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A New Converter Topology with PV/Battery Hybrid System with Energy Management Control Strategy

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ABSTRACT

This Paper aimed at developing a standard procedure for the design of large-scale institutional grid-connected solar PV systems using the roofs of buildings and car parks. Grid-connect PV systems with battery back-up (sometimes referred to as uninterrupted power supply or hybrid solar PV systems) are becoming increasingly popular. Grid-connected systems do not need batteries which reduces considerably initial capital costs and energy costs. For a comparable load, grid -tied systems use smaller PV arrays than stand-alone systems. In order to address this issue, a two-stage stand-alone scheme consisting of a novel transformer coupled dual-input converter llowed by a conventional full-bridge inverter is proposed. The proposed converter can realize maximum power point tracking and battery charge control while maintaining the proper voltage level at the load terminal. A suitable control strategy for the proposed converter devised for manipulating the converter to realize the first two aforementioned objectives, while the third objective is achieved by employing a conventional proportional integral (PI) controller to control the output voltage of the five level inverter through sinusoidal pulse width modulation.

INTRODUCTION

These days interest for control all through the world increments and these requests can't meet by traditional sources (like warm and hydro age) in view of restricted accessibility of coal and water. Henceforth whole world foot forward to the sustainable power sources like breeze and sunlight based vitality they never going to be vanish, and these are the most encouraging other options to supplant customary vitality sources [1], [2]. Be that as it may, successful use of inexhaustible sources and for getting greatest power yield requires quick acting force electronic converters [3]. For three-stage applications, two sorts of energy electronic setups are normally used to exchange control from the sustainable power source asset to the network: 1) single-stage and 2) twofold phase change. In the twofold phase change for a PV framework, the primary stage is generally a dc/dc converter and the second stage is a dc/air conditioning inverter. In first stage the DC-DC converter gives most extreme power following from PV module and furthermore delivers fitting DC voltage for organize 2 reversal. In stage2 (reversal arrange) inverter produces 3-øsinusoidal voltages or streams and it exchanges energy to stack associated or to the framework [4].The framework structure is extremely adaptable. PV modules are the principle building obstructs; these can be orchestrated into clusters to expand electric vitality generation. Ordinarily extra hardware is essential with a specific end goal to change vitality into a helpful shape or store vitality for sometime later. The subsequent framework will in this manner be dictated by the vitality needs (or loads) in a specific application. PV frameworks can be extensively characterized in two noteworthy gatherings [12].

1) Stand-Alone: These frameworks are disengaged from the electric conveyance matrix. Figure.1 portrays the most widely recognized framework

setup. The framework portrayed in Figure.1 is really a standout amongst the most perplexing; and incorporates every one of the components important to serve AC apparatuses in a typical family or business application.

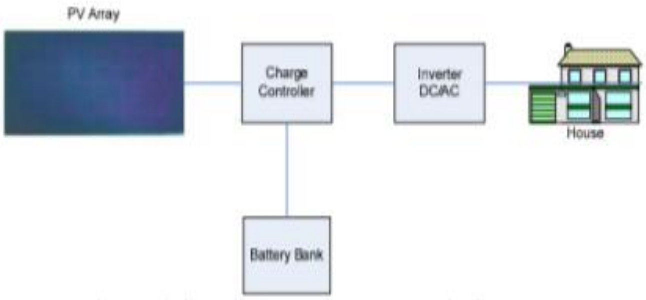


Figure.1.Stand-Alone Photovoltaic System

2) Grid-Tied: These frameworks are straightforwardly coupled to the electric dissemination arrange and don't require battery stockpiling. Figure.2. depicts the fundamental framework setup. There are many advantages that could be acquired from utilizing network tied PV frameworks rather than the customary remain solitary plans.

These advantages are: Smaller PV clusters can supply a similar load reliably.• Less adjust of framework segments are needed.• Comparable emanation diminishment potential taking• preferred standpoint of existing foundation. Disposes of the requirement for vitality stockpiling and the costs• related to substituting and reusing batteries for singular customers. Capacity can be incorporated if wanted to improve dependability for the customer. Exploits the current electrical infrastructure.• Efficient utilization of accessible vitality. Adds to the• required electrical network age while the customer's request is underneath PV yield.

