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Smoothing Control of Solar and Wind Power Fluctuation

S Balamurugan [a], Sabari L. Umamaheswari [b], P Karishma [c], Kante Sai Lasya [d], M J Suganya[e], Shanmugaraj[f]

[a,b] Assistant Professor, R.M.K. Engineering College, Chennai, Tamilnadu, India
[c,d] UG Student, R.M.K. Engineering College, Chennai, Tamilnadu, India
[e] Assistant Professor, Panimalar Engineering College, Chennai, Tamilnadu, India
[f] Design Engineer, Tata consultancy services, Tamilnadu, India
[a] sbm.eee@rmkec.ac.in , [b] slu.eee@rmkec.ac.in, [c] kari18202.ee@rmkec.ac.in,
[d]kant18201.ee@rmkec.ac.in, [e] shanmugaraj1988@gmail.com

Abstract

The Battery Energy Storage System (BESS) is the present way of smoothing wind- and photovoltaic-power generation fluctuations. The power quality of renewable energy power production system can be improved by Battery Energy Storage System. This method has attracted everyone by the way which it gives high quality power. Another one important issue is that the appliance of an energy storage system like BESS. While using BESS to manage Photo Voltaic and fluctuations produced by wind power , there will be a exchange between effort given by the battery and the degree of smoothness. So, if one wishes to have a smoothened output efficiency of the output reduces so the battery is used to compensate the loss. Eventhough many effective BESS methods are proposed , the earmark of wind and Photo Voltaic farms generally haven't been formulated. So in this work, it is better to use spare system which can store their capability such as lithium ion battery is employed to smooth power out fluctuations of wind and PV using Basic Smoothing Control Method (BSCM). The proposed system is implemented in MATLAB/SIMULINK software. The MATLAB simulation output verifies the results of the proposed method.

Keywords: BESS)-Battery Energy Storage System, Wind energy, Solar PV, Hybrid systems

1. Introduction

Renewable energy sources are the sources of energy which weren't get destroyed when it is harnessed. Renewable energies which are used by Humans requires certain technologies that produces natural phenomena, like light of sun, wind energy, waves produced from the ocean, flow of water and certain biological processes like anaerobic digestion, biological hydrogen production and geothermal heat. These mentioned sources of energy has many technologies which helps in producing wind energy and photovoltaic energy. Wind is a motionable substance which is produced by the irregular heating of the surface of the earth produced by sun. These variations consequently creates a force which pushes air masses around the atmosphere balancing the worldwide temperature or, on a way smaller scale, the temperature between land and sea or between mountains. Wind energy is not a stable source of energy. It varies continuously and provides energy in sudden bursts. About 50% of the entire wind energy is given at just 15% of the operating time. Wind energy produced has various fluctuations and thus cannot give any assurance for the continuous power .so, It is good to use spare systems such as hydro, reserve load,desalination plant, which has high reserve capacity and will meet the economic effects of resources variability.

Solar energy is one of the most ample and simply available natural resource, and has been harnessed by humans since past. Around a year, the Sun delivers quite 10,000 times the energy that humans currently use, and almost twice the quantity of energy which will ever be obtained from all of the planet's non-renewable resources. Solar power is obtained from sunlight which is used to produce electricity by using photo voltaic (PV) and concentrated solar power (CSP). Mirror and tracking system is used in CSP system which collects enormous area of sunlight and convert it into a light beam. Photoelectric effect is a process of converting light into electric current using photovoltaics.

Utilization of renewable energy are arising from viewpoints of environmental conservation and depletion of fuel. However, the generated power from renewable energies is usually fluctuating thanks to environmental status. Energy storage system is essential to reduce these fluctuations.

2. Control Strategies

Now a days, the method of smoothing wind and solar energy has attracted many people This issue is resolved, another issue is that, the usage of appliances which stores energy like BESS, has arisen. While using BESS to regulate solar and wind generation fluctuations, there's a conversion between battery effort and the degree of smoothness. So, if one wishes to have a smoothened output efficiency of the output reduces so the battery is used to compensate the loss. Although many effective battery energy storage systems based smoothing control method to reduce power fluctuation in conventional power system are formulated, this smoothing control method is not yet formulated in wind and solar energy producing farm. This method of Smoothing control by eliminating the power fluctuations is discussed rarely.

