Volume No: 1(2014), Issue No: 10 (October) ISSN No: 2348-4845

High Efficiency PV/battery hybrid system Interconnected to grid for power quality Improvement.

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Abstract-:

Photovoltaic (PV) cells are renewable energy sources. And batteries are dc power sources. The combined operation of both PV and batteries interconnected with grid is known as hybrid energy system. Grid integration is done by PV/battery hybrid energy conversion system by using voltage source converter. The converter proposed is micro grid bidirectional voltage source converter, high voltage regulation of battery converter with control technique of Maximum Power Point Tracking (MPPT) control scheme. A cascaded boost converter (dc-dc) with high gain is discussed in this paper.

The applications of VSC in micro-grid are as follows: (1) compensation of reactive power, (2) active power is generated is fed to grid connected across power system, and (3) elimination of harmonics produced by non-linear loads. MPPT algorithm is proposed for producing of switching signals for IGBT's. The battery energy source is using for balancing of power between PV cell and grid. The proposed PV/battery hybrid energy system for grid integration model is designed and is simulated by using MATLAB/simulink software.

Index terms:

Hybrid energy system, cascaded boost (dc-dc) converter, MPPT algorithm, reactive power compensation, current harmonics mitigation.

I.INTRODUCTION:

Renewable energy is derived from natural processes that are replenished constantly. Renewable energy resources and significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. 21.7% of electricity generation in worldwide is generated from renewable energy sources. Photovoltaic (PV) is a method of generating electrical power by converting sunlight into direct current electricity using semiconducting materials that exhibit the photovoltaic effect [1]. PV cells are nonlinear energy sources, they will not able to supply the power to loads on requirement conditions.

In order to use PV energy systems efficiently, interconnection to loads with power electronic converters are required. But PV energy systems are having low efficiency in conversion process, for that efficient conversion technique is needed. An electronic controller is to be designed to operate PV energy system at maximum power point (MPP) condition [2].

A converter is proposed for boost-up the energy from PV source. Cascade connection of conventional converters gives the wide range of conversion ratios. An interesting attractive converter topology is a high gain integrated cascaded boost converter having n-converters connected in cascade using a single active switch [3]. Schematic diagram for PV cell energy conversion is shown in fig. (1).

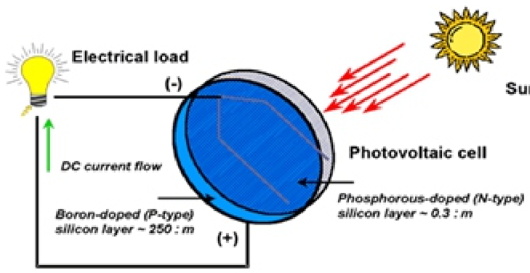


Fig. (1) Schematic diagram of PV cell

Micro-grid power converters can be classified into (i) grid feeding, (ii) grid-supporting, and (iii) grid-forming power converters [4]. The following are some of the elements that may be found in advanced micro-grids:

Electronically Controlled Distribution Systems, integrated Electricity and Communication Systems, Integrated Building Energy Management Systems, Smart, end-use devices, Meters as Two-way Energy Portals, and Combined Heat and Power.

The PV system and the inverter are connected to the grid in parallel with the load.

- The load is served whenever the grid is available.

- Energy produced by the PV system decreases the apparent load. Energy produced in excess of the load flows into the distribution system.

- The PV system has no storage and cannot serve the load in the absence of the grid.

- The PV system produces power at unity power factor and utility supplies all Volt Ampere reactive power.

This paper is structured as follows: In section II, system description. The proposed control strategies for HGICB DC-DC Converter, Battery Converter and µG-VSC are discussed in section III. The simulation results are

