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Design & Fabrication Of Novel Maximum Power Point Tracking (MPPT) Based Charge Controller For Enhanced Electrical Performance

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***Abstract*—**Due to the fact that conventional resources are gradually decreasing day by day, scientists are working hard to find other sources to produce energy. Solar energy is also used in the form of electricity as it is clean & evergreen accessible energy. Due to high population rate rapidly, electricity demands vary day by day as it is part of our lives. We are using electricity in every aspect of our lives i.e. from houses to offices, industries, transportation, agriculture etc. our country Pakistan is passing through electricity crises from many several years. Average load shading in our country is minimum 8 hrs/day, which is very high number in undeveloped country. Nowadays government of Pakistan is working on other sources of electricity i.e. solar energy & wind energy. These renewable resources can be naturally replenished and are considered inexhaustible, as compared to diminishing conventional fossil fuels [1]. The study by Energy Information Administration (EIA) shows that the total world energy consumption from renewable energy resources in 2014 is about 11%, which will increase to about 15% till 2040 [2]. Recently with the help of tremendous investment our government (Pakistan) has built a solar park with the capacity of 100MW at Bahawalpur[3]. Most favorable source of electricity is solar energy, which we got through PV cells but these PV cells are expensive and has less efficiency, due to these factors following are obstacles in its use, the cost per kWh of power can be reduced by improving the efficiency of the PV panel system[4]. Economical reflectors, lenses & condenser concentrators can be used. These mirrors focus the light intensity on the entire surface of the panel; it increases the output of the solar cell module because more electrons are generated[5]. However, the temperature of the panel rises due to the increased optical radiation over a longer period of time, which is turn lowers the open circuit voltage (Voc) & decreases its efficiency. For resolving the issue, a cooling system is required to maintain efficiency of P.V panel & P.V system. Sunlight can be converted into electricity via photovoltaic cells, moreover major drawback of photovoltaic PV cells are non economical, less energy conversion, ability, & frequency. Current-Voltage curve of P.V cell depends upon the temperature & amount of electromagnetic energy strikes on the panel. The highest power point on the current-voltage curve of PV cell where system production is high is called maximum power point (MPP)[6]. Due to temperature & isolation level, the M.P.P on current-voltage curve changes. To improve the efficiency/working of P.V panel, the efficient & cost effective charge controller with M.P.P.T is formed. This M.P.P.T controller is able to harvest maximum power from solar through irradiation & temperature[7]. It increases the battery life by protecting it from overcharging. In the midst of diverse maximum power point tracker of different approaches, perturb and observe (P&O) approach with some modifications provide excellent results. Physical implementation of proposed technique is done by designing M.P.P.T using DC-DC buck converter and microcontroller. The advantages and the need of such M.P.P.T controller are discussed and the design of M.P.P.T charge controller is checked with P.V charging system. The outcome represent that, this type of M.P.P.T controller performs more controlled functions than any other conventional charge controller.

***Keywords*—** MPPT, Charge Controller, Renewable Energy, Photovoltaic Cell, Battery

I. INTRODUCTION

Nowadays electricity is considered as one of the basic and important need in human lives. The main energy resources for generation of electricity are fossil fuels, hydro and nuclear. The electricity demand all over the world is increasing continuously due to the development in industries and increase in population. To meet this demand, the existing resources (oil, gas and coal) are not enough and they are decreasing day by day. According to geophysicists the world oil production will peak in 2015 after which production will decline ~ 3% / year. For non-conventional Gas the world is about half way of its peak and it will peak in 2035[8], same is the case with coal. So, the problem associated with fossil fuels in the world is that their reserves are rapidly decreasing, on the other hand due to their combustion, pollution is produced in the environment. Deficiency of typical energy resources & harmful effects on environment has urged the world to find alternative resources[9]. In search of alternative resources the concept of renewable energy gained much popularity. These resources that can produce sufficient energy to meet increasing energy demand and they have no harmful effect on environment.

