that a robot can use to detect the current ambient light level - i.e., how bright/dark it is. There is a range of different types of light sensors, including 'Photoresistors', 'Photodiodes', and 'Phototransistors'. The sensor included in the BOE Shield-Bot kit, and the one wewill be using, is called a Phototransistor.
To understand what a phototransistor is, we must firstdetermine what a transistor is. A regular transistor is an electrical component that limits the flow of current by a certain amount dependent on current applied to itself through another pin - so there is the collector, emitter, and 'base',which controls how much current can pass through the collector through to the emitter.
A phototransistor, on the other hand, uses the level oflight it detects to determine how much current can pass through the circuit. So, if the sensor is in a dark room, it only lets a small amount of current through. If it detects a bright light, it lets a larger amount of current through [4].

B.Software requirements (Arduino Integrated DevelopmentEnvironment):
The Arduino Integrated Development Environment (IDE) or Arduino Software - contains a text editor for writing code, amessage area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.
Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension (ino.). The editor has features for cutting/pasting and searching/replacing text. The message area gives feedback while saving and exporting and displays errors.

III.HARDWARE DESIGN AND ARCHITECTURE

The hardware architecture of this system adheres to the common paradigm of embedded systems design which consists of three main units with a communication unit acting as the gateway to the internet.

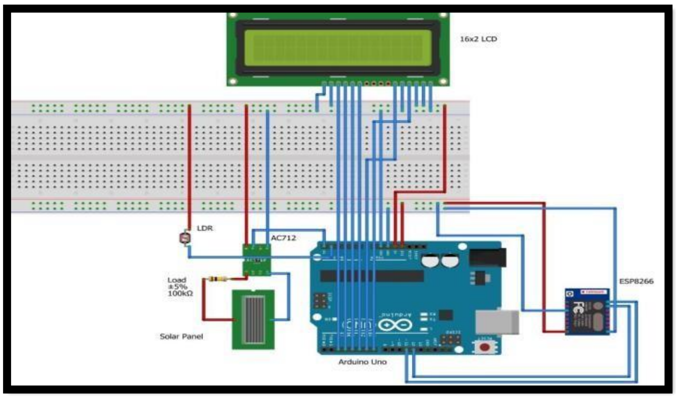

Fig. 4: Hardware and System Circuit

A.Input unit (Sensory unit)
This unit is responsible for reading the data of both voltage and current flowing through the load supplied by the solar panel, an AC712 hall-effect sensor was used to read the current through the load, and the Allegro AC712 uses voltage to sense current
up to 5A. In addition to the current sensor, an LDR was used to estimate the performance of the solar panel by retrieving the intensity of sunlight.

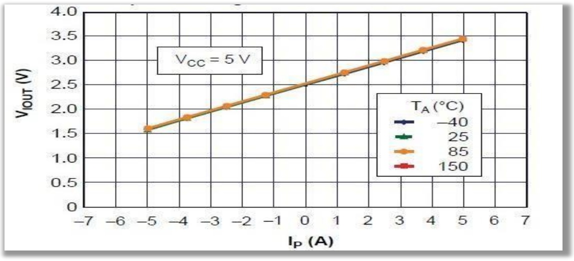

Fig. 5: Output Voltage VS Sensed Current of AC712

B.Processing unit

Arduino platform (Based on Atmega MCU) was thecore of the processing unit, Arduino Uno model was used to read the analog values of the input unit via input pins which then had been converted with the Built-in 10-bit ADC converters (Pins: A4, A5) before being processed. The 10-bit ADC of the Uno can handle up to 5V which is represented by decimal numbers between 0-1024, we used a special formulato calculate the actual voltage of the input.

C. Output Unit

This unit is responsible for representing the resultinformation of our system. A 16x2 LCD Display was used to display the information of sensors reading on-premises, whilea mobile device was used to receive and display the result information over the internet with a chart view.