The control strategies published in many papers are used mainly for small-scale BESS based smoothing. So, they hadn't consider shared the power among many BESS. This BESS is the effective and suitable control strategy for large scale power industry so there is an urgent necessity for this method. In this project the assumption is the capacity of the Wind Pressure ,PV hybrid generation system (WPPVGS) and BESS has been found out and we are not able to adjust the output power of WPPVGS, the only way to control the power output is by using a large area BESS for smoothning the WPPVGS fluctuations.Wind/Solar/BESS hybrid power systems below Fig 1 is used to smoothen WP and PV power fluctuations instantaneously.

3. Battery Systems

Lithium-ion batteries are secondary cells which is build up with Positive electrode(LiCoO2), negative electrode(C) and electrolytes which consists of Li Salts. The battery with Lithium ion metal oxide as cathode and graphite anode has a potential difference of 3.7V.

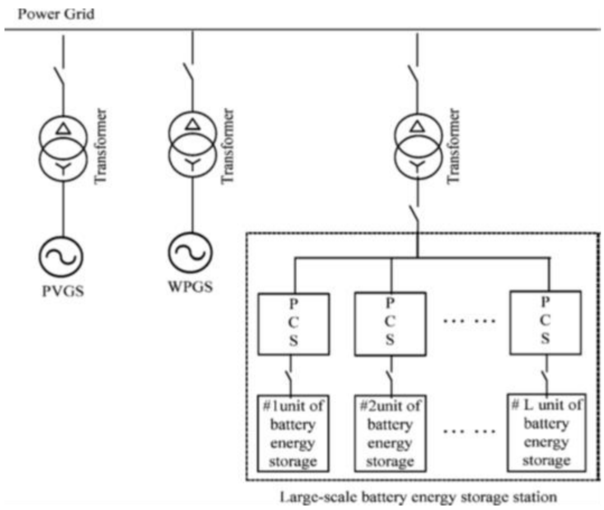

Fig 1: System Module Setup

There are also Li cells with a lithium metal oxide nickel manganese CoO2 mixed negative electrode which will posses 3.7V. The positive terminal is not stable but the liquid electrolyte due to process of decomposition converts to solid electrolyte by the process of interrelation the battery gets charged or discharged during this process Li is doped into graphite electrode on charging and it can be removed while discharging and doped into anode. The volume fading of Lithium – ion ranges around 12-24% after a time period of five hundered cycles.

Many process will occur which leads to ageing inside the positive electrode gets degraded in the beginning of the surface .

Eventhough, the SEI has a major role in the protection of positive electrodes and the electrolyte from further degradation, decomposing of the electrolyte takes place very slowly during cycling and parasitic consumption of Li growth of SEI linearly varies with Li because of increase in thickness and contact loss.SEI growth will increase impedance both due to SEI area of active material within the anode and cathode is reduced .The size of SEI and the progression of gas are increased due to high temperature and SOC.Further degradation methods includes plating of anode with Li by low temperatures and high rate of change .Due to decreased SOC degradation of cc (current collector) occurs . The charging and Discharging process changes the anode volume which leads to high DOD cycling, which results in the stress which causes loss of contact with cc (current collector). As if like Anode, the change in volume in cathode during the cycling process may increase the stress and can also lead to micro cracking and contact loss within the current collector and electrode. Mechanical stress could also be increased by phase changes within the electrode. Due to high potential difference slightly dissolution occurs in Lithium Metal oxide which can have high impedance .There is a chance of growing surface films on negative electrode.