The power extracted from PV module based on temperature & irradiation level. In solar P.V. system, the modules (solar panels, inverter) & batteries are very expensive items. When there is a direct connection between battery and a PV. Module, battery acts like a load and pull down PV. module voltage to required battery voltage. Since battery has low internal resistance due to which the PV. module short circuit current (ISC) flows in battery. Batteries are directly connected or attached with PV. module & which has no safety verses overcharging, In the result the life of battery declining[10]. Conventional charge controller is used commonly for safety of batteries from overcharging but they are not that much efficient that it extract maximum power from PV. module to battery.

To extract the maximum output power handed over by PV. panel, it is essential to force the panel at the operating point consistent to the maximum power. The operating point is known as maximum power point. The easiest way to get M.P.P. is to force the PV. panel voltage to the M.P.P or to adjust the current the best level as that of M.P.P using indirect techniques. Indirect techniques are well suited for steady weather condition, where the MPP so does not change. But when the ambient condition like temperature and isolation changes, the I-V and P-V curves also changes. It means that the previous M.P.P is not used/valid under these conditions. Therefore, to be continuously in the M.P.P as long as necessary to track such changes in the I-V curves & discover the new M.P.P. This development is known as maximum power point tracking (M.P.P.T)[11]. In this paper, study and design of M.P.P.T charge controller is presented and implemented to operate a fixed P.V panel at M.P.P.

II. SYSYTEM DESCRIPTION

A. *Components*

The key components of P.V. system are batteries, modules, & there connection are done through charge controller. M.P.P.T. charge controller has been made to increase the performance of the whole system which is shown in below diagram.

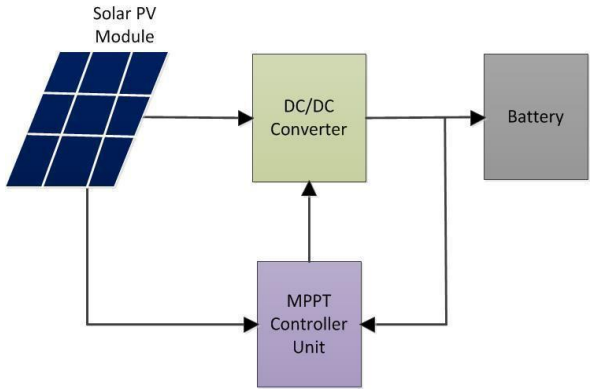

Figure 1. Block diagram of PV system with MPPT charge controller

The system contains, P.V., module, M.P.P.T. unit and battery. Here we will discuss M.P.P.T charge controller. For getting maximum power from P.V module, the M.P.P.T charge controller is inserted in between battery & PV module. Each diagram shown in Fig 1 is explained above.

B. *DC/DC Convertor*

DC/DC converter is an electronics circuit. which is used for leveling conversion of DC voltage. The DC/DC converter is used in switching-mode regulator. It consists of storage element (inductor, capacitor etc.) and switching elements (transistors, diodes etc.) in different topologies in order to achieve desired DC output. The connections of storage elements are in such way to minimize ripples from output voltage. The switching elements are used to produce duty cycle (D). Duty cycle is the ratio of "on time T_{on}" duration to the total switching duration "T". The main purpose of DC/DC converter is to step up or step down the input voltages which are done by changing duty cycle [12]. PWM controller is used to change duty cycle according to desired output. The main 2 topology for use for DC/DC converter are buck and boost, other topologies are derived from these two topologies. In our charge controller buck DC/DC converter is used.

C. *MPPT Alogrithm (Perturb & observe)*

Here perturbation is given to array voltage & PV. Module[13]. Voltage of PV. module is either increased or decreased and examine its power either it is increased or decreased If voltage is increase so the power is also increased. So it is concluded that unit of PV. operating power is at left side of M.P.P. if there is indirect relation b/w voltage & power so the P.V operating point is exist at left side of M.P.P. and therefore there is a need for further disturbance to reach to the level of M.P.P. The PV cure, and P&O algorithm has shown in both Fig 2 & 3.