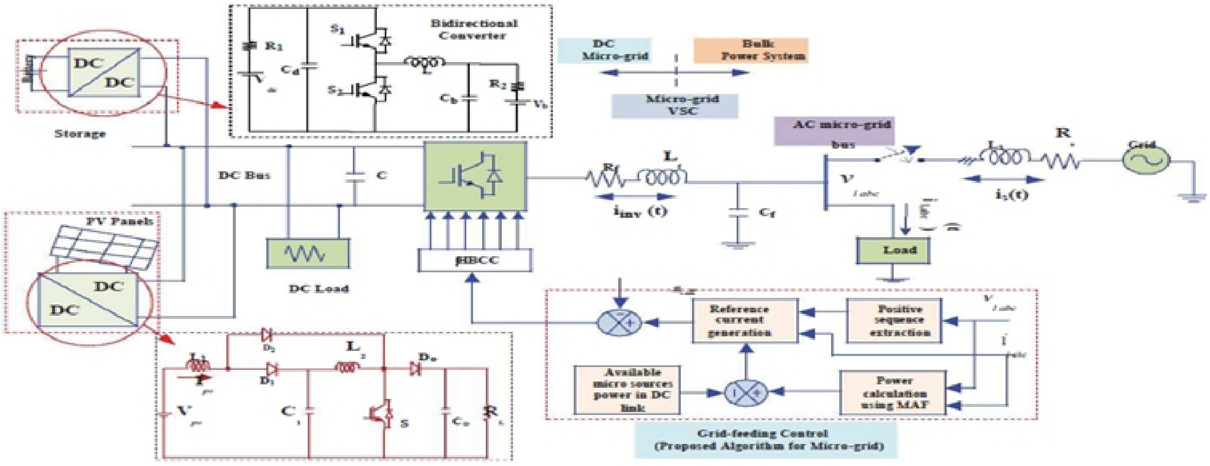


Fig.2. Schematic diagram for PV hybrid energy system

A.PV array model:

Modeling of PV cell involves the estimation of the I-V and P-V characteristics curves to emu late the real cell under various environmental conditions [5]. The equivalent circuit of PV array is represented as shown in fig.(3).

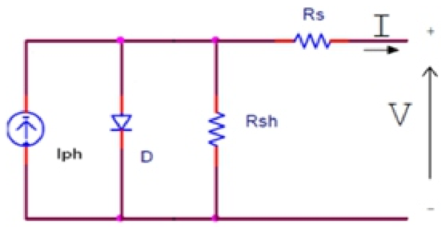


Fig.3.Equivalent circuit of PV array cell.

The output current I written as:

$I = I_{Ph} - I_s\,[\exp((V+IR_s)/(NV_T))-1] - (V+IR_s)/R_{sh}$

Here N is diode identity factor

The identity factor varies for amorphous cells, and is nearly in between 1-2 for polycrystalline cells.

The typical I-V and V-I characteristics PV cell are shown in fig.4. (A). I-V curve, and P-V curve in fig. 4. (b) Respectively.

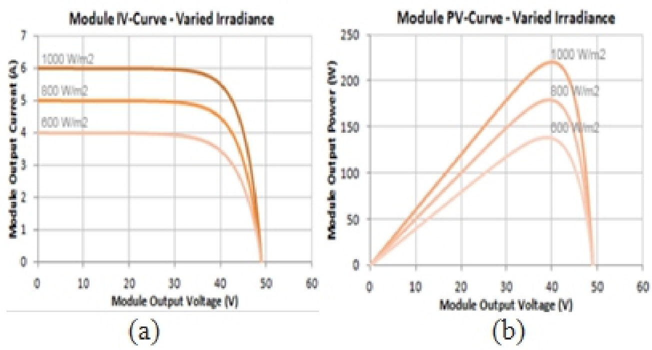


Fig. characters tics of PV module 4. (A) I-V curve, 4. (B) P-V curve

When the P-V curve of the module is observed, one can locate single maxima of power where the solar panel operates at its optimum. In other words, there is a peak power that corresponds to a particular voltage and current. The change in P-V curve represents that the insolation level and temperature is not constant in day.

B.Modeling of battery converter:

Battery converter is designed for the controlling of battery output based upon changing's in output of PV array module. Energy output of PV module is not constant throughout operating period [6]. For that controlling technique is proposed for battery converter. The proposed control strategy for battery converter is shown on fig. (5).

