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Research Paper

PWM based solar charge controller using IoT

Dr. H Ravishankar Kamath [1] *, S S P M Sharma B [2], V Siva Brahmaiah Rama [2]

[1] Professor ICE Department at Manipal University Karnataka
[2] Assistant Professor Electrical Department at Mewar University Rajasthan

Abstract

IoT has numerous applications; in which one of them is solar power tracking and modulating network. Energy saving mechanism 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 the laptops/cell phones. The gadget has been used is W5100, the web server which will be accumulated on W5100 module is employed as an IoT platform. As webservers are unconstrained of platforms, they can be adoptable in cell phones/ laptop which is instructed by the relays and sequentially webservers compute the solar charge controllers through W5100 module. The proposed system deals with solar power tracking and sends the information to laptop/cell phone with the help of web servers for energy lessening. The proposed system is capable of identifying the battery charging conditions under different circumstances whenever needed and can be further upgraded to track other utensils. There are diverse modules utilized in solar charge controller circuit which makes it as an IoT based device like Arduino Ethernet shield (W5100), Atmega328p, solar panel, battery, which is hugely cost-effective and also low energy utilization. [1].

Keywords: *IoT; Arduino Ethernet Shield; Atmega; Solar Charge Controller.*

1. Introduction

The ultimatum for heterogeneous approaches constructed on the batteries like hybrid vehicles (HV) and distantly operated gadgets are conceptualized in the recent times. The devices consisting of substantial potential are not used widely because of extended charging duration and cost investment process. [1]

The gadgets that can continuously examine the solar power tracking and modulating the network can assist immensely in lessening the thriftless of energy. The proposed system is competent of checking whether the design is turned on and off conditions when it is affixed and charges whenever it is necessitated and can scan other gadgets. Accessibility of diversified modules which are coupled with the solar charging circuit will be treated as an IOT operated devices like Arduino based Ethernet, Atmega 328p, solar panel and battery charging unit. [2]

Based on this conceptualization the proposed system consists of the underlying architecture of solar charge controller which comprises of battery managing microcontroller units. [2]

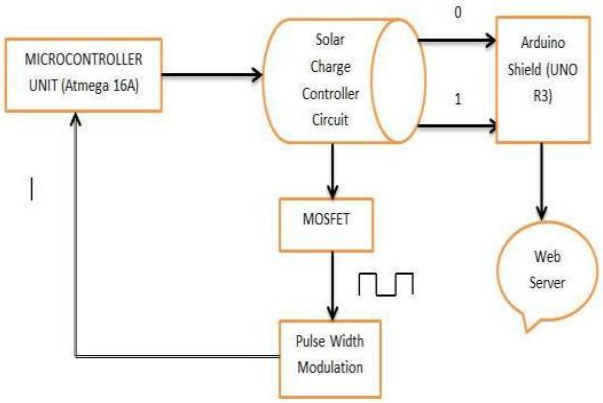


Fig. 1: Representation of PWM Based Solar Charge Controller Using IoT.

2. System architecture

2.1. Hardware requirements

i.) W5100 Ethernet shield (as a web server and a regulator).

W5100 is operated at smallest power, enormously energy saving Ethernet shield which can be performed at 5V. W5100 is an open source and programming can be done with the help of Arduino Uno. W5100 imparts a network (IP) which is proficient for both TCP and UDP, and it also accommodated for Php, Html, etc. and acted as a brace for different Application Programming Interfaces. By using W5100 Ethernet shield, we can promptly design the regional servers which can be executed remotely by readdressing the static IP of the router. [2]

ii.) Arduino Uno R3 (FDTI Panel).

The Arduino Uno R3 panel is utilized as an FDTI panel with spick and span program into W5100 module.