Temperature and SOC of charge are found to be significant stressors in lithium-ion capacity fade. The process of degradation happens in uncycled batteries and increases by high temperature and high SOC. High discharge rates are also found to increase capacity loss in lithium-ion batteries, with degradation of the carbon anode contributing most to aging at high powers; high charge powers are similarly found to increase degradation rates. While capacity loss is due partially to loss of active material, additional studies suggest that changes in cell resistance shift the potential window for charging lithium-ion cells, which results in significant undercharging of those batteries because the cells age.

Much like in lead-acid batteries, increases in lithium-ion cell impedance cause power fade. SEI growth and Impedance growth is because of changes in porosity and accessibility of active material which contributes to power fade and also along with Impedance growth and leads to contact loss between electrode materials and the current collector. Impedance growth increases more at high and low states of charge than in the middle, suggesting that power fade is highly dependent on SOC.

Variable charge has been utilized in lithium-ion batteries to scale back charging time, very similar to for lead-acid cells. The charging process of the battery speed up when they are charged at 1000Hz or by varying frequency pulse charge from 100-1000 Hz. High current pulse charge followed by a decay current is found to decrease charge time over constant current constant voltage charging, but is also reported to increase impedance and capacity fade. Dynamic charge tests mimicking electric vehicle driving are found to end in higher capacity fade than constant charge. In comparing to Lithium-ion cells, the negative effect of current distribution for NiMH tells was greater.

4. Mathematical Modelling of Wind System

The energy extracted from the wind is called wind energy. This energy is directly proportional to the cube of the speed of the wind. It is an tedious process to acknowledge the characteristics of the wind in all aspects such as its velocity, the direction of wind and its variation. The tedious process involves the following such as to find the appropriate place, to speculate the self sustaining wind farm projects to generate wind energy and to design the wind turbine.All of these criteria depends on the characteristics of the wind.

One of the prominent characteristics of the wind is nonlinear nature and its arbitrariness. The wind is very variable, both contiguously and mortally. Moreover, this difference is present in a large scale, in both area and time. This is essential because the wind energy extracted differs with the cube of wind velocity. This variability is owing to climatic change across the world also the lean of earth on its axis and its spinning leads to different distribution of the wind across the planet. Also, for any climatic region, there's an excellent deal of variation for a smaller scale, which is recited by many factors like ratio of land and water, presence of mountains etc. The plant growth effects wind distribution because of temperature moderation, absorption of moisture and due to the reflection caused by solar energy. Comparing to low level areas the wind is more observed in the top of hills and mountains. The velocity of the wind is varied by certain obstacles such as trees and buildings. For certain locations the variation of the speed of the wind and the wind pattern varies from years to years and the wind distribution varies from decade to decade.. These future predictions of wind variations aren't well understood , thus it makes the process as a tedious process to form predictions of the economically self dependent wind park projects.

The prediction of wind distribution is easier for an year, but to predict the distribution of wind for a lesser time period.it is difficult to estimate the energy of wind. These differences are because of the atmospheric conditions. Depending on area, there can also be substantial differences with respect to the day timings (diurnal variations), which can be predicted fairly. It is essential to consider these variations as they can influence the large-scale production of wind energy and grid connected resultant integration and also the power generation system which is associated must get ready for these variations. Also, we should take under consideration of the fact that the short term turbulence in the wind causes variations within the power delivered quality.

5. Mathematical Modelling of Photovoltaic Cell/

The semiconductor unit that transforms so the light of solar to electricity is named as 'Photovoltaic cell', and therefore this phenomena is known as 'Photovoltaic effect'. To make a solar PV array, cells are assembled in sort of series-parallel configuration for requisite energy. The generated electrical power by a solar Photo Voltaic array fluctuates counting on the conditions in which it operates and field factors like the sun's location by geometrical means, irradiation levels and atmospheric temperature. A solar cell is a non-linear device and can be represented as a current source model. The current source I_{ph} represents the cell photo current, I_d is reverse saturation current of diode, the intrinsic shunt resistance is R_{sh} and the intrinsic series resistance of the cell is R_s. To simplify the analysis the value of R_{sh} and R_s is neglected because the value of R_{sh} is too large and the value of R_s is too small hence they are neglected. Photo Voltaic cells are grouped in larger units called Photo Voltaic modules, which are interconnected during a configuration of parallel-series to make Photo Voltaic arrays or Photo Voltaic generators.

