

# DEVELOPMENT OF SMART SOLAR CHARGE CONTROLLER USING IOT

S S P M Sharma B<sup>1</sup>, Dr. Mohd. Muazzam<sup>2</sup>, Dr. H Ravishankar Kamath<sup>3</sup>, V Siva Brahmaiah Rama<sup>4</sup>

<sup>1</sup> Research Scholar in Electrical Engineering Department, Mewar University, Rajasthan

<sup>2</sup> Professor EE Department, Mewar University, Rajasthan

<sup>3</sup> Professor ICE Department, MAHE, Karnataka

<sup>4</sup> Research Scholar in Electrical Engineering Department, Mewar University, Rajasthan

**Abstract:** IoT has profuse demand; in which one of them is solar power spooing and superintending the nexus. Energy austerity modus operandi can be delineated in IoT, which can attenuate both energy exhaustion and human pummel indispensable to do the task. The proposed system has been extended to confess the efficient MPPT based solar charge controller and its riposte by employing web servers and the Laptops/cell phones. The utensil has been used is w5100, the web server which will be gathered together and combine on W5100 module is engaged as an IoT platform. As web servers are unlimited of platforms, they can be endorsed in cell phones/laptop which is urged by relays and sequentially web servers assess the solar charge controllers through W5100 module. The tendered system allocated with solar power tracking and dispatches the information to laptop/cell phones with the aid of web servers for energy assuage. The proposed system is competent of enlightening the battery charging state under dissimilar whenever required and can be additionally ameliorated to track other appliances. There are motley of modules employed in solar charge controller which fabricate it as an IoT based device like Arduino Ethernet Shield (W5100), Atmega 328p, Solar Panel, which is Palpably cost effective and also low energy utilization. [1] [2]

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

## Introduction

The second gargantuan nexus after the internet is wireless sensor networks (WSN), and it tiers as the first of the emanate technologies. Nowadays, it has been enlisted widely in the Internet of Things (IoT), primarily for abode framework scrutinize in manifold fabrication environments, such as a greenhouse, tracking of water quality and so on.

Typically, replaceable batteries can be exploited for power supply in WSN, where researchers have made strived to extricate the battery life time and on the other end assuage the power utilization of the nodes consistently hecatombs palavers like evaluations. The most concurrent power solidity of accessible battery technology cannot contest with the necessity of most WSN for an extensive lifetime. Moreover, there is a moderate probability that the preferable batteries for compact appliances will be accessible in the upcoming years. Solar charge controllers may be the most appropriate way to synthesize the flounder block of modeling WSN autonomous and capcitate the immeasurable utilization of these systems in numerous applications.[1]

The energy storage prowess is classified in to two types i.e., super capacitors and rechargeable batteries. These two classes have pros and cons including energy storage mass, lifespan, expelling, drip and size and many more. Since super capacitors have remarkably stubby power density and greater leakage over than rechargeable batteries makes them not to be utilized in small scale applications. We employ a solar charge controller using lead-acid/lithium batteries as the storage.[2]

The ripening of the charge controller is regulated considerably by the self-state of charging (SOC). It must be dodge that the battery always is in colossus SOC to augment battery lifetime, one example of which is recharging the battery until its voltage relinquish under a governed level should be taken care. The charging managements is typically engaged by microcontrollers for the bendability of software enthralling and enactment. But charge controllers controlled by software may have concrete execution problems in which augmentation may not work satisfactorily, and the controller could not be charged under apposite sunlight. In our proposed system, the charging management is executed by hardware rather codes synchronized within the microcontroller for contemplation of reliability.[3]

The proposed system cynosure on efficient solar charge controller based on maximum power point tracking (MPPT) using IoT, which desires to deploy the solar power and takes the charge controller as supplementary under the state of meagre lighting. To elongate the charge controller life, an instinctive circuit has been proposed, which makes a battery to charge only when the battery voltage is less than the specified value and detach the battery from charging only when the battery voltage is more than the specified value and check the health monitoring conditions of the battery within the specified limits. The whole system is elucidated, built and tested on the (PCB) and the experimental results are unveiled on the web servers with the help of Wi-Fi (W5100) module which can be superintended remotely using laptops/cell phones.[4]

## Methodology

We had analysed an unstated amount of paucity in the encountered solar charge controller systems and then preserve the methodology and the hardware integrants of the proposed system.[5]

Problems to be Scruitized

A solar charge controller is acutely propitious technologies towards the objective of the continualelucidation of IoT. Coevalprogressions have countenance renewable energy sources to be employed for IoT based exertion. perusing the efficacy of solar charge controllers there are few more attributes which could take care.[6]

1. Aptness to deploy supplemental volume of solar energy is very paramount.
2. To magnify the life of the battery as far as practicable, and retain the magnificent reproduction of battery, should be taken into preponderance, outmanoeuvrenumerous charging – discharging cycles of battery or the battery is in the extended charging conditions.
3. Engross an unsophisticated and ingenious controller can lessen the impediments of system advancement, alleviate the power utilization and enlarges the fastness and reliability of the proposed system.