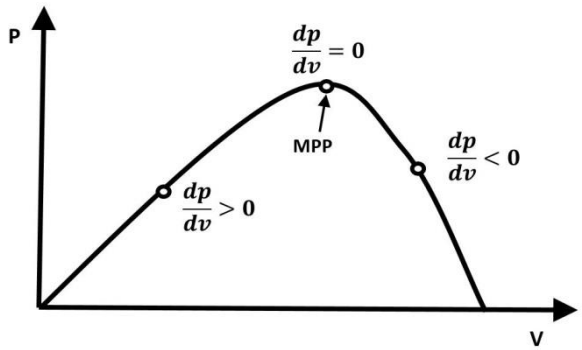

Figure 2. P & O algorithm PV curve

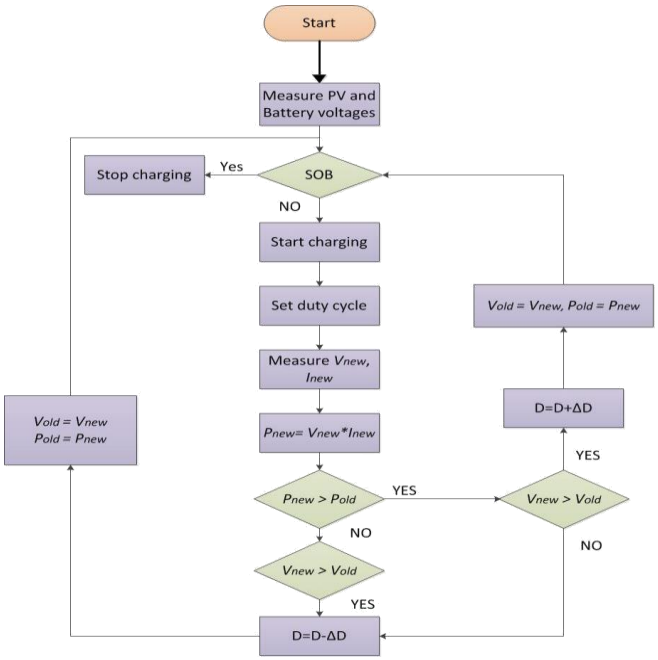

Figure 3. P & O algorithm

D. Battery Charging

The charging process is in 3 stages bulk charge, float charge & absorption charge. When battery is connected to PV. module through charge controller, initially when battery is fully discharged it consumes a large amount of charging current called bulk charge. During charging battery voltage increases gradually until point "a" as shown in Fig 4.10. Battery charging to its full capacity needs to keep charging beyond point "a" called absorption charge [14]. Self-discharge of battery always happen because of the internal resistance of battery, therefore at low current (mA) is provided to keep battery at fully charge state called float charge. The designed M.P.P.T charge controller avoids overcharging of battery and thus decreasing charging current. Charge controller is used to protect the battery from over charging & deep discharging is discussed in[15] I-V charging process of lead acid battery and charging stages are shown in Fig 4

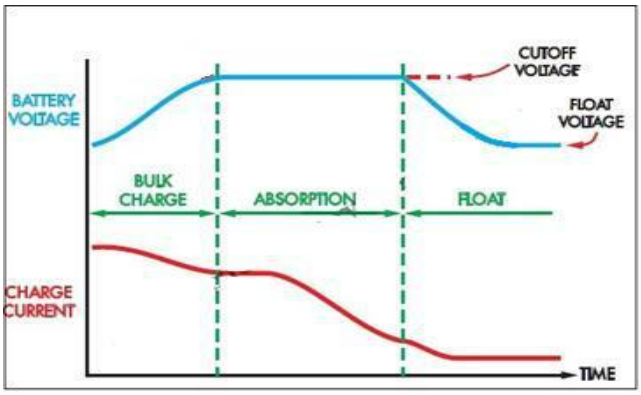

Figure 4. charging stages of battery

III. HARDWARE & RESULTS

The schematic diagram of the recommended M.P.P.T. charge controller is mapped through Altium designer software. Altium software is like Kiel software which is used for electronic design, automation & printing of circuit boards (P.C.B.), ingrained software design & field programmable gate array (F.P.G.A.). The block diagram M.P.P.T charge controller consists of three parts, buck converter, microcontroller and power supply as shown in Fig 5 & 6.