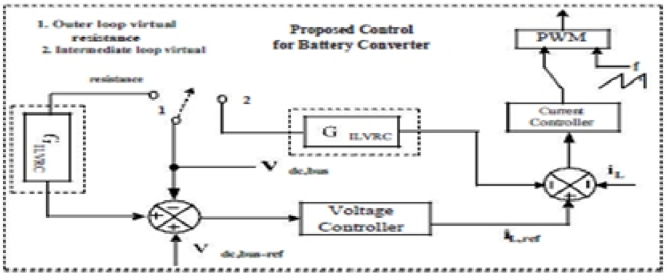


Fig. (5) Control strategy of battery converter

State space analysis is done for control strategy of battery converter, the results are as follows:

$$\frac{di_L}{dt} = \frac{v_{c1}d(t)}{L} - \frac{v_{c2}}{L} - \frac{(r_s + r_L)i_L}{L}$$

$$\frac{dv_{c1}}{dt} = \frac{v_{dcbus} - v_{c1}}{C_1R_1} - \frac{i_L d(t)}{C_1}$$

$$\frac{dv_{c2}}{dt} = \frac{v_{dcbus} - v_{c2}}{C_2R_2} - \frac{i_L d(t)}{C_2}$$

The above equations are useful for understanding of operation of battery converter. A micro-grid VS converter is proposed on AC side of energy system proposed, destabilization of dc-link will be caused due to the connection of power appliances to voltage source converter, for that connection of capacitor to the dc-link. With increasing of negative input- conductance the dc-link voltage control gets typical and stability of system also gets affected. To avoid this problem the following techniques are proposed (i) by adding large capacitance on dc-link (ii) resistances of passive type at DC filters.

C.Design of voltage and current loops:

Design steps for inner and outer loop compensators of ACMC are as follows [7]:

i) Place one zero as high as possible, yet not exceeding resonating frequency of the converter.

ii) Place one pole at frequency of output capacitor ESR to cancel the effects of output capacitor ESR.

iii) Adjust, gain of compensator to trade-off stability margins and closed-loop performance.

iv) Another pole should be place at origin to boost the dc and low frequency gain of the voltage loop.

The inner loop (current) gain can be written as:
$T_i(s) = G_{id}(s)R_i\,G_{ci}(s)F_m$.

The outer loop (voltage) gain can be written as:
$T_v(s) = G_{vd}(s)G_{cv}(s)(1+G_{ci}(s))F_m$.

The overall loop gain therefore can be written as:
$T_1(s) = T_s + T_v$

D.Control of μG-VS converter:

The microgrid-voltage source converter is having operation of eliminating the affects due to unbalanced load conditions and harmonic components, by injecting active and reactive powers.

The grid currents are written as follows:

$i_{ga} + i_{gb} + i_{gc} = 0$
The currents at PCC are as:
$i_{gabc} + i_{invabc} = i_{Labc}$
By concluding the equations can be written as:
$i_{inva} + i_{invb} + i_{invc} = i_{La} + i_{Lb} + i_{Lc}$
The instantaneous active powers can be as follows:
$P_{(g)} = v_{pa}i_{ga} + v_{pb}i_{gb} + v_{pc}i_{gc}$

The reference currents for microgrid-voltage source converter are as follows:

$$i_{inva} = i_{la} - \frac{v_{ga} + \beta(v_{gb} - v_{gc})}{\Delta}(P_{lavg} - P_{\mu s} + P_{loss})$$

$$i_{invb} = i_{lb} - \frac{v_{gb} + \beta(v_{gc} - v_{ga})}{\Delta}(P_{lavg} - P_{\mu s} + P_{loss})$$

$$i_{invc} = i_{lc} - \frac{v_{gc} + (v_{ga} - v_{gb})}{\Delta}(P_{lavg} - P_{\mu s} + P_{loss})$$

Here $\Delta = \tan\phi/\sqrt{3}$

III.CONTROL STRATEGY OF HGICB:

A PV array or generator will have one point on its current/voltage characteristic that corresponds to maximum power output. This is referred to as the maximum power point or MPP, The systems which are directly connected are not operate at MPP, significant amounts of energy gets wasted. A dc-dc converter is required to better match the PV generator to the energy system; this is referred to as MPPT.

The typical circuit diagram for PV system with MPPT control technique is shown in fig. (6).