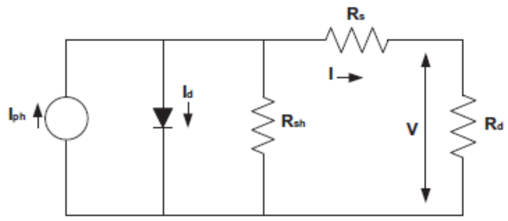

Fig 2: Current source model

6. Proposed Methodology

The proposed system methodology is using Battrey Energy Storage System (BESS) to control the power fluctuations .Here photovoltaic generation system is first connected to an inverter for inverting the dc output to dc output and then through the transformer the output is fed to the power grid.Like that through a transformer the output of the wind power generation system is also fed to the powergrid.Battery energy storage station is first connected to an inverter and then the ac output is fed to the powergrid through a transformer. The above mentioned three are interconnected through a powergrid. Here first the output of both the wind and the PV is combined together and when the load changes the output power also changes.Then the change in the output power is thus corrected by the battery.

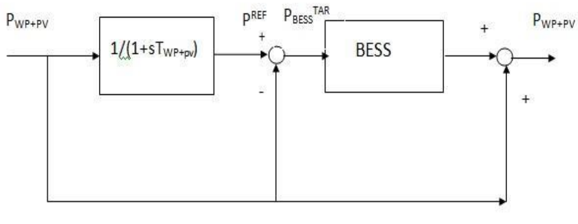

Fig 3: Architecture of the proposed model

7. Operation of Converters

The Boost converter without the utilization of a transformer steps up the input voltage magnitude to a required output voltage magnitude . The main and the essential components of the boost converter are diode, an inductor and a high frequency switch. During this process a high-power supply is given to the load so the voltage becomes larger than the magnitude of the input voltage. The voltage change happens due to the manipulation of the duty cycle.

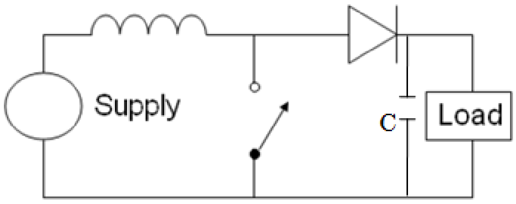

Fig 4: Boost converter circuitry arrangement

8. Modes of Operation

There are two modes of operation in a lift converter. These operations are supported by the two operations that is the opening and closing of the switch. When the switch is closed it is called as primary mode; this is often referred to as the operation of charging mode. Another one is the open switch; this mode is often referred to the operation of unload mode.

• Charging Mode:

The Operation of Charging Mode is when the switch is being closed the charging elment i.e inductor will get charged by the switch which acts as a source.The Exponential natured loaded current except for simple conditions it is assumed to that the charging current is varying linearly .Current flow from the source to the load is restricted by the component called diode and therefore the discharging of the capacitor manages the demand of load .

• Discharging mode:

The Operation of Discharging Mode; the switch is being opened and the diode is forward biased. Now the inductor gets discharged and alongside the switch charges the capacitor and the load demand is managed by capacitor . The charged current variation is extremely little and in huge cases it is think to be constant throughout the operation.

