# MATLAB/Simulink를 이용한 오프그리드형 고효율 태양광 충전 시스템 설계

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# Design of an Off Grid type High efficiency Solar charging system Using MATLAB/Simulink

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ABSTRACT

An Off grid or remote solar electric systems are an energy supply to our home or to our companies without the utility of Grid at all. Off grid solar systems are very important for those who live in remote locations especially for developing countries where getting the electric grid is extremely expensive, inconvenient or for those who doesn’ t need to pay a monthly bill with the electric bill in general. The main critical components of any solar power system or renewable energy harvesting systems are the energy storage systems and its charge controller system. Energy storage systems are the essential integral part of a solar energy harvesting system and in general for all renewable energy harvesting systems. To provide an optimal solution of both high power density and high energy density at the same time we have to use hybrid energy storage systems (HESS), that combine two or more energy storage technologies with complementary characteristics.

In this present work, design and simulation we use two storage systems supercapacitor for high power density and lithium based battery for high energy density. Here the system incorporates fast-response supercapacitors to provide power to manage solar smoothing and uses a battery for load shifting. On this paper discuss that the total energy throughout of the battery is much reduced and the typical thermal stresses caused by high discharge rate responses are mitigated by integrating supercapacitors with the battery storage system. In addition of the above discussion the off grid solar electric energy harvesting presented in this research paper includes battery and supercapacitor management system, MPPT (maximum power point tracking) system and back/boost convertors. On this present work the entire model of off grid electric energy harvesting system and all other functional blocks of that system is implemented in MATLAB Simulink

**Key Words**

Photovoltaic, Lithium Based Battery, Bupercapacitors, MPPT and Back/Boost Convertors.

## Ⅰ. Introduction

Due to prolonged extraction and use of conventional energy resources; namely coal, petroleum and natural gas have caused unpleasant effects on the environment and their inability to meet up for the ever increasing power demand due to increase in population, renewable energy resources are become popular in the world [2,4,6]. Solar Energy is one of the Sustainable ultimate sources of energy, which is naturally replenished (supply) in a short period of time.

Solar energy has the advantages of maximum reserve, inexhaustibleness, and is free from geographical restrictions, thus making PV technology a popular research topic. In this world 80% of the green houses gases are released due to the usage of fossil fuel based. The world primary energy demand will have increased almost 60% between 2002 and 2030, averaging 1.7% increase annually, increasing still further the Green House Gases. Oil reserves would have been exhausted by 2040, natural gas by 2060, and coal by 2300. This causes issues of high per KW installation cost but low efficiency in PV generators. Currently more research works has been focused on how to extract more power from effectively the PV cells. There are two ways such as solar tracking system and Maximum Power Point Tracking (MPPT). The Maximum Power Point Tracking (MPPT) is usually used as online control strategy to track the maximum output power operating point of the Photovoltaic generation (PVG) for different operating condition of insolation and temperature of the PVG. The author compares and evaluates the percentage of power extraction with MPPT and without MPPT. It clearly shows that when we use MPPT with the PV system, the power extraction efficiency is increase to 97%[3]. An important part of the system is the electric energy storage system. One alternative used to provide this storage is the super-capacitor. Because of its advantage in power density compared to batteries, it is starting to become more frequently used as energy storage for various types of systems. The study of developing a PV charging system for Li-ion batteries by integrating MPPT and charging control for the battery is reviewed[3,4].

## II. Body

### 2.1 The Overall Block Diagram Of Off Grid Solar Power System

Solar Cells or Photo Voltaic Cells are devices or we can say transducers that convert the energy available from sunlight directly into electrical energy which is DC in its nature. PV Cells are based on the principle of photoelectric effect. PV Cell as the single unit generates a very small amount of voltage in the range of 0.5 to 0.8V depending upon the technology which is being used. For commercial use these cells are connected or integrated in series and parallel to form a PV array in order to give a decent amount of voltage which could find some application in the commercial world [5].

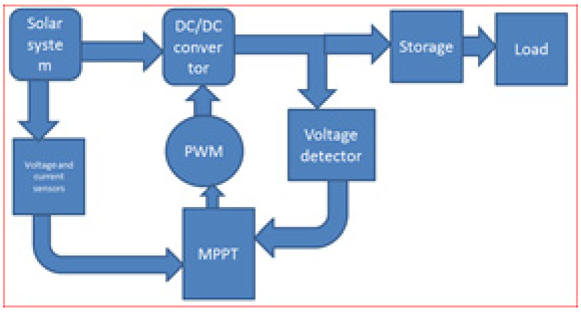


Fig. 1 Over all block diagram of the system

### 2.2. SYSTEM DESCRIPTION

In different research's authors review the various types of non-isolated DC/DC converters for the photo voltaic system. Optimal operating performances by different converter topologies are one of the main points which can be summarized in this research work[1,5,7]. It concludes that the best type of converter for PV system is the buck-boost Dc/Dc converter that connects to the supercapacitor and boost Dc/Dc converter connects to the battery. The overall block diagram of PV panel with DC/DC converter and MPPT is shown in this Figure 1. The detail models of PV solar cell, solar array and maximum power point tracking (MPPT)s are discussed on [1,3,7].

