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Analysis of Hybrid Solar PV Connected with Single Phase and Multilevel Inverter with Battery

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ABSTRACT

This paper works on modelling of solar PV to generate DC voltage and then connected to chopper as well as inverter from which the outputs derived and analyzed in various control system and different inverter system like single phase inverter and multiphase inverter. In the next phase the hybrid connection trying to establish to achieve the single phase sinusoidal output voltage and to charge the electric vehicle charging station battery station. The output voltage & current as well as active and reactive power has been explored and analyzed. The simulation has been done on a Matlab software and simulation results obtained and analyzed. Climatic analysis is also essential requirement for the enhancement of the outputs as desired and the irradiation of the solar as well as direction analysis done to get the best output in the desired particular location.

KEYWORDS: *Maximum power point tracking system (MPPT), Pulse Width Modulation (PWM), Insulated gate bipolar transistor (IGBT), Total harmonic distortion (THD), Solar Panel, Charging Station, EV charging*

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INTRODUCTION

The world consists of many fossil fuels reserves and the fast ever-growing pollutants of environment has made the necessity of renewable energy sources very important now a days. Renewable energy sources consists of many fields like solar, wind, biomass energy but solar energy proves one of the most important field of research and upliftments due to its abundance availability and pure clean form of energy generation. At present, solar electric photovoltaic (PV) era is ahead redoubled significance as a RES application because of distinctive blessings like simplicity of allocation, high responsibility, absence of gasoline value, low preservation and absence of noise and wear thanks to the absence of moving factors or practical's. Moreover, the alternative energy characterizes a clean, pollutants-loose and inexhaustible power supply. Additionally to those elements are the declining value and expenses of solar PV modules, associate degree increasing efficiency of sun cells, producing generation enhancements and economies of scale [1].

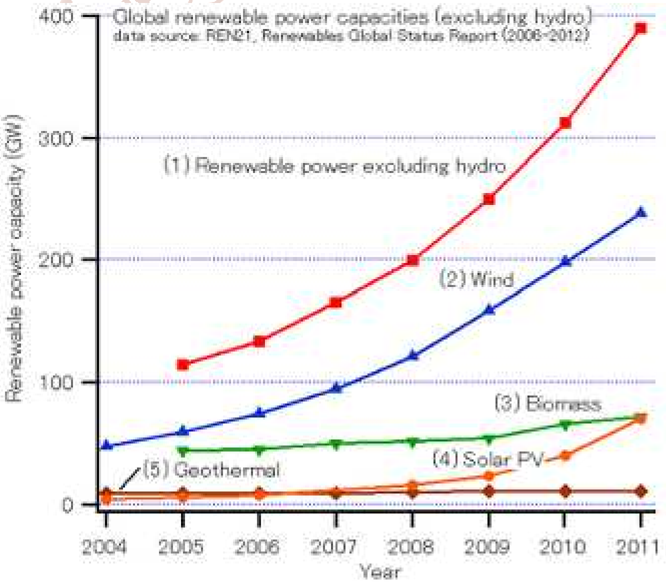

Fig 1- Renewable Energy Industry

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 whole world is moving with automobiles. Huge amount of fossil fuels are burned for automobiles. Nothing on earth is free of cost, but what if we could find a way to implement free rides? Indeed it would be wonderful if our cars could continue to run without us having to spend billions o3n fossil fuels every year and to deal with natural hazards that their combustion leave behind. Considering the availability and pollution of fossil fuels we need a substitute. The best substitute is electric vehicles which will not create any pollution to environment. The main impediment is the storage capacity of electric power, the ride is restricted up to battery capacity. This storage issue can be beaten by adding solar power to automobiles. [2]

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 strings 60 and series connected modules per strings 10. With open circuit voltage 37.14V and short circuit current 8A.

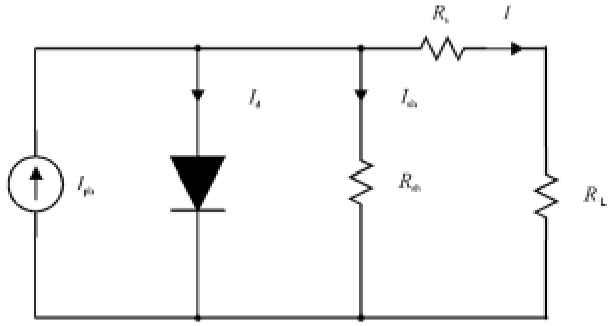

Fig --3: P-V cell Model

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

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

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

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

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

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

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.