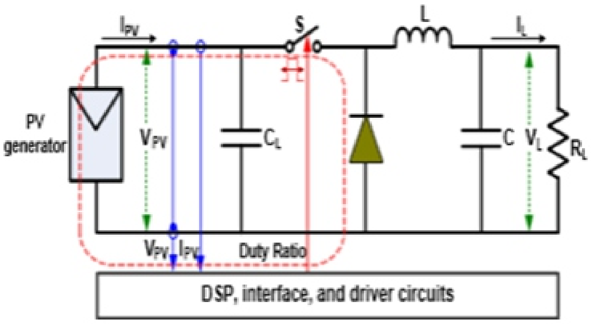


Fig.(6). Circuit diagram of PV system with MPPT control

There are different approaches in the implementing of MPPT algorithm, they are described as below:

-Constant voltage MPPT algorithm.

-Perturb and observe (P&O) MPPT algorithm.

-Incremental conductance (INC) MPPT algorithm.

The controlling of proposed converter is by using incremental conductance (INC) MPPT algorithm.

The system performance of converter is affected when INC MPPT algorithm is used by step size (Δd or ΔV_ref) and perturbation frequency (f_MPPT). The block diagram of MPPT with reference voltage control is shown in fig. (7), and block diagram of MPPT with direct duty ratio control is shown in fig. (8).

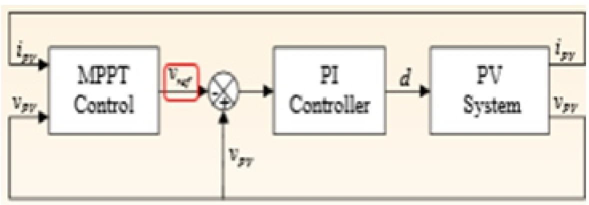


Fig.7. block diagram of MPPT with V_{ref} control.

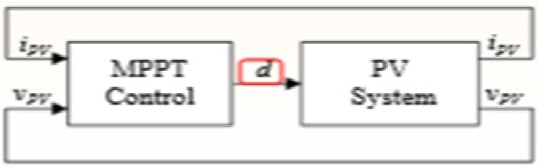


Fig.8. block diagram of MPPT with duty ratio control.

The INC algorithm is less confused by noise and system dynamics compared to the P&O algorithm.

The flow chart of power flow with INC MPPT algorithm for proposed HGICB converter is shown in fig. (9).

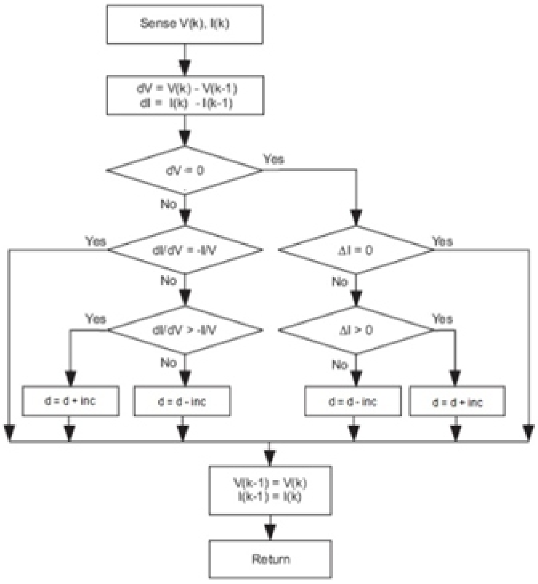


Fig. (9). Flow chart of power flow with INC MPPT algorithm

IV.SIMULATION RESULTS:

The proposed high gain integrated cascaded boost converter for PV hybrid power system developed and simulation done in MATLAB/simulink software. And the control strategy is designed for converter operation to get maximum power point, for that an algorithm is proposed based on MPPT technique.

For the analysis of proposed converter transient response, the pv energy system ratings are increased and decreased and also for testing of robustness of proposed converter. The duty cycle is calculated using MPPT algorithm, by changing PV voltage and current in proportion to insolation levels are applied to HGICB converter.

The simulation model for proposed high gain integrated cascaded boost converter with harvesting energy system of PV hybrid system is shown in fig. (10), and control circuit model with MPPT technology designed in MATLAB/simulink software is shown in fig. (11).

To compensate harmonics and reactive power due to unbalanced and non-linear loads at PCC is perfectively done by proposed micro grid- voltage source converter by injecting generated active power.