The method that we used while designing MPPT [5,6,7] system is called as incremental conductance method which uses the PV array's incremental conductance $dI/dV$ to compute the sign of $dP/dV$. When $dI/dV$ is equal and opposite to the value of I/V (where $dP\,dV=0$) the algorithm knows that the maximum power point is reached and thus it terminates and returns the corresponding value of operating voltage for MPP. The output of the MPPT gives to the PWM (pulse width modulation) for the sake of controlling the coming DC/DC converter and charging the storage devices (supercapacitor and battery). Modeling and design of storage devices are discussed in detail on [1,8,9].

### 2.3. Simulation results of the system

Figure 2 shows the simulated results of the battery SOC (state of charge), current and voltage respectively as shown in figure 2 as the current increases flowing to the battery the voltage decrease and the state of charge condition is good. Figure3 shows the simulated results of the supercapacitor current, voltage and SOC (state of charge) respectively, here the state of charge of the supercapacitor is less than the battery but the charging and discharging time of the supercapacitor is very fast. Figure 3 shows simulated results of supercapacitor power and battery power, on this result the required maximum power is 2500 watt and the supercapacitor power is similar with the needed output but not the output of the battery due to chemical reaction delays. Figure 4 shows the simulation result of the needed power and the summation (SUMP) power of supercapacitor and battery that improves the efficiency of the PV array result of the system.

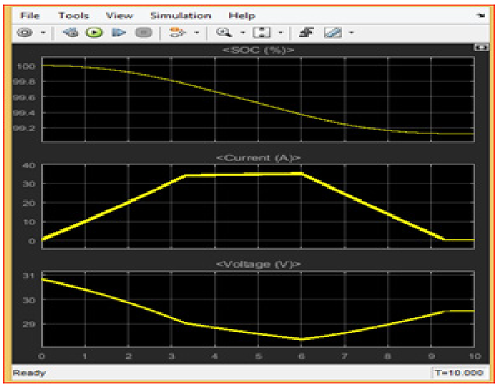


Fig. 2 Battery soc,current and voltage

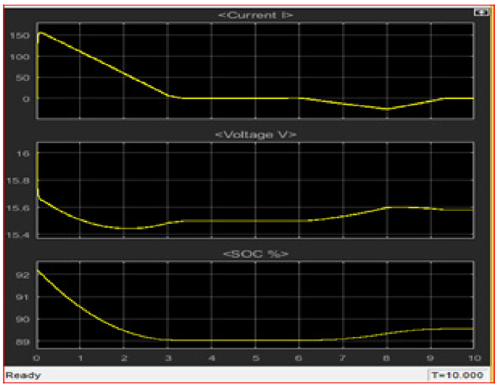


Fig. 3 Battery current,voltage and soc,

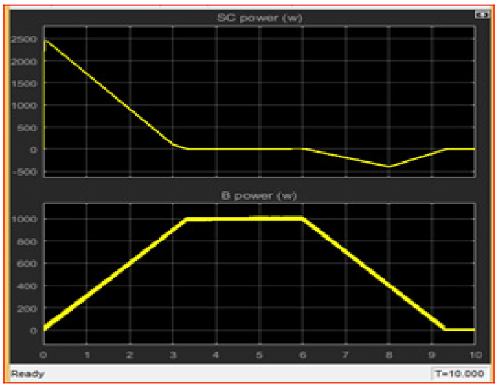


Fig. 4 Supercapacitor and battery power

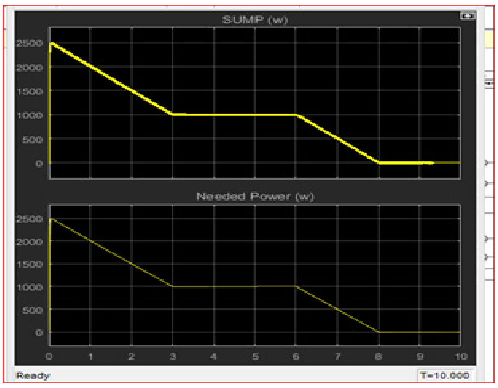


Fig. 5 Needed and SUMP power

## Ⅲ. CONCLUSION

In this paper, the model of grid off solar system has been presented, in order to predict the efficient charging and discharging performances of supercapacitor and battery storage systems using PV modules. The duty cycle of back/boost converter is controlled through MPPT controller to track the maximum power from solar array.

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