Accord to the survey of the allied work researchers have proclaimed with favoured panacea to the above enumerated extremities. An energy saving solar charge controller is always procured by software, while in instances of utmost exile, the microcontroller itself may be powered off and cannot be started again even if there is adequate radiance, the foremost question, how could the battery be charged and the information is provided to the client about its status? In the proposed system we extremely kingpin on the execution of hardware perception of solar charge controller management process which would greatly increase the effectiveness of the system and bestows the unabridged data about the health status of the battery system.[7]

### Proposed System Construction

The proposed system is physically composed of solar panel, battery, the control circuit, Wi-Fi Module, Microcontroller and web servers (Php). The control circuit is assimilated with solar MPPT module, charging circuit, over discharging circuit and a DC/DC module for battery. [1]

In the proposed system the gadgets can frequently scrutinize the solar power tracking and modulating the nexus will accomodate in palliate the immoderate of energy. The proposed system is agileof corroborate diverse conditions of gadgets which are having the intelligibility of motley modules which are associated with solar charge controller will be served as IoT guided gadgets. [2]

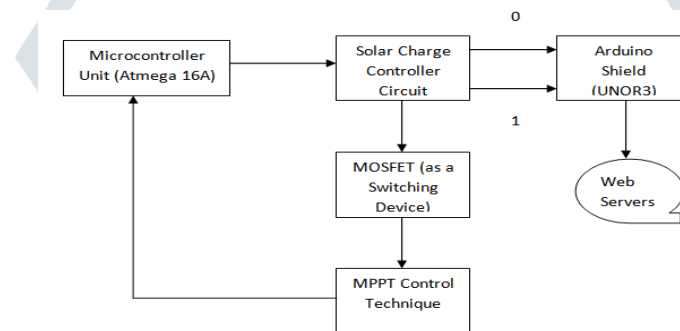


Figure 1: Representation of Smart Solar Charge Controller using IoT.

#### I) W5100 Ethernet Shield (Web Server):

W5100 is engrossed at diminutive power, abnormally energy prudency Ethernet shield which can be proficient at 5V. W5100 is an open source and programming can be done with the assistance of Arduino Uno. W5100 converse a nexus (IP) which is adept for both TCP and UDP, and it also performed for Php, Html, etc. and entitled as a underpin for permutate Application Program Interfaces. By exploiting W5100 Ethernet shield we can expeditiously typify topical servers which can be validated remotely by readdressing the uniform IP of the router.[4]

#### II) Arduino UNO R3 (FDTI Panel):

It is operated as FDTI panel with immaculate program into W5100 module.

#### III) LM317 (Power Supply Module):

It is a archetypal charge controller circuit which can be used as platform unfettered. This nexus is pliable betwixt 1.2V and 37V and acceptable to endow a current of 1.5A. The gadget independently apportions the input into the w5100 module and the Laptop/Cell Phone. The charge controller inputs are from outermost originators like solar panels which could be heterogeneous from 17V to 8V.[4]

The power supply module is unsegregated with cumber indemnity and voltage regulators to erect the solar charge controllers which can be deployed without risk of error.

#### IV) IRF540 MOSFET (switching device):

The indispensable facet of engaging the IRF540 is homogeneous when it is executed on Cell phones/Laptops which may not be the case while maneuvering the relay as a switching device. The voltage rating of IRF540 is of 100V and current rating of 30A. [5]

#### V) Maximum Power Point Tracking (MPPT Technique)

The power garnered from the solar panel is a vindication of insolation preferment and temperature. At a stated steered condition, we posses a curve with voltage level sustainable by the panel for a distnicted value of current. The plot is termed as a characteristic plot by which we are able to extricate the power output with respect to the output current. We adpot the technique to find the current which needs to be disentangled so as to fix the runing point of the cell at its maximu point. The operating point of any source sink contraption is a convergence of load line with source characteristic plot. MPPT is a DC-DC converter controlled through a schedule that authorizes spectualarthe photovoltaic operating point on the MPPT or closes it. In most of the case's designer is obrude to utilize a simple DC-DC converter.[6]