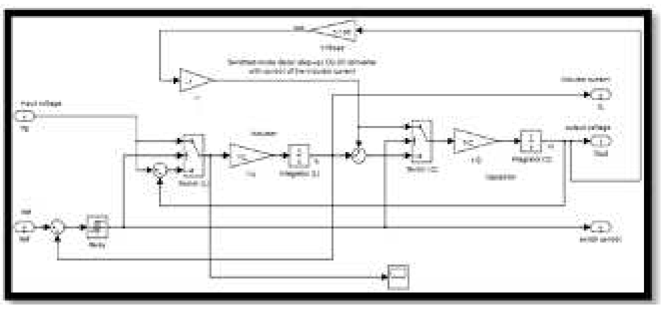

Fig -4: Subsystem Of boost converter

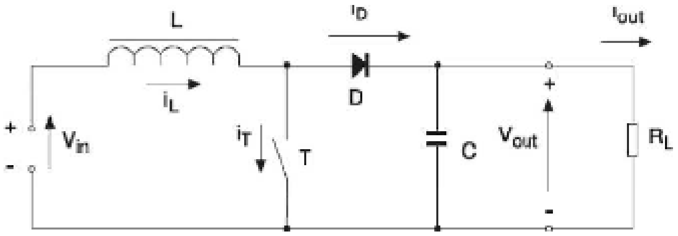

Fig -5: Circuit diagram of boost converter

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

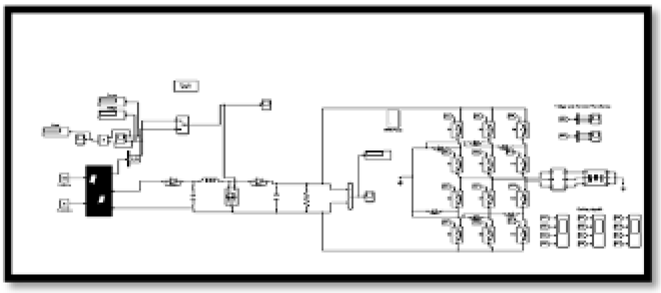

Fig -6: Proposed Model

In our work whole model is designed with solar PV of 60 strings and 10 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.

In the initial model designed the solar PV connected to the multilevel inverter to achieve the three phase output and analyzed the results.