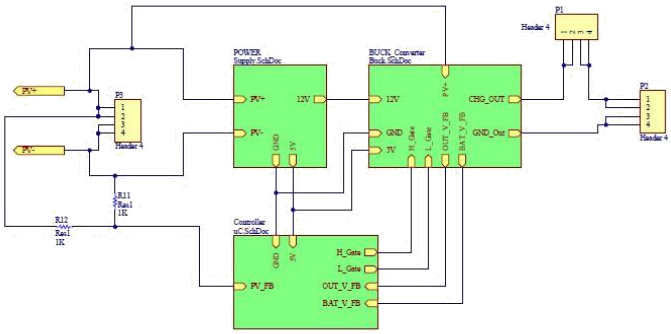

Figure 5. Block diagram of MPPT charge controller

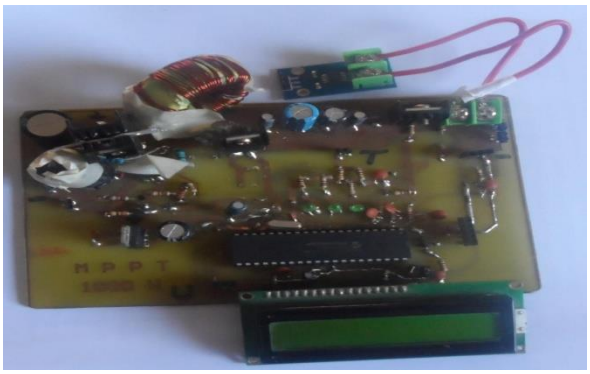

Figure 6. OurDesigned MPPT

A. Results

During testing of hardware, firstly the weather was cloudy & dusty due to which the output values keep changing. The duty cycle (D) of P.W.M. is the main factor on which the M.P.P.T charge controller output power depends, through oscilloscope diff input power are observed by changing duty cycles of P.W.M as shown in Fig 7.

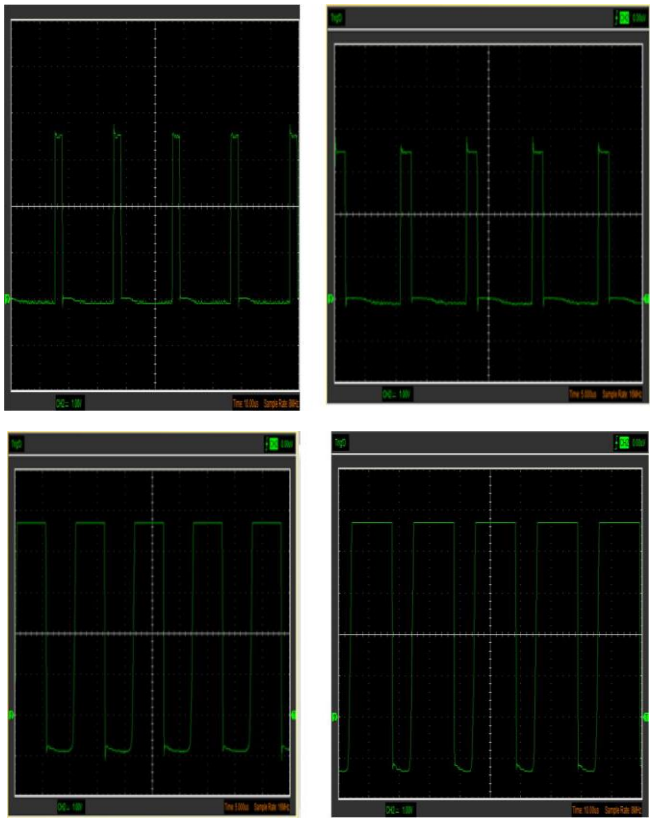

Figure 7. duty cycle at different power

B. *Comparsion of PWM & designed MPPT charge controller*

In our experiment when our battery is fully charged, it stopped charging from being over charging but gives small & low amount of current i.e.5mA. to fulfill need of battery because it discharge by itself. Here the efficiency & reliability of battery is improved by M.P.P.T charge controller[3]. Here the results are shown in below graphs 8 & 9.