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iii.) LM317(Power supply Module, i.e., Voltage Regulator)

LM317 is an essential charge controller circuit which can be treated as a platform independent. This circuit is adaptable betwixt 1.2V and 37V and able to supply current more than 1.5A. This widget independently dispenses the input into the W5100 module and the Laptop/Mobile Phone. The charge controller module inputs are from the external source like solar panels which could be varied from 17V to 8V. [2]

The Power Supply Module is integrated with encumbering preservation and voltage regulators to produce the solar charge controllers which can be utilized securely.

iv.) IRF540 MOSFET (switching device)

The essential factor of utilizing the IRF540 is indistinguishable when it is operated on Mobile Phone/ Laptop which may not be the case while using the relay as a switching device. The switch IRF540 is having a voltage rating of 100V and current rating of 30A. [3]

v.) Pulse width modulation technique

PWM technique is used to sway the digital output signal by switching it on and off very rapidly, just by differing the width of the on/off duration is going to effect on outputs. [3]

VOUT = TON/ (TON+TOFF)*VIN

PWM is authorized to provide the wide span of digital output at distinct power floor which is indistinguishable to analog outputs.

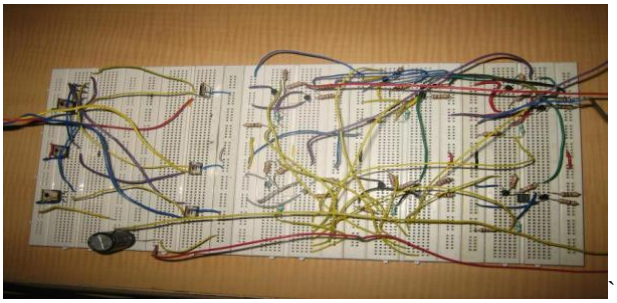


Fig. 2: PWM Based Mosfet Driver (Hardware).

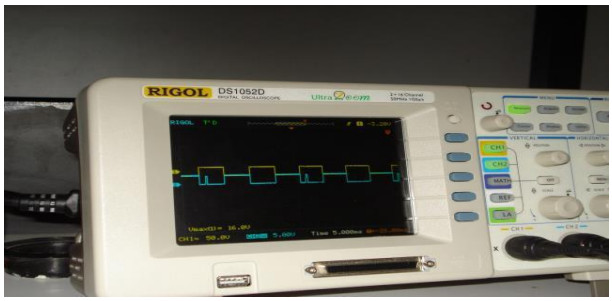


Fig. 3: Output of PWM Technique.

2.2. Software requirements

i). Arduino IDE.

Arduino hourly opts for the process of flash firmware onto the W5100 module in which it is essential to have all the libraries and board should be correctly established on it. [4]

ii). W5100 Web server

The W5100 module and its alterations are furnished and underpin PHP, JAVA, AJAX, etc. Manageable webservers can design and utilized remotely. [5]

By utilizing PHP API for the battery system, this can be reinforced on all the devices and which further leads to interact with the tools and consign the vigilance through the web server to the W5100 Module.

iii). There are heterogeneous modules accessible, which can be paired up with solar charge controller circuit at that instant channel is going to change its phase into IoT based system. W5100 is productive about its cost; utilization of power is minimum and excellent temperature control.

iv). The module is supervised by the W5100 web server. The W5100 module and its alterations are furnished and ii.) The module is supervised by the W5100 web server. The W5100 module and its alterations are furnished and underpin PHP, JAVA, AJAX, etc. Manageable webservers can design and utilized remotely.

v). The function of charging the battery is supervised by the device which real charging. i.e., solar panel is connected to charge controller circuit it is going to charge battery, and it can also lift through IoT web platform, i.e., web servers

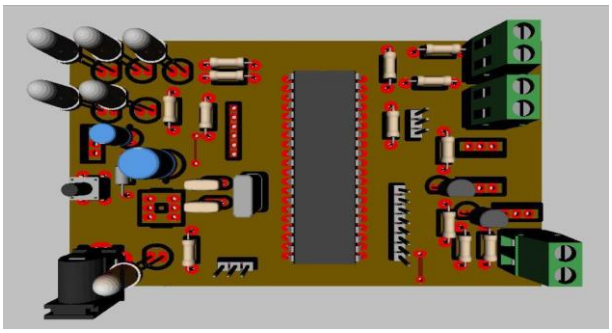


Fig. 4: PCB Layout of Circuit.

vi). MATLAB Simulation of PWM based MOSFET

MOSFET's prerequisite is gate voltages to switch it on we need gate capacitor with at least gate voltages, and similarly, when it is turned off it has to discharge. [6]

A MOSFET can't be shifted from conducting to a non-conducting region immediately, so gate currents are applied to it for switching purpose.

