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Battery Storage System and Super Capacitor Implementation to Improve Reliability and Power Quality

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ABSTRACT

In many areas the reliability of power supply is essential requirement like rural areas hospitals, and other special services requires a sustainable solutions. Mostly such services are covered with the diesel based power supply that will be hazardous as per the climatic factor and much expensive also. The solution required for such kind of problems is a Renewable source of energy like solar or wind energy. The Solar PV option is less expensive and easy to implement in any building. This work is based on the Solar PV connected with the bidirectional inverter with the battery storage system. In earlier days the Solar PV directly connected to the grid and user can take benefits in the day time only. Now a days BESS concept will make the energy storage very easy and can be used in the night time as well as in case of emergency. An off grid system can be used in such a places where the extension of transmission lines are difficult due to some climatic challenges.

KEYWORDS: *Maximum power point tracking system (MPPT), Photovoltaic (PV), Battery Energy Storage System (BESS), Total harmonic distortion (THD), Super capacitor.*

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INTRODUCTION

Solar energy is considered as an infinite, clean, safe and Reliable source of energy. Photovoltaic (PV) systems are Particularly suitable for rural areas, where a reliable distribution system might not be available. Therefore, PV generation can provide energy independence to rural areas. However, the interaction between a numbers of PV inverters may lead to an unstable system. Rural areas can include: isolated rural areas, peri-urban areas and Small Island that are separated from national grid. The off-grid or AC Mini-grid system provides independent energy source that creates distribution networks for local communities and rural areas. The PV inverter is interface between the solar generator and the rests of AC Mini-Grid. In order to test a real PV inverter in an indoor environment, the PV Array Emulator (PVAE) is required. Alternatively, Thevenin source can be used in this paper experimentally. Numerical model the PV array model is updated according to datasheet of BP Solar where the six modules are connected in series and combined in two string parallel according to circuit diagram of the solar system installed on concrete laboratory at University of Leicester. [1].

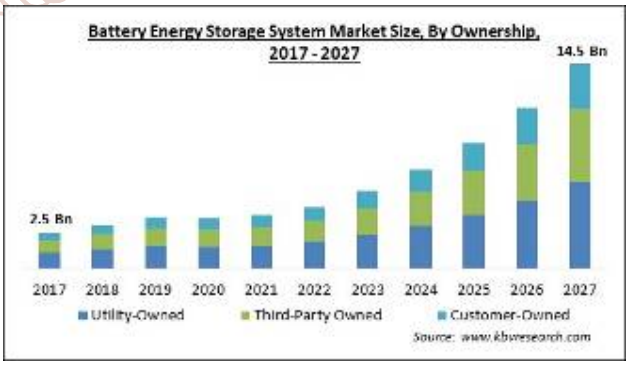

Fig 1- Renewable Energy Industry

A 120V solar Panel has been modelled and connected with the bidirectional inverter and connected with 14 AH generic battery model of Lithium Iron Battery type. The PV array connected directly to boost converter to boost the output voltage.

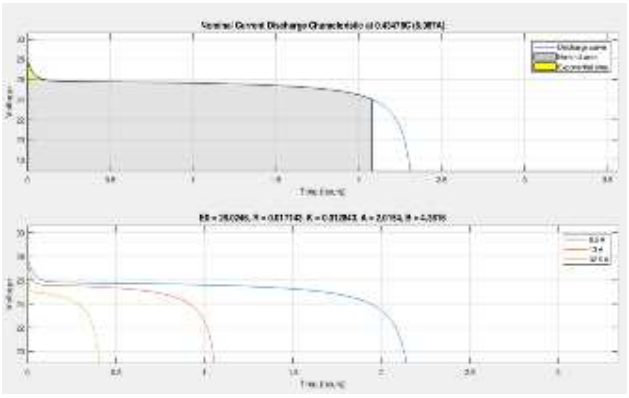

Fig 2- Battery Discharge Characteristics

Now As per the financial terms electricity generation using renewable sources have higher price as compared to the non-renewable resources. But now a days the major challenge is to generate a good quality power with lesser incremental cost as much as possible and with lesser carbon emission. In that case we use renewable sources to generate power with good quality. So we should adopt the most convenient and cheapest way for generation transmission and distribution. In order to get an optimum power generation hybrid electricity is used so that increase in price may get compensated by the use of renewable assets.