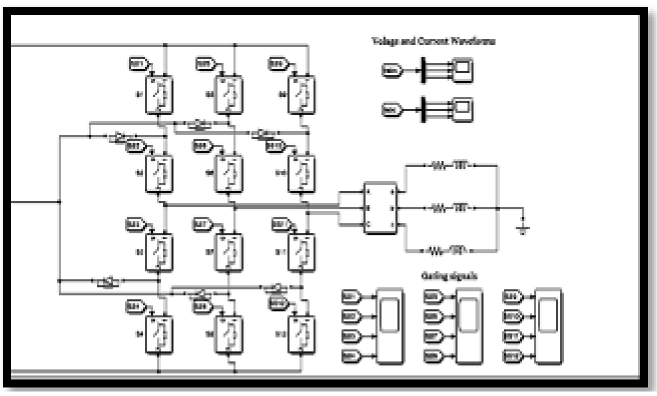

Fig -7: Multilevel three phase inverter

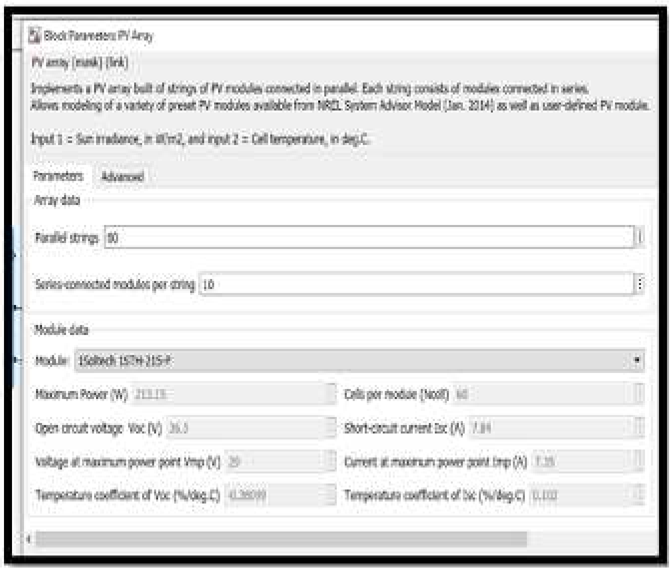

Fig -8 Solar Panel Parameters

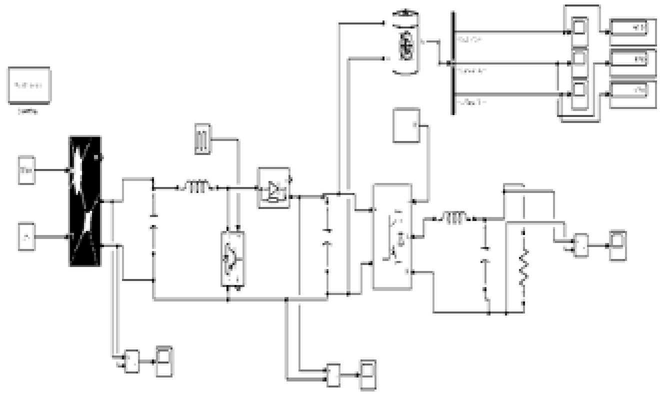

Fig -9: Proposed model with single phase output and battery arrangements

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.

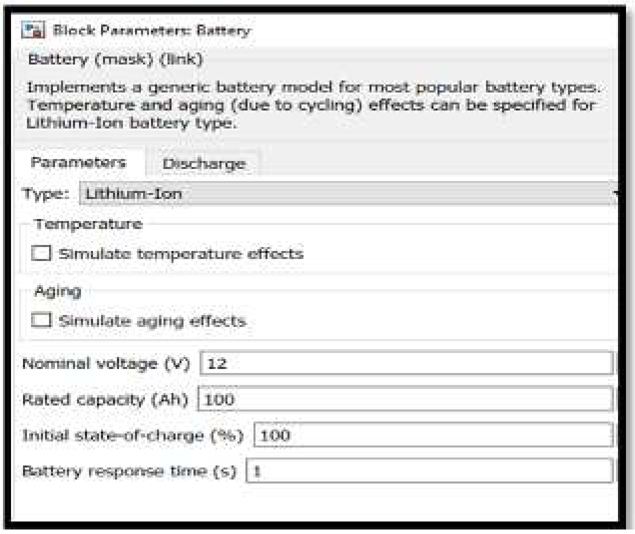

Fig -10: Lithium ion battery parameters

Combination of Domestic load and EV charging is asked in subsequent steps. For optimum desired output from solar panels, we need to point them in the direction that captures maximum sunlight south if we are in northern hemisphere or north if we are in southern hemisphere. There is a simple thumb rule for calculation of tilt angle for fixed mount solar panels. Subtract 15^0 from the latitude of your location during summer and add 15^0 to your latitude during winter. The other method to find the value of optimum tilt angle for solar panels during winter is calculated by multiplication of the latitude by 0.9 and then adding 29^0.For an example if latitude of place is 34^0, then the tilt angle will be [(34*0.9) +29] =59.6^0. This method is more accurate as an angle is 10^0 steeper than in the general method. For summer the tilt angle is calculated by multiplying the latitude by 0.9 and subtracting 23.5^0. In the above case example this angle would be [(34*0.9)- 23.5] =7.1^0.