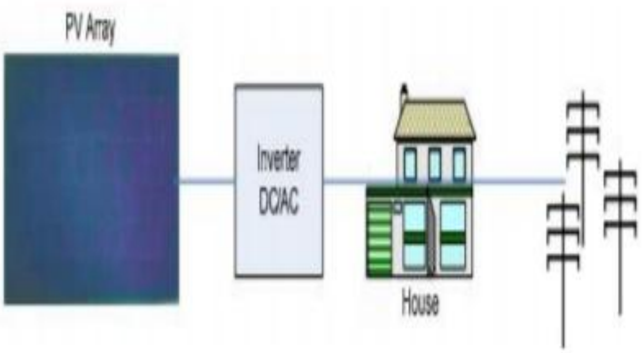


Figure.2.Grid-Tied Photovoltaic System

Highly sophisticated frameworks might be conceivable were battery stockpiling or a generator (or both) can be joined with a lattice association for extra dependability and planning adaptability (at extra cost). [13] Most of the introduced private, comme rcial and focal scale frameworks utilize pre-manufactured level plate sunlight based modules, since they are broadly accessible.

OPERATING PRINCIPLE OF PROPOSED CONVERTER

The schematic graph of the converter is portrayed in Fig. 3. From this figure, it can be noticed that no devoted converter is utilized for guaranteeing the MPP operation of the PV cluster, which prompts the enhanced usage of the converters included.

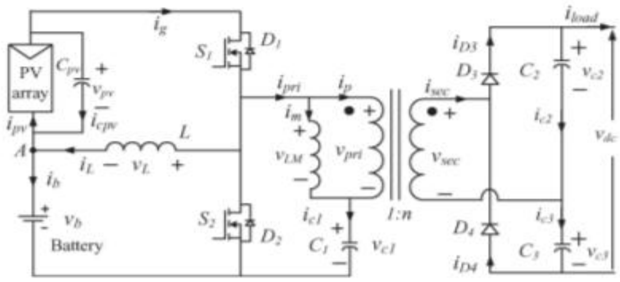


Figure. 3. Schematic circuit diagram of proposed converter

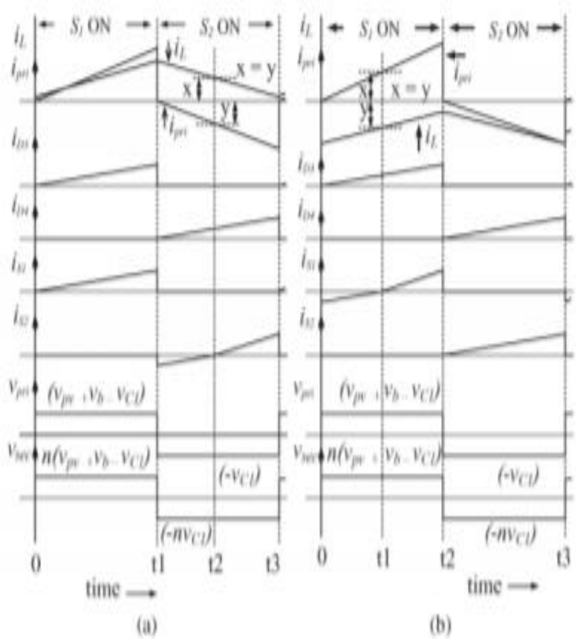


Figure. 4. Waveforms of currents flowing through and voltage across different key circuit elements of CONVERTER when (a) iL is positive and (b) iL is negative

A. Operation of the Converter When Inductor Current is Positive

The waveforms of the streams moving through and voltages crosswise over various key circuit components of converter, while the present coursing through the inductor L is certain, are appeared in Fig. 4(a). The different conceivable exchanging modes amid this condition are dissected in this segment.

a) Mode I (0 to t1; S1 and D3 conducting): At the point when S1 is turned on; the PV exhibit voltage vpv is inspired crosswise over L, and the inductor current iL increments. Amid this period, the voltage awed over the essential twisting of the transformer is vpri = (vpv + vb − vC1), wherein vb is the battery voltage and vC1 is the voltage over the capacitor C1. Thus, the essential current of the transformer, ipri, increments, and the capacitor C1 gets charged.