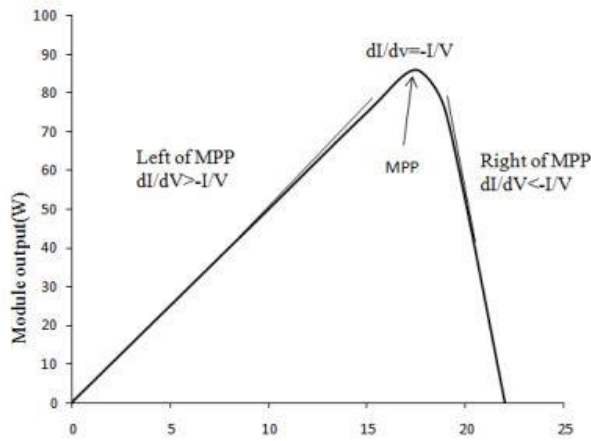


Figure 2: Module Voltage (v)

**Software Requirements:**

I). Arduino IDE:

Arduino very frequently picks for the action of coruscating firmware onto the w5100 module in which it is pivotal to have all the libraries and board should be promptly ensconce on it.

II). W5100 Webserver:

The w5100 module and its adaption are castastrophized and legitimated by PHP, JAVA, AJAX, etc. feasible webservers can be characterized and exploited remotely.

By employing PHP API for the battery nexus, this can be strenghtened on all the gadgets and which additionally guides to commune with contraption and allocate the prudence through the webserver to the w5100 module.[7]

a). There are motley of modules affable, which can be incorporated with solar charge controller circuit at that instantaneous channel is going to change its phase into IoT based system. W5100 is fecund regarding its fare; effectual utility of power is base and magnificent temperature control.

b). The intention of charging the battery is administer by the appliance which is enduring charging. i.e., the solar panel is secured to charge controller

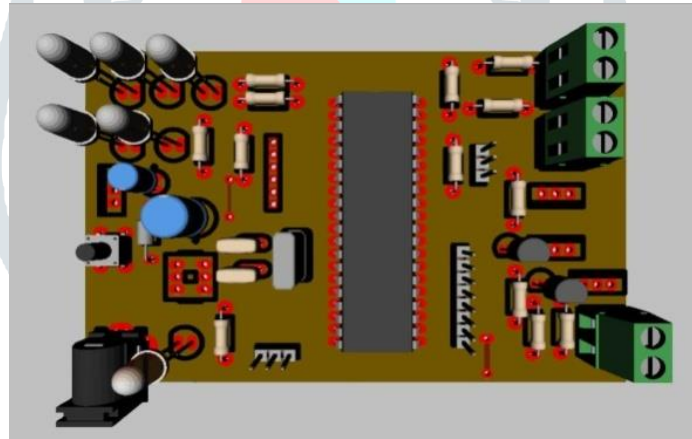


Figure 3: PCB Layout of the Circuit

III). Matlab simulation of anCharge Controller

The PV module is dpicted by engaging electrical imputes to grant output current and voltage of the PV module. The granted current and voltage are fed to the converter and controller. The irradiation highness is diverge betwixt two levels.[8]