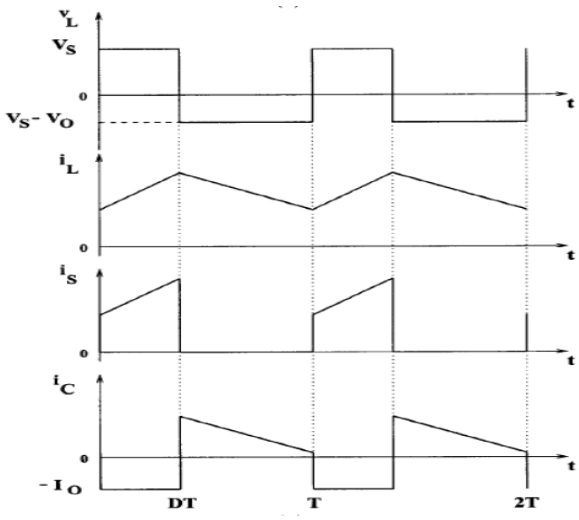

Fig 5: Waveforms of Boost converter

9. Functioning of Hybrid Model

The combined power of solar and wind i.e., the hybrid power is fed into the bypass first order filter then the output from the filter is given to the comparator which acts as a booster. The output which comes from the comparator has certain fluctuations and it results in decrease within the efficiency of the output compared to the input.so the output power from the comparator is fed into the BESS where the facility get smoothened and it increase the efficiency of the output power.

10. Simulation Results

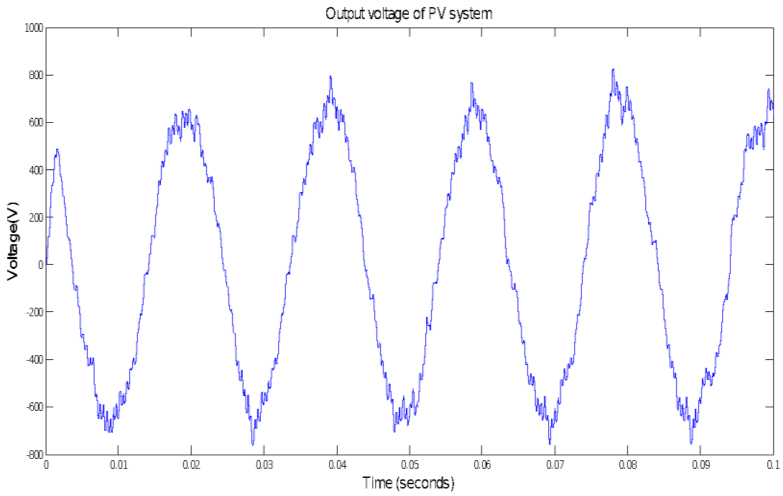

Fig 6: Photo Voltaic system output voltage

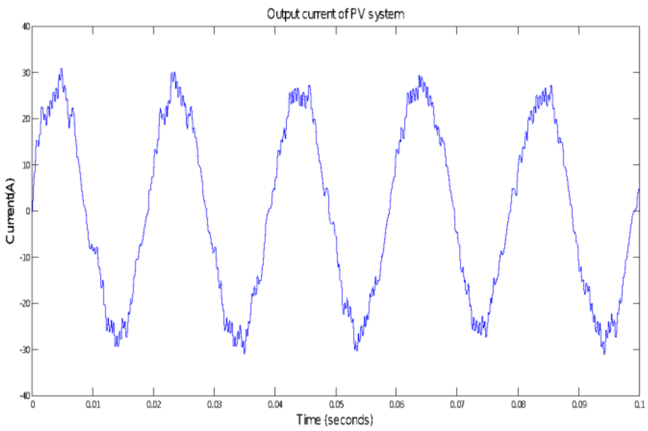

Fig 7: Output current of PV system

These are the output voltage, current and power of PV array. The rated capacity of the Photo Voltaic system is considered as 10KW.The power output graph shows that the output is nearly 10KW.The Photo Voltaic array output is fed to the boost converter.