Most of the PWM Charge Controller is operated on frequency, so in the proposed system PWM technique used will produce a frequency of 60 Hz.

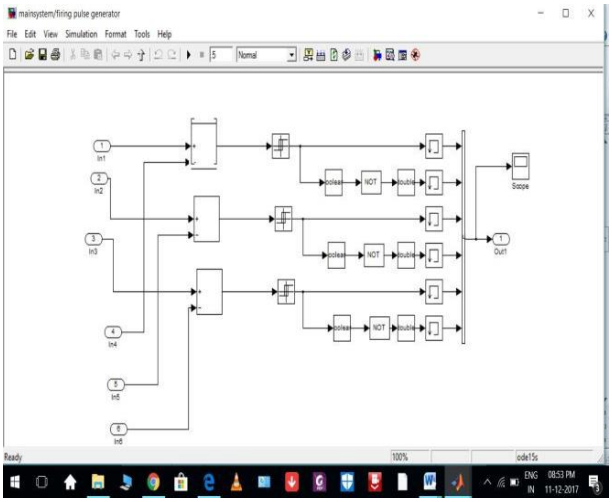


Fig. 5: Simulation of PWM based MOSFET.

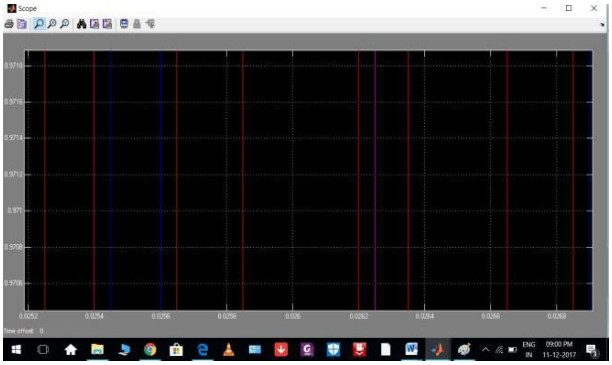


Fig. 6: Result of PWM Technique.

3. Proposed system

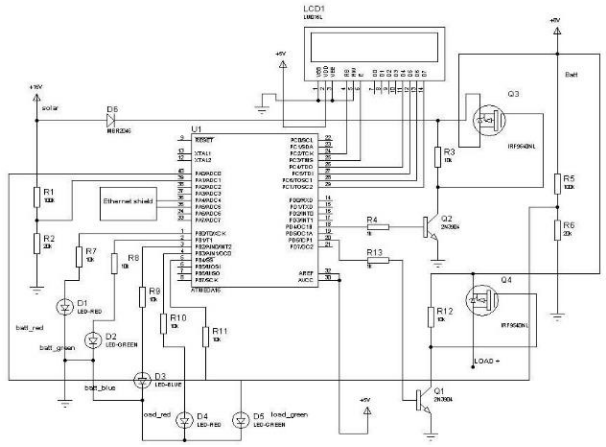


Fig. 7: Alternative Circuit Design.

The proposed can do the task in a way that is not similar to the existing systems in sundry features like automation in operation and user-friendly interactions.

The proposed system is going to work with a solar charging circuit, and it is supervised with the help of W5100 module which is sequentially tracked by the mobile phone/laptop. This system can be comfortably executed with the solar charge controller and any Smartphone/ Laptop. [7]

The solar power supply of 17.5V is progressed in the charge controller circuit which will be reduced a bit due to external factors like voltage regulator efficiency, but on an average voltage and current remains persistent. To avoid the reduction charging currents of Mobile/Laptop we can utilize secondary power supply so that device stays with the same power supply. [7]

The same circuit can be utilized to charge various electronic gadgets by using the substitute of USB ports with separate charger pins.