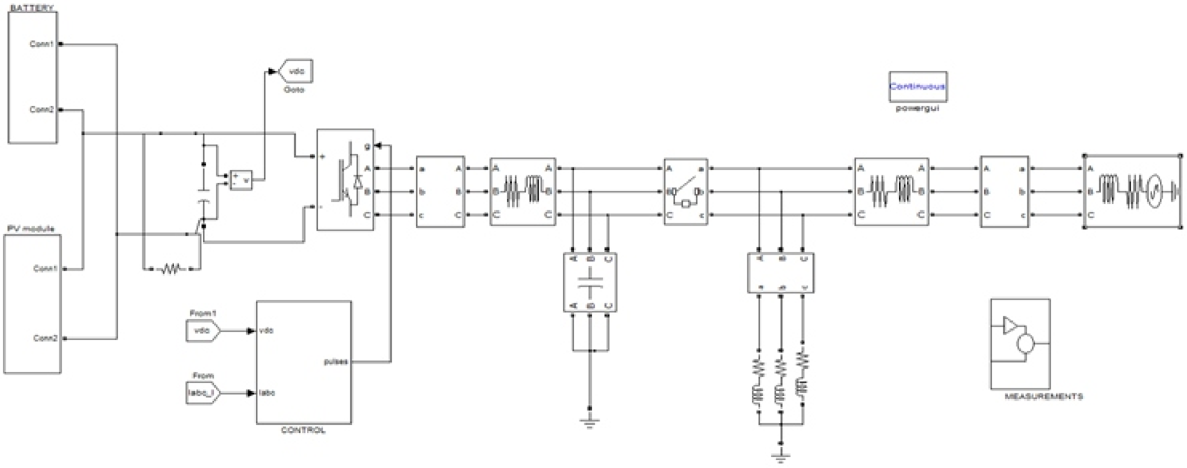


Fig. (10). Simulation model of HGICB converter with PV hybrid energy harvesting system

The performance of proposed converter INC MPPT algorithm at different insolation levels is verified by designing simulation model. The converter is tested at variable PV model voltage and current in proportion to insolation values, at that same time the duty cycle of MPPT algorithm is calculated.

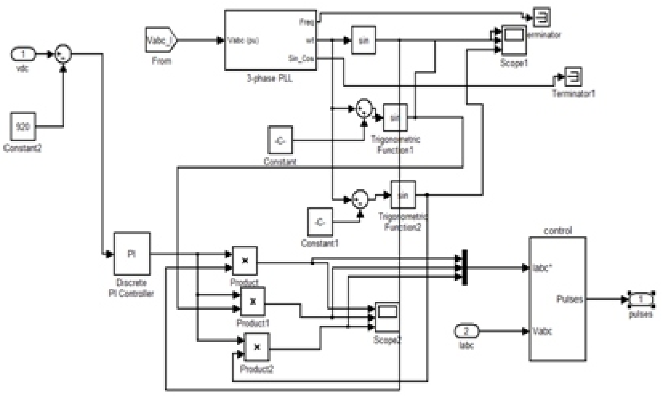


Fig. (11). Simulation model for control strategy of MPPT algorithm.

The irradiance level wave form of PV model is shown in fig. (12), and dynamic performance of micro-grid voltage source inverter is studied by simulation model and results are verified. And the loads are at unbalanced condition with MPPT algorithm of INC technique.