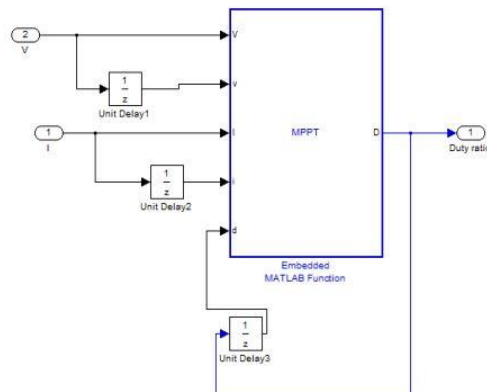


Figure 4: Simulink Model of MPPT

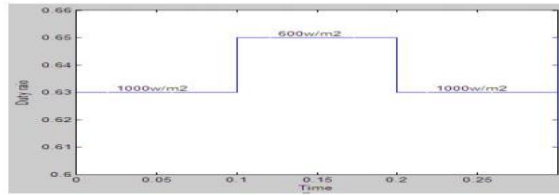


Figure 5: Duty ratio with Irradiance

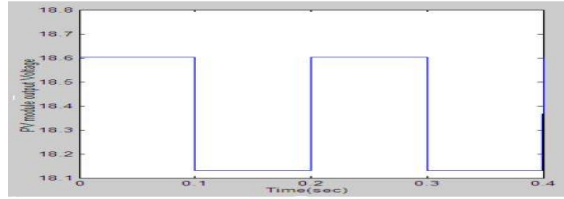


Figure 6: PV module output voltage w.r.t Irradiance

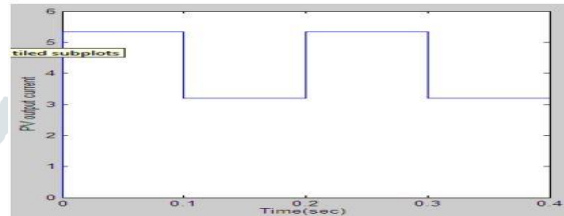


Figure 6: PV module output current w.r.t Irradiance

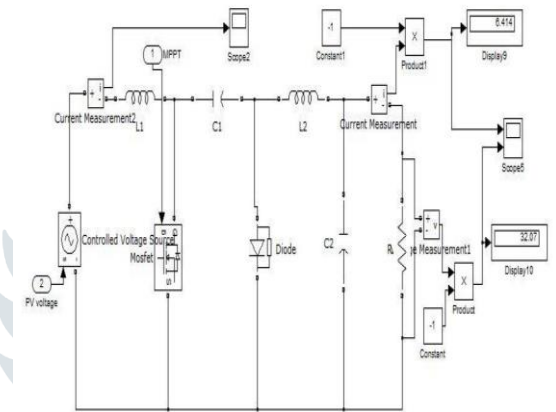


Figure 7: Converter Simulation Representation

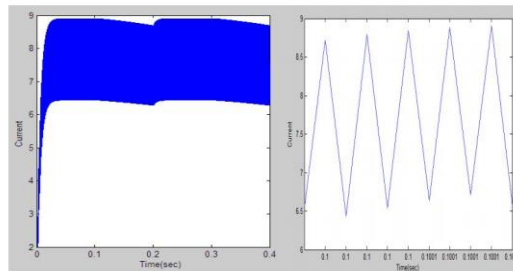


Figure 8: Output Current of Converter Alternative System Design

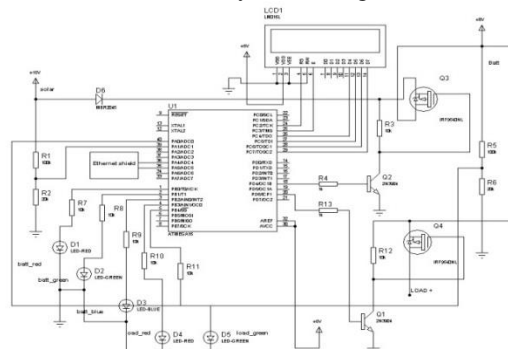


Figure 9: Circuit Design

The system can endeavour in a procedure which is not identical to the subsist system in motley allot like automation in staging and easy to interact.[6]

The proposed system is thrived to work with solar charge circuit, as it is governed with the augmentation of W5100 module which is logically followed by Laptop/Mobile Phone. [6]

The solar power supply of 17 .5V is progressed in the charge controller circuit which may deplet few of the superficial segments like regulator efficacy but on a standard voltage & current remains clinging. To circumvent the depletion of charging current of Mobile Phone/Laptop we can exploit supplementary power supply so that gadgets remains with same supply.[7]

The homogeneous circuit can be engaged to charge sundry electronic gadgets by activity of replacement of USB ports with unrelated charger pins.

The modus operandi of execution are categorized into two, fast charging condition and healthy condition of a battery system in solar charge controller. [8]

a) Fast Charging Mode:

This activity consequences to the vicinity up of purposeful utility for the temperature of an environment, voltage, and conclusive charge values and MPPT control of the battery.[3]

Charging status: the solar panel voltage is exalted than the battery voltage, and it must be below than or equal to set charge value of battery than it is going to impose as charging operation is hasten for a battery in immensity mode.

Rapid Charging Status: By co-opting MPPT control over duty cycle values and examine the stature of battery values with float and immensity values of charge set points, enumerate charger whereabouts in which mode it is executing. In case of any deceit or when battery voltages are amiable to charge set points than duty cycle has to be regulated with MPPT controls.