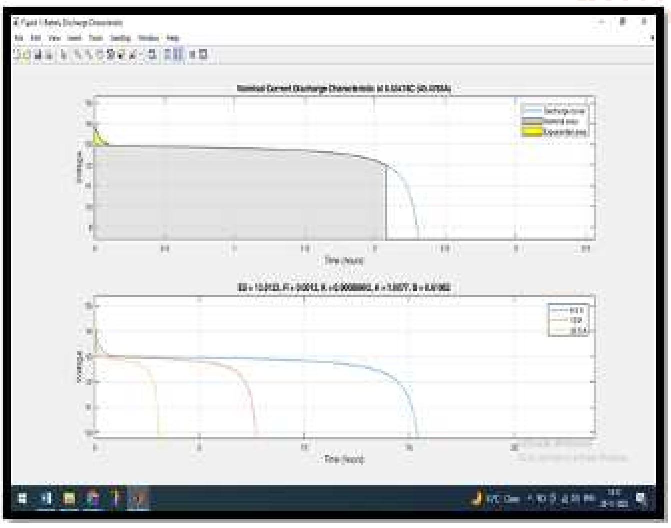

Fig -11: Battery Discharge Characteristics

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 watt hour 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

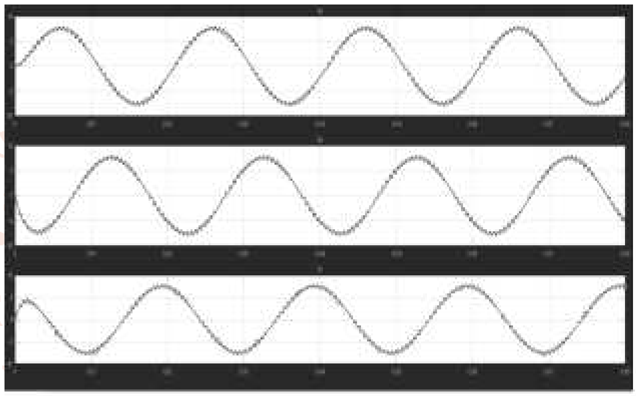

Fig -12: Current waveforms

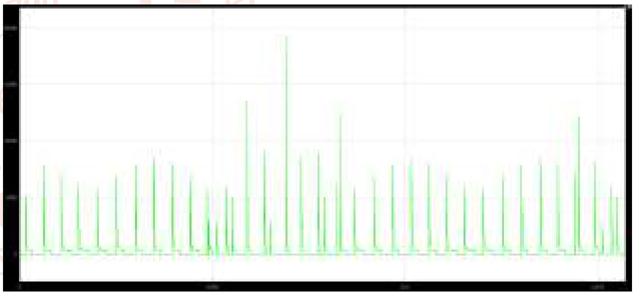

Fig -13: Voltage before entering MLI

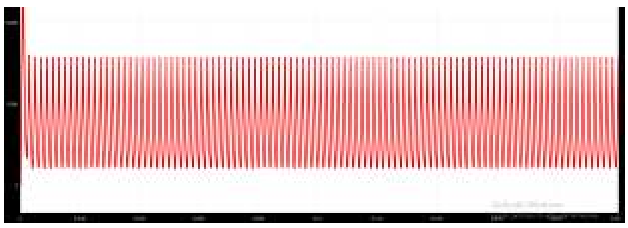

Fig -14: Power output

Fig -15: Single phase voltage at the output

Fig -16: SOC of battery

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 and then generation goes to multilevel inverter from where it can be connected in load or grid, In our system an RLC branch has been placed instead of load with some scopes to see the output results, the output comes in the final position is a smooth sinusoidal voltage waveform, scope of some filters required to reduce the harmonics. In the next phase a hybrid connection has been established with a single phase output load and the battery connection for the charging of DC batteries that may be of storage capacity or can be used for the electric vehicle smart charging station. We got the results that near about 120 volts of smooth sinusoidal voltage has been generated and ready to serve the load and in battery side as in the results we can see that the state of charge is in between 100 to 95 units and voltage is nearby 4-5 volts.

FUTURE SCOPE

In the current proposed work harmonics values may be in disturbing limits and losses will be more, some steps has to be taken to reduce harmonics in a calculated manner, As discussed in the beginning that the Solar PV capacity and directions can be calculated as per the weather condition and sun path of a particular building location and direction. So analysis must be done before installation of solar power plant and to capture maximum power from the solar irradiations.

For maximum power point tracking system many work is in the progressive stages like fuzzy control system and the climatic analysis can be a great step towards the designing of fuzzy rule set to get the best output from the system.

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