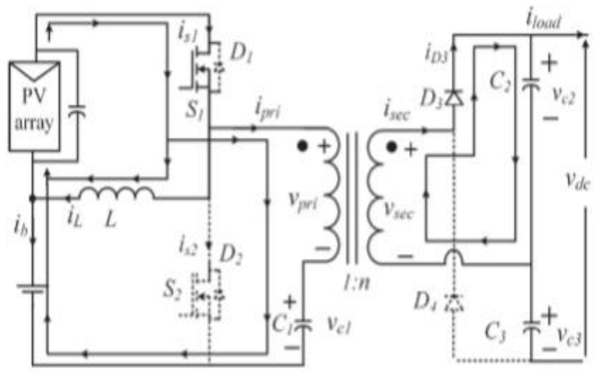


Figure.5. Equivalent circuit diagram of converter when operating in mode I and inductor current is positive

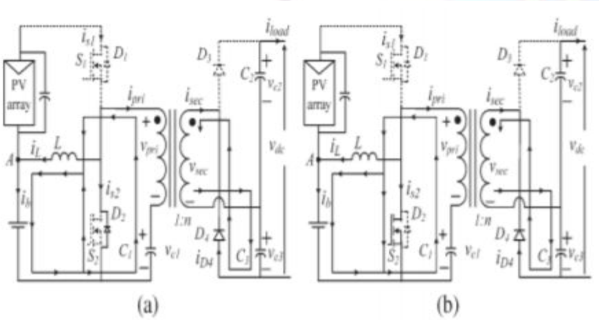


Figure. 6. Equivalent circuit diagram of converter when inductor current is positive: (a) Mode II and (b) mode III

The present coursing through the auxiliary twisting of the transformer, isec, likewise increments. The diode D3 is forward one-sided, and the capacitor C2 gets charged. The voltage crosswise over C2 is given by vC2 = n(vpv + vb − vC1), wherein n is the turns proportion of the transformer. The comparable outline of CONVERTER amid this mode is appeared in Fig.5.

b) Mode II (t1 to t2; D2 and D4 conducting): This mode starts when S1 is killed and S2 is turned on. At the beginning of this mode, iL is sure, and as S1 is killed, ipri is zero. Since iL > ipri, the diode D2 begins directing. The proportionate circuit graph of converter amid this mode is appeared in Fig. 6(a).

c) Mode III (t2 to t3; S2 and D4 conducting): At the point when iL ends up noticeably littler than (−ipri), the diode D2 is turn around one-sided, and the switch S2 begins directing. Whatever is left of the operation continues as before as that of mode II. The proportionate circuit chart of CONVERTER amid this mode is appeared in Fig. 6(b).

B. When Inductor Current is Negative

The waveforms of the streams moving through and voltages crosswise over various key circuit components of converter, while the present coursing through the inductor L is negative, are appeared in Fig. 6(b). The different conceivable exchanging modes amid this condition are examined in this segment.

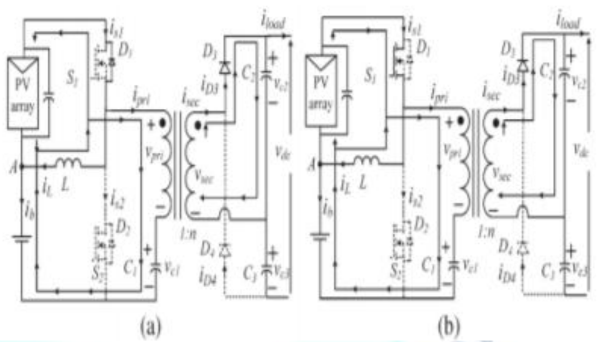


Figure. 7. Equivalent circuit diagram of converter when inductor current is negative: (a) Mode I and (b) mode II

d) Mode I (0 to t1; D1 and D3 conducting): This mode starts when S1 is turned on and S2 is killed. At the beginning of this mode, iL is negative, and ipri is zero. Henceforth, the diode D1 begins directing. Whatever is left of the operation is the same as that of mode I talked about in the past area. This mode proceeds until ipri winds up noticeably equivalent to (−iL). The proportional circuit outline of converter amid this mode is appeared in Fig. 7(a).

e) Mode II (t1 to t2; S1 and D3 conducting): At the point when ipri ends up noticeably more noteworthy than −iL, the diode D1 is invert one-sided, and the switch S1 begins directing. Whatever remains of the operation is the same as that of mode I talked about in the past segment. The identical circuit graph of converter amid this mode is appeared in Fig. 7(b).