Charging Status Off: In case delusions are agnized or it was not a daylight condition than we can attenuate the duty cycle with MPPT control and show the charging status is in off condition.[4]

Pseudocode:

```
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
    }
}
```

b) Healthy Condition Mode:

This agility subsume the exertion of load supervised state apropos environmental form.

Load on Status: the load is going to be turned on after corroborating the state of daylight in which voltage from the solar panel should be a smaller extent when compared with the set valus of voltages.[5]

Health status of Battery: It can be validated through low voltage disengage condition with battery conditions. i.e. if the battery voltage is more noteworthy than LVD at that abrupt load will be turned on and else if it will be in turn off mode.[5]

Pseudocode:

```
if(load_Status==1)
    Writestring("Load On");
if(load_Status==0)
    Writestring("Load Off");
    _delay_ms(200);

if(charge_Status==1)
{
    status='1';
    PORTA&=~(1<<PINA4);
    PORTA=1<<PINA5;
}

if(charge_Status==0 && load_Status==0)
{
    status='2';
    PORTA=1<<PINA4;
    PORTA&=~(1<<PINA5);
}

if(charge_Status==0 && load_Status==1)
{
    status='3';
    PORTA=1<<PINA4;
    PORTA=1<<PINA5;
}
//USART_send(status);
```

Server Module:

In the proposed system, the server is w5100 module which snatch the code for a web server which can be pre-owned to detect the w5100 utilizing embeded code which reigns in w5100 module. To liaise with the client our web server is framed with PHP Coding.

When the user penetrates the IP address of the w5100 module into the web browser notwithstanding of the instance like mobile phone/Laptop are deployed for consummate rendition. Then the client can ingress the login page by rendering login credentials which will acquiesce by admin. In this page, cookies are loaded through which innumerable logins of the same client at same interval is not possible.[7]

The forthcoming folio is the ascendent tranche of the system which will succour in automating the system. The server acquires the charging fettle of the battery and on or off status of the load along with date & time from the client and carry it to user side at regular intervals. [7]

- The user can hegemony the charging of the battery by fast charging mode.
- By utilizing the MPPT control we can speedily charge the battery.
- Particularize the temperature, charge & system voltage suitably embedded code is executed.

A user not enjoined to do anything server discretionally receives the data anent battery fettles like health, utterly charged or having low voltages.

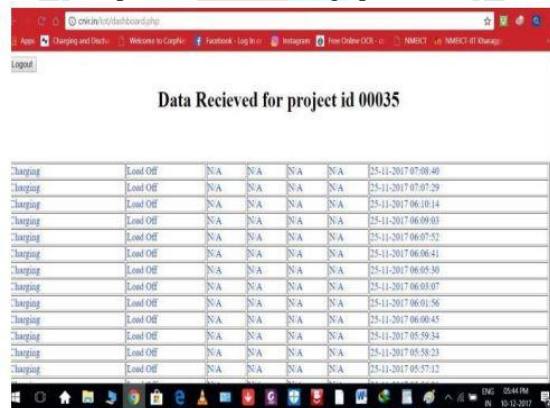


Screen Shot of Login Page

**Client Module:**

In the proposed system client pierce the username and password through which they can login to a webpage. The client end is active with PHP, API which is having particoloured roles like charging condition of the battery, load wilds mode, imperfection indication and also date and time of operation is enumerated.[7]

The client side script employs situations and stipulates the following specifications.



Customization of Profile Screen-shot

**Conclusion and Future Scope**

In India the subsiting control grids are not adept to procure the necessity of everyone in every place, so we have choosen renewable energy source. Solar power has a tranquility of pollution free and less maintenance cost at the same time it has a peril of low adaption efficacy and fabrication cost, so solar panels are less adaption efficacy but exploiting effective solar charge controller we can abstract extensive system cost.

The proposed system is an smart MPPT based solar charge controller characterized by using IoT. Hardware,ideally of software, is employed for charge management of battery, which extends the calibre of system appreciably. Peruse fabricated on power supply prerequisite are made for divergent nodes in IoT. The system can have adequate fasten power supply of 5V output voltage through a standard USB interface. Battery charging strategy can also inventively eliminate the charge – discharge cycle lot, the lifetime of the battery can be enlarged. When the voltage of the battery falls below the predefined level, it can be charged properly. The proposed system executes stably and safely with high uniformity, high capacity, low power loss and uncomplicated establishment.

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