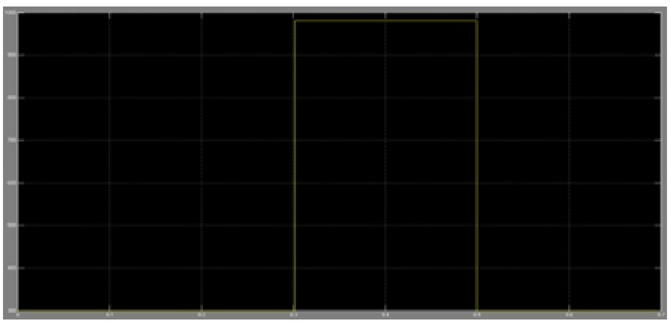
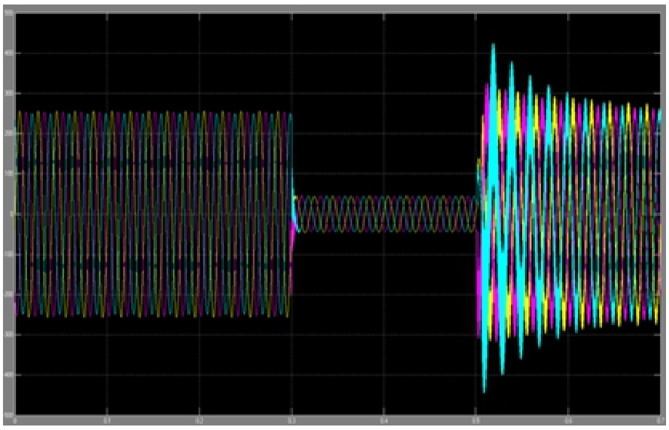
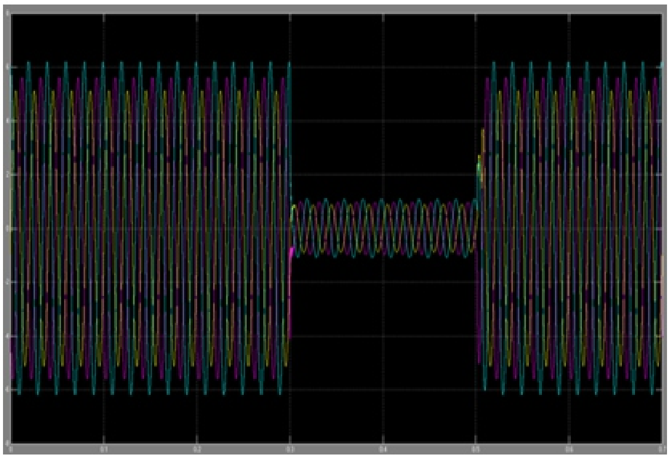


Fig. (12) Simulation result of PV cell irradiance

Simulation results of grid side voltage and grid side currents of μG-VSC are shown in fig. (13).The simulation waveforms of inverter voltage (V_inv) and inverter current (I_inv) are shown in fig. (14) and (15) respectively.



13. (A)



13. (B)

Fig.13. Simulation results of μG-VSC (A) grid side voltage, (B) grid side current

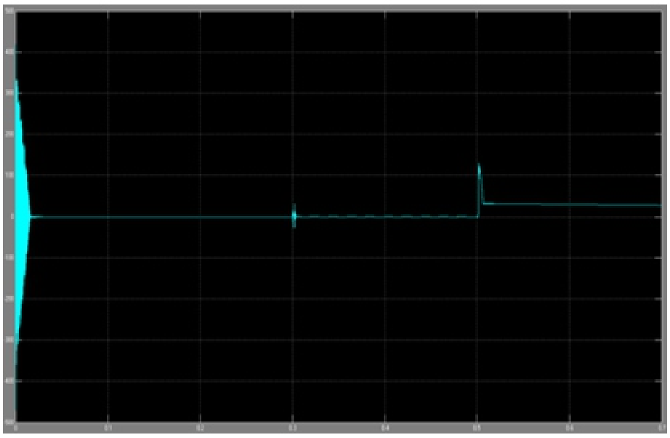


Fig.14. simulation wave form of inverter voltage

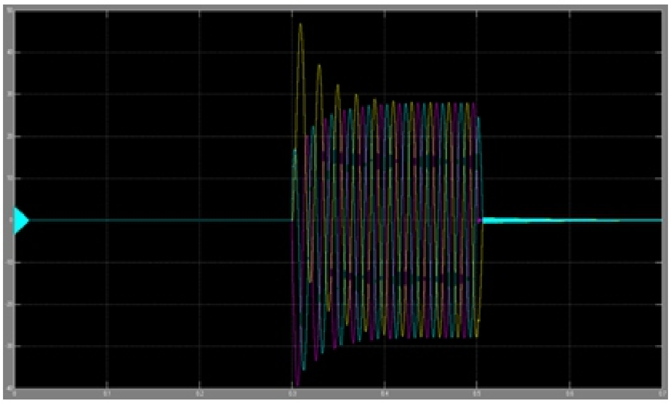


Fig.15. simulation wave form of inverter current

Simulation waveforms of grid voltage (V_grid) and grid current (I_grid) are shown in fig. (16), the active and reactive powers of energy harvesting system under proposed cascaded converter with INC MPPT algorithm are shown in fig. (17).and the DC link voltage dynamics of energy harvesting system of PV hybrid input source are shown in fig. (18).