There are two methods of execution, fast charging condition and healthy condition mode of a battery system in Solar charge controllers. In the first process is going to analyze the battery charging requirements with the source voltages, and the second method is entirely dependent on the health status of a battery based on load conditions. [7]

a) Method 1: Fast Charging Mode

This process involves the setting up of specific values for the temperature of environment, system voltages, deciding the charge set values and PWM charging of battery, etc.. [8]

Charging Status: The solar panel voltage is higher than the battery voltage, and it must be less than or equal to the charging point set a value of the battery than it is going to indicate as charging process is running for a battery is in bulk mode.

Rapid Charging Status: Assign the duty cycle values and check the status of battery values with the float charging set points and bulk charging set points and indicate the charger position in which mode it is operated in case of any error or when the battery voltages approach the charge set point then the duty cycles had to reduce immediately.

Charging Status Off: In case of errors are identified, or it was not a daylight hours than we can regulate the duty cycle and indicate the charging status is in off condition.

In this mode of execution, the battery charging status can be checked whether it is plugged in or out of with solar panel and based on the environment condition it is going to indicate the charging state of a system [9]

Pseudocode:

```
void charge_Cycle(void)
{
      if (solar_value > batt_value && batt_value <= bulk_Ch_Sv)
      {
            if (batt_value <= float_Ch_Sv) // charging start
            {
                  charge_Status = 1; // indicate the charger is
in BULK mode
                  duty= 232;
                  pwm(2,duty); // 88 % duty cycle // rapid
charging

            }
            /*else if (batt_value >float_charge_sp && batt_value
<= bulk_charge_sp)
            {
                  charge_Status = 2; // indicate the charger is
in rather mode
                  error = (bulk_charge_sp - batt_value); //
duty cycle reduced when the battery voltage approaches the
charge set point
                  sp= error *100 ; //sp= error* sp // assume
sp=100
                  if(sp < 0)
                  {
                        sp=0;
                  }
                  else if(sp>100)
                  {
                        sp=100;
                  }
                  else if(sp>0 && sp <=100) // regulating
                  {
                        duty = (sp*255)/100;
                  }
                  pwm(2,duty);
            }*/
      }
      else
      {
            charge_Status=0;  // indicate the charger is Err
            duty=0;
            pwm(2,duty);
      }
}
```

Screenshot I – login Page



b) Method 2: Healthy Condition Mode

This mode includes the process of load monitoring conditions concerning environmental conditions. [8]

Load on Status: The load will be turned on after checking the condition of daylight in which the voltage from the solar panel should be less than the user-defined/set values or voltages.

Battery Healthy Status: The healthy status conditions of a battery can be checked through the low voltage disconnect condition with battery conditions. i.e., if the battery voltages are more significant than the LVD (Low Voltage Disconnect) than load is going to turn on and else if it will be turned off mode.

Pseudocode:

```
void load_Control(void)
{
      if (solar_Value < 5  ) // load will on when night
      {
            if(batt_Value >lvd)   // check if battery is healthy
            {
                  load_Status=1;
                  PORTD|=1<<load_Pin; // load is ON
            }
            else if(batt_Value < lvd)
            {
                  load_Status=0;
                  PORTD&=~(1<<load_Pin);//load is OFF
            }
      }
      else // load will off during day
      {
            load_Status=0;
            PORTD&=~(1<<load_Pin);//load is OFF
      }
}
```

```
void battery_Led(void)
{

     if( (batt_Value > system_Volt) && ( batt_Value
<bulk_CH_SP))
     {
          leds_off_all();
         PORTB|=1<<batt_Green_LED; // battery voltage is
healthy
     }
     else if(batt_Value >= bulk_CH_SP)
     {
          leds_off_all();
         PORTB|=1<<batt_Blue_LED; //battery is fully charged
     }
     else if(batt_Value < system_Volt)
     {
          leds_off_all();
          PORTB|=1<<batt_Red_LED;// battery voltage low
     }
}
```

In this process, the battery condition of charge controller is tested in diversified area like a healthy condition of Battery voltages in the system and what is present status of battery whether it is fully charged or low charged.