The warming of global surface is increasing 0.6 degree Celsius per century. This warming caused by huge release of carbon dioxide and carbon monoxide. This causes acid rain, depletion of ozone layer and radioactive emission these effects can be minimized by searching some effective solution, this solution also include energy conservation with improved energy efficiency.

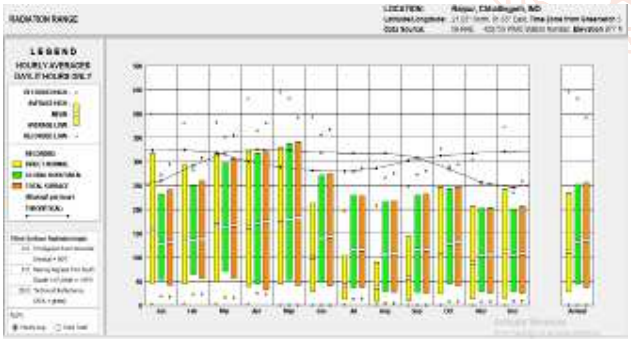

Fig 2- Average Daylight Hours

The major issue of maximum power extraction and better output depends upon the climatic conditions and the site location, by the use of various climatic consultant software we can find out the nature of irradiation and the average daylight hours in the particular selected location. In India by some notifications and building bye laws, it is notified that one percent of total connected load of the building or twenty five percent of the roof top area must be captured by Solar Panels of the particular capacity details discussed in the bye laws of the particular state or laws followed by central ministry.

MODELLING OF PV ARRAY

Electrical Model of photovoltaic cell Implements a PV array built of strings of PV modules connected in parallel. Each strings consists of strings connected in series parallel, 4 parallel strings and series connected modules per strings 2. With open circuit voltage 21V and short circuit current 8A and cells per module is 72.

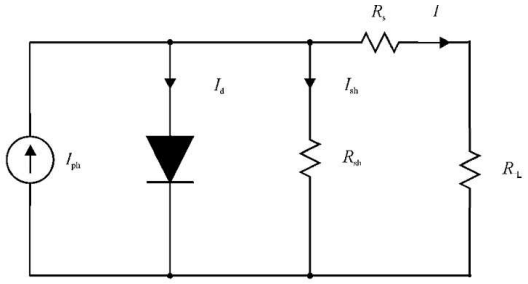

Fig --3: P-V cell Model

$$I = I_D - I_{RP} - I_{ph} \quad \text{..... (1)}$$

$$I = I_{ph} - I_0 - \left[exp\left(\frac{V+IR_s}{V_T}\right) - 1\right] - \left[\left(\frac{V+IR_s}{R_p}\right)\right] \quad \text{..... (2)}$$

$$I = n_p I_{ph} - n_p I_{rs} - \left[exp\left(\frac{q}{KTA} * \frac{V}{n_s}\right) - 1\right] \quad \text{..... (3)}$$

$$I_{rs} = I_{rr}\left[\frac{T}{T_R}\right]^3 exp\left(\frac{qE_G}{KA}\left[\frac{1}{T_r} - \frac{1}{T}\right]\right) \quad \text{.....(4)}$$

$$E_G = E_G(0)\frac{\alpha T^2}{T+\beta} \quad \text{.....(5)}$$

$$I_{ph} = [I_{SCr} + K_i(T - T_r)]\frac{s}{1000} \quad \text{.....(6)}$$

Where, Iph is the Insolation current, I is the Cell current, I0 is the Reverse saturation current, V is the Cell voltage, Rs is the Series resistance, Rp is the Parallel resistance, VT is the Thermal voltage (KT/q), K is the Boltzmann constant, T is the Temperature in Kelvin, and q is the Charge of an electron. [3]

BOOST CONVERTER

The PV system generates DC voltage in all the variable conditions of solar radiations. The generated voltage is low and variable and it must be somewhat high and constant at the input of inverter. So we need a boost converter device to boost the voltage as well it try to maintain constant boosted voltage.