D. Communication Unit

The purpose of incorporating this unit in the system was to achieve the internet of things technology, to do that we havechosen to use the ESP8266 Wi-Fi Module which uses AT commands to communicate with Arduino and establish a connection to our locally deployed server over the internet using an access point, then retrieves the processed data as a payload and converts them into a modulated signal for transmission. On the other side, the server (which in this case we used a laptop) acts as a bridge between the main systemand our mobile device, it is worth mentioning that the ESP8266 operates on 3v3. Do not mix complete spellings and abbreviations of units: "Wb/m^2" or "webers per square meter,"not "$webers/m^2$."

IV.SOFTWARE DESIGN AND ARCHITECTURE

Development of such a system requires extended and optimal integration of software stack and tools optimal integration of software stack and tools, many softwaretools were used to accomplish this project which we can describe as follows:

1. Microcontroller software:

Arduino C was used to write the main program of our microcontroller. It was written using the Arduino Integrated Development Environment with additional Atmel tools foruploading the program. The external library was included in our code such as software serial, hardware serial, ESP8266, and the Blynk library which we used to create client-sideconnection and representational objects of view widget of the mobile application. The Blynk library helped us achieve the hard work easily as its modular nature allowed us to write asynchronous non-blocking code which is the best way toapproach internet applications on different platforms.

2. ESP8266 Software tools:

The ESP8266 is usually a headless device when it is provided by third-party manufacturers, we needed to use a special UART to USB converter for flashing the AT firmware into the module, and we used a program called ESP tools to accelerate the process of firmware updating and ESP toolchains for interfacing with Arduino.

Server System Setup:

Server-side programming was not quite complicated as it required configuration rather than coding, we used Blynk localserver for being an open-source solution, and performed various configurations to fit our requirements, the server was written in java which makes it portable and platform-agnostic, however, encountered several bugs and reached out to the coredevelopers for fixes.

1. Simulation android on the laptop:

Blynk has a great mobile app for both android and IOS devices, we used the simulation android in the laptop to apply the required configurations of our server, and we created multiple widgets on the Blynk app to view our data and monitor the system continuously.

2. Mobile Application:

Blynk has a great mobile app for both android and IOS devices, we used the application on an android device and applied the required configurations of our server, we created multiple widgets on the Blynk app to view our data and monitor the system continuously.

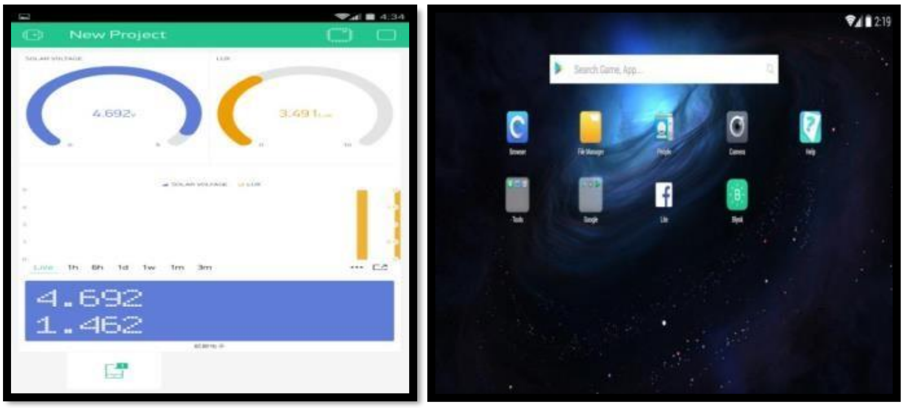

Fig. 6: Android Simulation of Blynk App

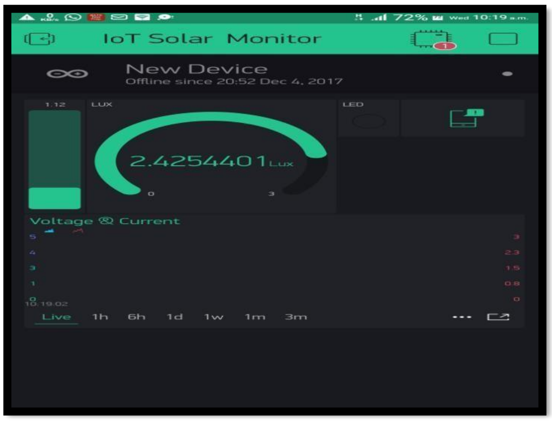

Fig. 7: Screenshot of the Blynk App Dashboard

V.USE CASE

When powered on the Arduino starts reading data from sensors while the ESP8266 module attempts to establish aconnection to the server over the internet, the progress and the status of the connection can be monitored via a serial monitor on the Arduino IDE, once the network connection is initializedthe LCD displays information of sensor readings, on the mobile side assuming the Blynk app has been launched, user can notice a notification on the screen indicating the status of the system whether it still offline or it has gone online, on the latter case the widgets on the app start displaying information immediately.