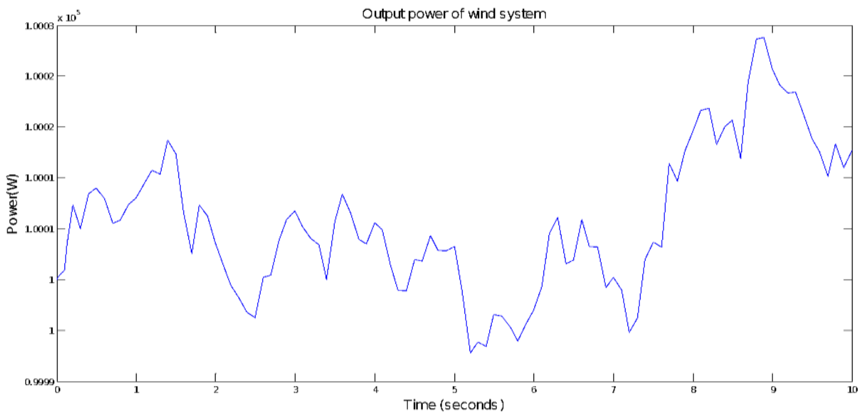

Fig 8: Wind system output power

Fig 8 shows the wind turbine output power . The rated capacity of wind turbine system is considered as 100KW.The output waveforms shows that the power output is nearly 100KW

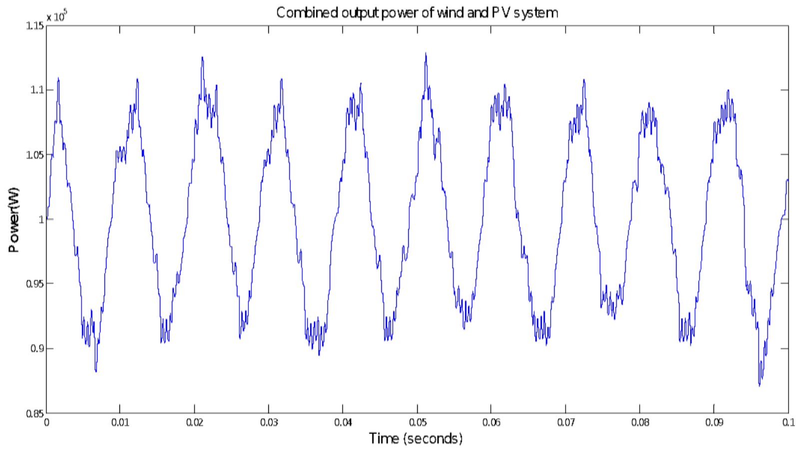

Fig 9: Combined PV and wind power fluctuations

Fig 9 shows the combined output power of PV and wind, it is clear that up to 0.05 sec fluctuations in output power occur due to the variation in the wind speed. At 0.05 sec a load is connected which shows a change in the output power. At 0.07sec a battery is connected to which smoothen the output power fluctuations. It can be verified using the output waveform of the combined system.