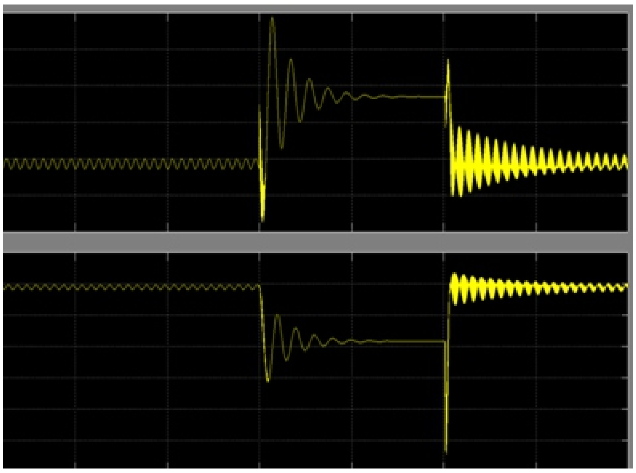


Fig. (16). Simulation wave forms of grid voltage (V_grid) and grid current (I_grid)

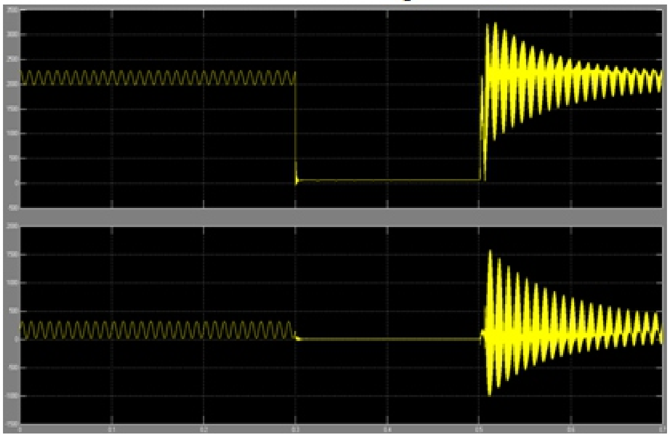


Fig.17. Simulation results of active power and reactive power

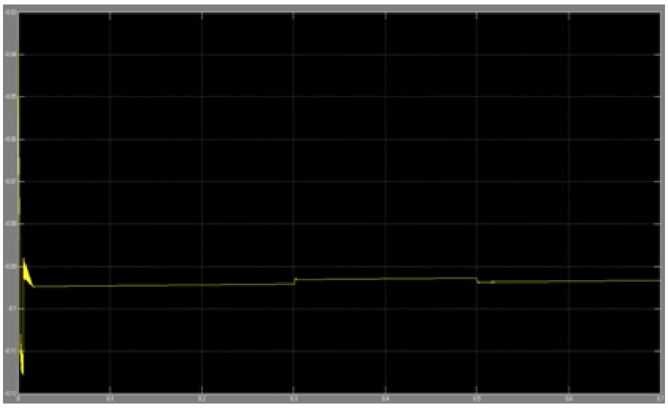


Fig.18. Simulation result of DC link voltage dynamics

V.CONCLUSION:

The proposed PV hybrid energy system is having the better energy conversion system and the performance is evaluated throughout this paper. Micro-grid voltage source converter (μG-VSC) is having application in this paper as grid side voltage source converter.

For better conversion of energy for low voltage applications like PV cells a cascaded boost converter of high gain is proposed. The efficient control strategy is also proposed for getting maximum power from solar cell i.e. MPPT technique of INC type.

The DC link voltage control is done efficiently by using hybrid energy system and efficient battery converter. The compensation of reactive power and ripple current reduction for unbalanced non-linear load at PCC is done proposed μG-VSC.

The performance of the proposed cascaded boost converter with INC MPPT algorithm is verified by using MATLAB/simulink software and waveforms are studied.

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