Here are software simulations of the app in case of sufficient lighting:

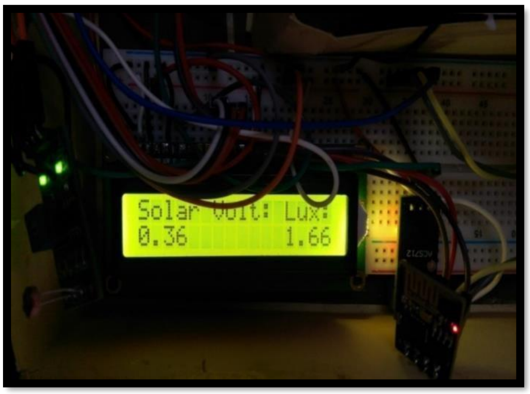

Fig. 8: Monitoring LCD Screen

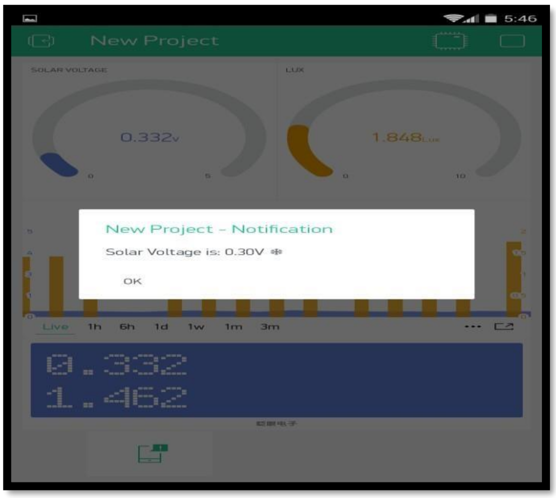

Fig. 9: Monitoring Page of the software (low voltag

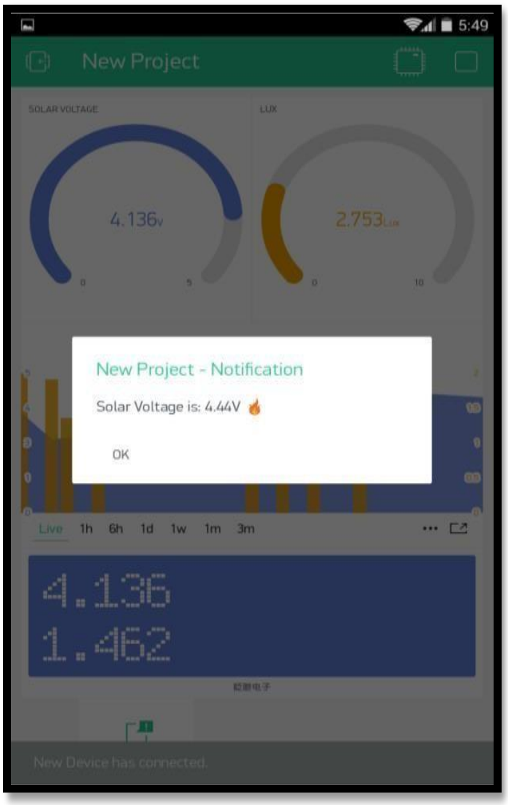

Fig. 10: Monitoring Page of the software

VI.CONCLUSIONS AND RECOMMENDATIONS

The Internet of Things (IoT) is a system of related computing devices, mechanical and digital machines, objects, people, or animals that are provided with unique identifiers and also the potential to transfer data over a network without requiring human-to-human or human-to-computer interaction. Physical items are no longer disconnected from the virtual world but can be controlled remotely through Internetservices.

This type of Monitoring helps the user in the analysis of renewable energy usage.

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