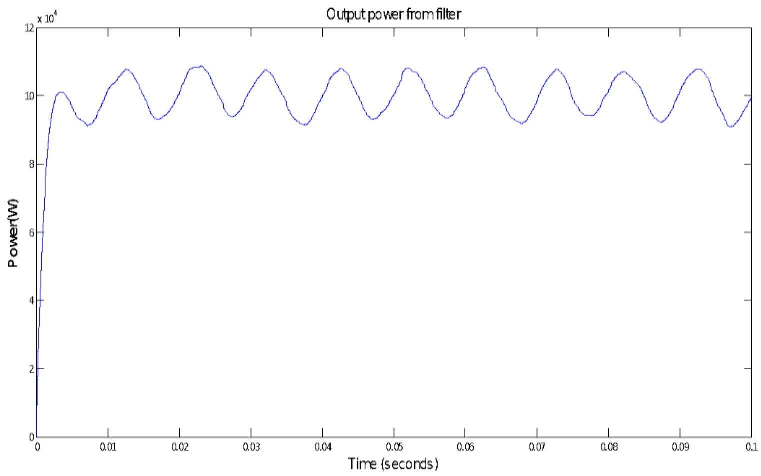

Fig 10: Output power from filter

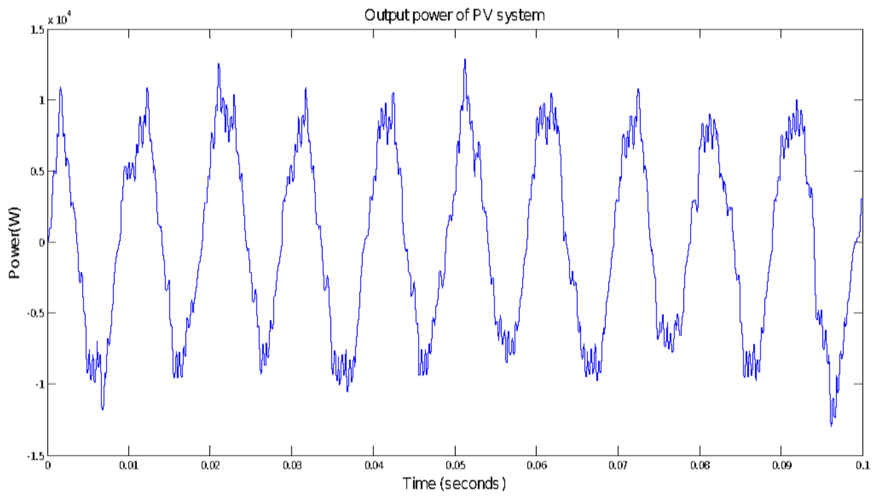

Fig 11: PV output power

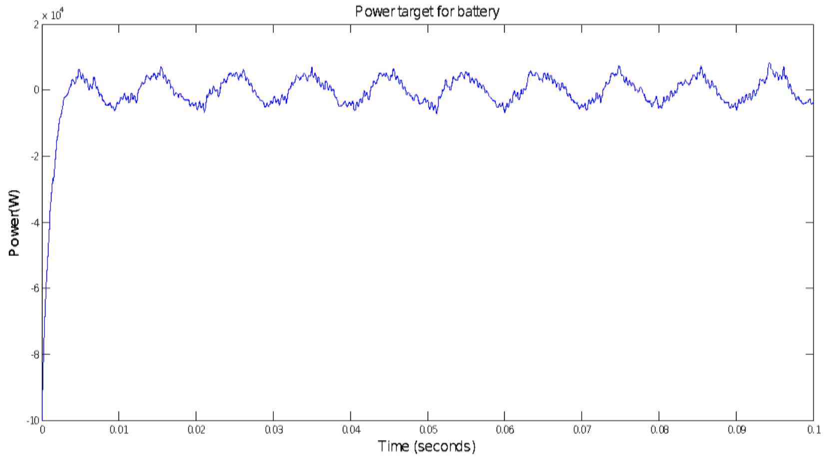

Fig 12: Target power from battery

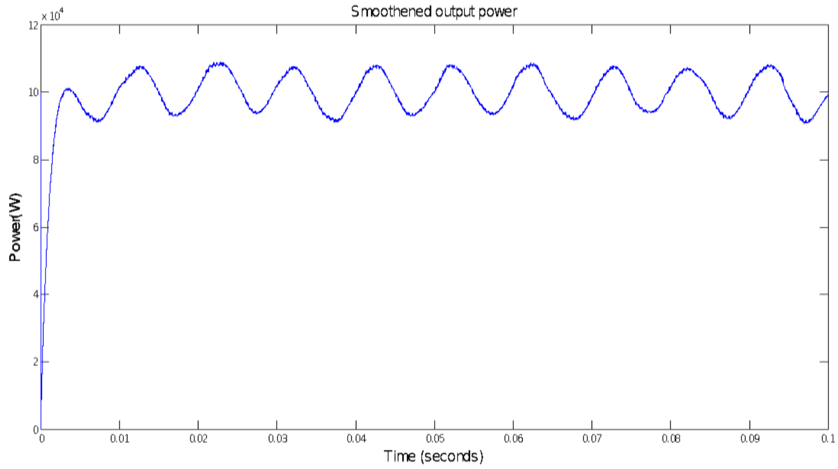

Fig 13: Smoothened output power

Fig 13 shows the combined output power of wind and PV where smoothened output power is obtained.

11. Conclusion

Wind and PV systems change in output power were smoothened using battery energy storage system. At first the wind and PV systems were modelled separately and from that the output was obtained. Then they combined together to get the combined output power of wind and PV systems. The fluctuations in the output power were smoothened using battery with Basic Smoothing Control Method (BSCM).

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