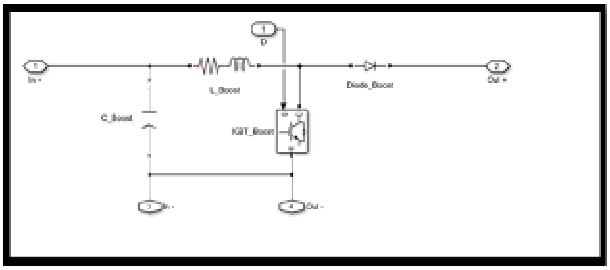

Fig -4: Subsystem Of boost converter

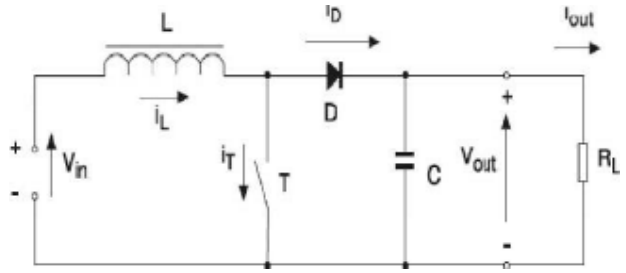

Fig -5: Circuit diagram of boost converter

The Fig. 5 shows a step up or PWM boost converter. This consists of a dc input voltage source VIN; boost inductor L controlled switch T, diode D, filter capacitor C and load resistance RL. When the switch S is in on state, the current in the boost inductor increases linearly and the diode D is off at that time, when the switch s is turned off, the energy stored in the inductor is released through the diode to the output RC circuit. The transfer function for the boost converter is [4]

METHODOLOGY

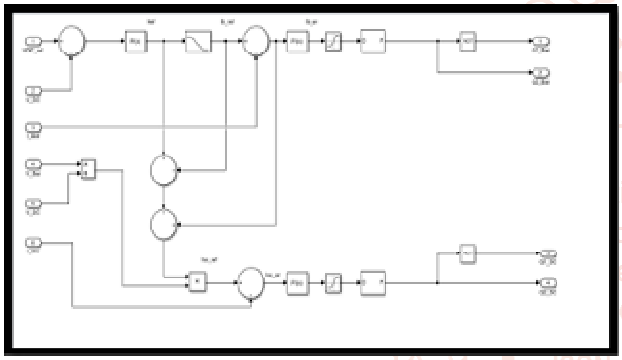

Fig -6: Combined control Battery & Super capacitor

In this work the maximum power point tracking technique has been used with perturbation and observation technique for the generation of duty cycle signal. Pulse width modulation technique has been generated by the intake of state of charge and the PI controller technique.

The controller of the battery and super capacitor modelled based on the PI controller based signals to generate reference signals for battery and super capacitor in both the conditions for instant response.

In our work whole model is designed with solar PV of 4 parallel strings and 02 series connected module per string, strings connected in series parallel combination. As one location has been identified for the experimental purposes. In India having 5 types of climatic zones and the generation also depends upon it like in Chhattisgarh the climate is composite means mixed type of climate in which irradiations and the sunny days as well as number of hours of a sunny day is almost better than the average. Solar PV generation has a great opportunity as a part of green energy.