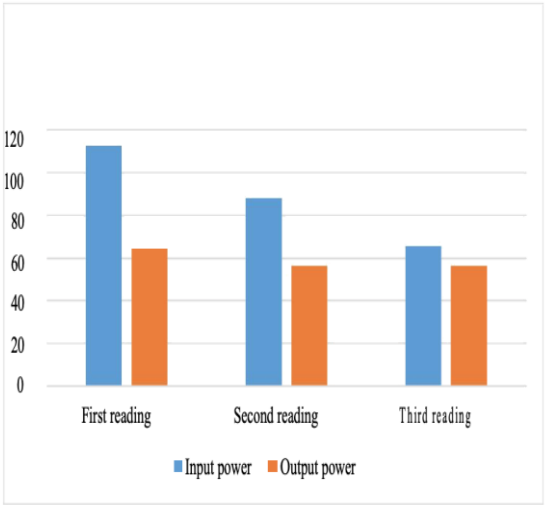

Figure 8. Input and output power: when PWM charge controller is connected

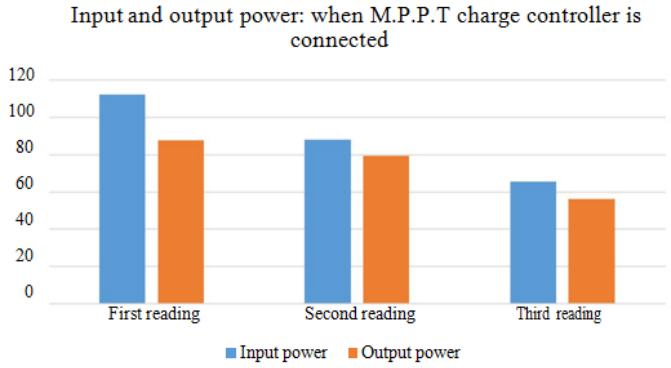

Figure 9. Input and output power: when M.P.P.T charge controller is connected

C. *Efficiency comparsion of PWM & designed MPPT charge controller*

We conduct two tests. We connect M.P.P.T charge controller & conventional P.W.M charge controller with different panels having same specification on the same theme. 3 results of both powers (i.e. input & output) are observed. Fist test was starts at 2.15 pm, at that time weather was little bit cloudy due to which irradiance level was changing continuously. 3 separate readings were observed from 2:15 pm to 3:45 pm to check & compare both charge controllers o different irradiance level & weather condition (I.e. sunny & cloudy)

Table 1. Comparison of PWM and deigned M.P.P.T charge controller

		Input Reading			Output Reading			
	Reading Time	Ipv (A)	Vpv (V)	Ppv (W)	Iout (A)	Vout (V)	Pout (W)	Efficiency (η)
P.W.M charge controller	2:15 PM	7.6	14.8	112.48	4.9	12.4	60.76	54.01 %
	2:45 PM	6.1	14.2	86.62	4.8	11.9	57.12	65.94 %
	3:45 PM	4.8	14.0	67.2	3.80	12.9	49.02	72.94 %
M.P.P.T charge controller	2:15 PM	7.6	14.8	112.48	6.8	13.9	94.52	84.03 %
	2:45 PM	6.1	14.2	86.62	5.783	13.86	80.15	92.53 %
	3:45 PM	4.8	14.0	67.2	4.0	13.99	55.96	83.27 %

Conclusion

To yield maximum power & enhanced the efficiency of batteries from P.V module, M.P.P.T. is tested & implemented in our paper. Different algorithms for M.P.P.T are described in literature[16]. In this thesis, P&O algorithm is practically implemented with some modifications using microcontroller. The high efficiency of M.P.P.T. controller &, Buck-type DC/DC converter are the major components of this hardware. The M.P.P.T which is based on microcontroller is implementing P&O algorithm is constructed and tested to charge battery. Both charge controllers are tested on 200 W solar panel & on 12 V batteries. Our modified algorithm provides us effective & authentic high level power performance under change of atmosphere (i.e. irradiance level & Temperature). Thus we concluded from the observation & results that our suggested charge controller is more efficient & reliable than others.

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