Server Module:

In the proposed system, the server is the W5100 module which clasps the code for the web server which can be utilized to control the W5100 using embedded code which exists in the W5100 module. The web server is designed with PHP which is suitable to communicate with the client. [9]

When the user penetrates the IP address of the W5100 module into the web browser whichever may be the cases like Laptop/Mobile Phones are used for ideal staging. Then the client can access the login page in which he has to provide the login credentials which will be submitted by the admin. In this page, cookies are stowed through which multiple logins of the same client can't be possible at a time.

The next page is the leading section of the system which assists in automating the entire system. The server receives the charging condition of the battery and on & off status of the load along with date and time from the client side and conveys it to the user side at regular intervals.

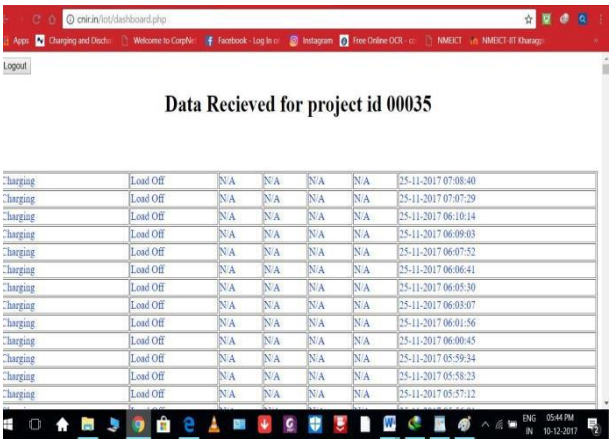
- The user can control the charging of the battery with the help of fast charging mode.
- By using PWM, we can rapidly charge the battery system.
- Setting up the temperature, charge & system voltages accordingly embedded code is executed.

A user needs not to do anything server attentively accepts the information regarding battery conditions like healthy, fully charged or having low voltages

Client Module:

In the proposed system client penetrates the username and password through which they can, fortunately, login to a webpage. The client end is employed with PHP API which is having assorted functions like battery charging status, an operation mode of load, fault indications and also date and time of operation is specified. [9]

The client-side script utilizes circumstances and indicates the following parameters.



Screenshot II – Profile Customization

- Battery condition is healthy (battery is fully charged, or battery has low voltage)
- In case of battery is fully charged check the terms of load
- Setting the values of the battery (Minimum & Maximum).

Setting the values is discretionary as a usual which can be predetermined. The maximum amount can be assigned as 99%, and minimum value can be attributed to 35%. The client can access the IoT based solar charge controller using Wi-Fi directly. [9]

4. Conclusion and future scope

In India the operating grids are not competent to fulfill the needs of everybody in every place, so we opted for renewable energy sources. Solar power has a benefit of pollution-free and less maintenance cost at the same it has a drawback of low conversion efficiency and fabrication cost, so solar panels are small conversion efficient but using efficient solar charge controller we can deduct the overall system cost. [1]

The proposed system can be automated the charging process of a system. This method can turn on/off when the load is connected and charging whenever needed depending upon the conditions using PWM Technique and increasing the life cycle of solar charge controllers. Further advancements can be made to improve hardware performance of systems. [3]

BIOGRAPHY

- Dr. H Ravishankar Kamath is a Ph.D. professional with over 27 years of experience in Delivery Planning, Academic System Development, Academic Quality Enhancement, Operations Management, Administration, Student Management, Documentation, Liaison & Coordination and Team Management. Currently serving AS PROFESSOR ICE department at MANIPAL INSTITUTE OF TECHNOLOGY MANIPAL, MANIPAL UNIVERSITY Karnataka.
- Mr. S S P M Sharma B is an M.Tech professional with over six years of experience in the Examination system, Academic Quality Enhancement, Training & Placement. Currently serving AS Assistant Professor Electrical Department at MEWAR UNIVERSITY RAJASTHAN.
- Mr. V Siva Brahmaiah Rama is an M.Tech professional with over six years of experience in the Examination system, Academic Quality Enhancement. Currently serving AS Assistant Professor Electrical Department at MEWAR UNIVERSITY RAJASTHAN.

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