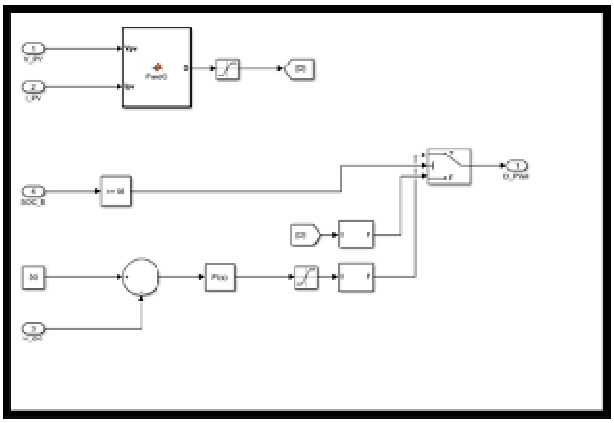

Fig -7: Maximum Power Point Tracking

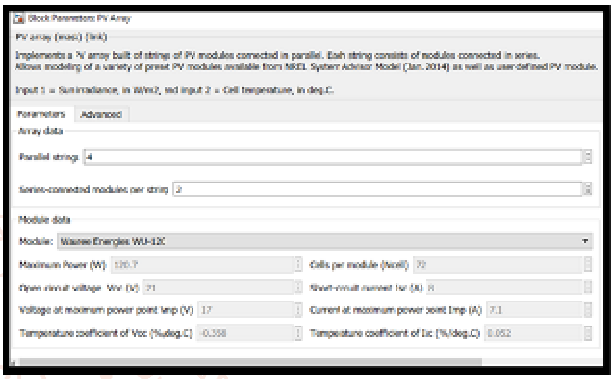

Fig -8 Solar Panel Parameters

Boost converter increases the voltage and then it can be supplied to the battery for the charging we have also taken this hybrid connection in our model for the research and development and the results are in the last section. Lithium ion battery has been taken with the nominal voltage of 12 volts.

Further connection has been provided after the boost converter an IGBT based inverter is connected with arm as for the single phase supply and after the inverter a low pass filter has to be connected for the smooth and better waveform and finally the results came that a single phase sinusoidal voltage has been generated to supply in the home for the power usage.

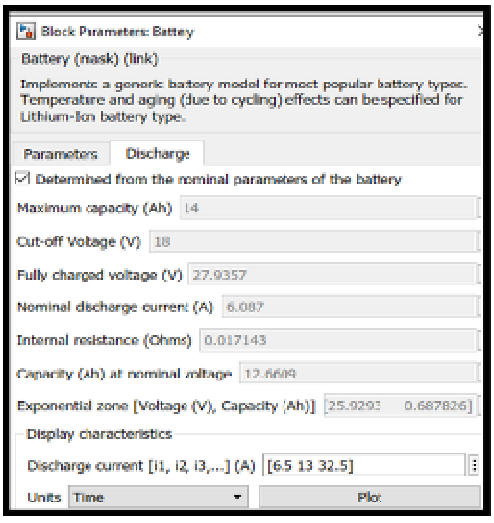

Fig -10: Lithium ion battery parameters

For charging one 48 volt 12 AH battery the required watt hour will be=576 watt hour. Considering 30% losses required the required watt hour will be=748.8 watt hour. The watthour is divided by the panel generation factor of site 4.5, so the total watt peak needed to charge one 48 volt battery will be 748.8/4.5=166.4-watt peak. If 110wattpeak is the available module then 166.4/110=02 modules will be required to charge 48 volt battery. The size of the inverter should be 25% bigger than the total load due losses in the inverter.so 576×1.25=720 watt inverter is at least required to charge one 48 volt battery at 1C rate. For 48 volt system, 02 days of autonomy and 60% depth of discharge the required AH capacity for solar battery will be 47AH at least. [10]

RESULTS

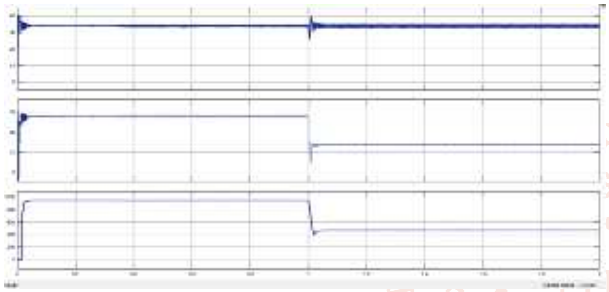

Fig -12: PV Scope

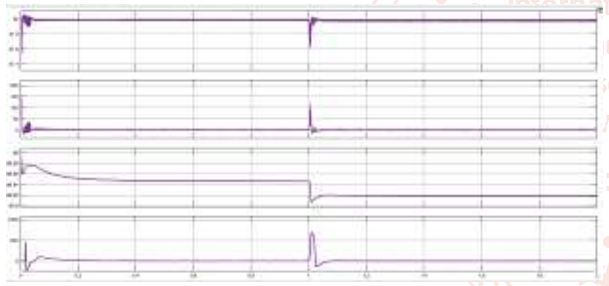

Fig -13: Supercapacitor

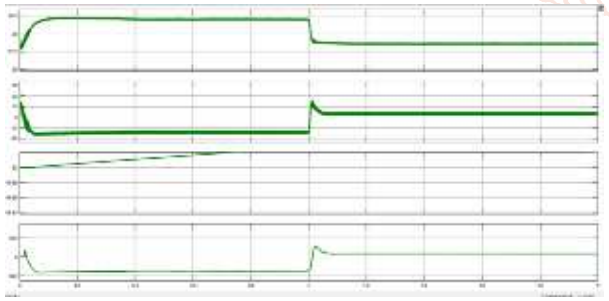

Fig -14: Battery Scope

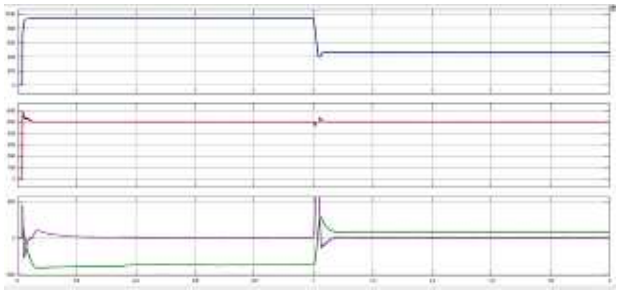

Fig -15: Power PV, Power load, Power battery, Power Supercapacitor

The warming of global surfaces increasing day by day. The warming caused due to release of toxic gases. Main reason of these gases in the environment is due to air pollution caused by generation plants that all uses fossil fuels like coal, fuels, gas etc. This causes acid rain, depletion of ozone layer and radioactive emission these effects can be minimized by searching some effective solution. Solution must include energy conservation with improved energy efficiency.

Major aim is to reduce carbon footprints and now a days solar PV also installing in the commercial as well as residential buildings.

CONCLUSION

A model has been designed and simulations been done with series parallel combination of strings. The solar PV system when come in operation the voltage generated is boosted by the boost converter. This model after simulation in Matlab software it can be seen that the response of the battery storage is very fast without any interruption and it provide a stable and reliable output. Rural areas that include isolated rural area peri-urban areas and Small Island which separated from national grid can be used the AC Mini- Grid system which provides independent distribution networks for local community. Battery provided energy storage and increase efficiency and provide permanent source of electricity that is independent from variable power generator storage energy from RES and release it when needed at time when RES generator is not sufficient.

A. Now a days government of many countries take initiatives for the subsidy regarding Solar panels as well as battery storage system also this initiate will make a considerable change in the world of energy and power demand and challenges.

FUTURE SCOPE

In this work a battery and super capacitor has been used for the rapid response at the time of requirements and to improve the power quality of the system. The next move we can do is to reduce the peak power demand by the use of BESS in larger scale at the time of peak demand. Many states face the problem of peak demand and peak time the peak load curve has to be flatten as per the law and regulatory commissions by the use of demand side management. This method can also be done to reduce the peak demand by the storage system in larger scale and switching the load portion in the battery storage system to reduce peak load curve.

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