f) Mode III (t2 to t3; S2 and D4 conducting): This mode starts when S1 is killed and S2 is turned on. Amid this mode, both iL and ipri are negative, and the switch S2 conducts. The negative current in the essential twisting of the transformer brings about negative current in the auxiliary twisting of the transformer. Consequently, the diode D4 is forward one-sided, and the capacitor C3 gets charged. Amid operation in this mode, vL = −vb, vpri = −vC1, and vC3 = nvC1. The equal circuit outline of CONVERTER amid this mode is the same as that show1n in Fig. 6(b), with the exception of that the bearing of iL is switched. From Fig. 3, we have

$$v_L = v_{pv}, \quad \text{when } S_1 \text{ is on}$$
$$v_L = -v_b, \quad \text{when } S_2 \text{ is on} \quad (1)$$

Therefore, the average value of V_L is

$$V_L = D\bar{V}_{pv} - (1-D)V_b \quad (2)$$

From (2), it can be construed that the PV voltage can be controlled by controlling D as battery voltage Vb can be thought to be a firm source. Along these lines, the MPPT operation of the PV exhibit can be accomplished through a legitimate control of D. The normal yield voltage of the CONVERTER, Vdc, is given by

$$\begin{aligned} V_{dc} &= (V_{C_2} + V_{C_3}) \\ &= [n(V_b + V_{pv} - V_{C_1}) + nV_{C_1}] \\ &= n(V_b + V_{pv}). \end{aligned} \quad (3)$$

Applying KCL

$$i_L + i_{cpv} = i_b + i_{pv} \quad (4)$$

$$I_b = I_L - I_{pv} \quad (5)$$

From (5), it can be noticed that, for IL > Ipv, the battery is charged and, for IL < Ipv, the battery is released. Accordingly, by controlling IL, for a given Ipv, battery charging and releasing can be controlled. The disadvantage of CONVERTER and the related outline requirements are introduced. The points of interest of the control procedure formulated for CONVERTER are examined.

CONTROL STRUCTURE

The controller of a remain solitary framework is required to play out the accompanying errands: 1) extraction of greatest power from the PV cluster; 2) control the battery utilization without disregarding the points of confinement of cheat and over release; and 3) dc– air conditioning transformation while keeping up the heap voltage at the endorsed level. The subtle elements of the control calculation formulated for converter are displayed in this area. So as to accomplish the coveted functionalities, converter is required to work in one of the accompanying modes. 1) MPPT mode: Maximum power is separated from the PV cluster when the framework is working in this mode. In any case, keeping in mind the end goal to work in this mode, one of the accompanying conditions must be fulfilled: 1) Available most extreme PV control Pmpp is more than the heap request Pl, and the surplus power can be devoured by the battery without being cheated; and 2) Pmpp < Pl and the battery have the ability to supply Pl − Pmpp without being over released. The PV control in MPPT mode is given by Ppv = Pmpp = (Pb + Pl), where Pb is the battery control which is characterized as positive amid charging and negative while releasing.

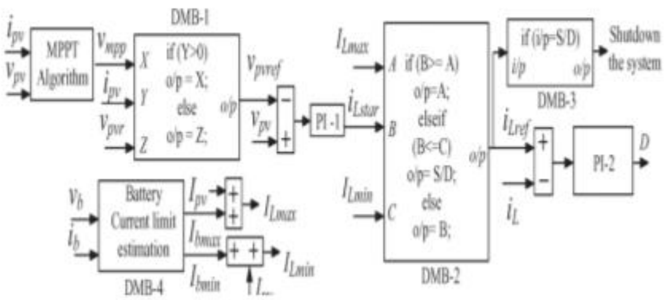


Figure. 8. Control structure for the proposed converter

3) Non-MPPT mode: In light of the condition of charge (SOC) level of the battery, its charging current is required to be restricted to a most extreme reasonable farthest point Ib max to keep the battery from getting harmed because of cheat. The most extreme charging current farthest point Ib max limits the greatest power that can be consumed by the battery to Pb max = Ib max ∗ Vb. At the point when Pmpp > Pl and the surplus power is more than Pb max, the framework can't be worked in MPPT mode as it would cheat the battery. Amid this condition, control extraction from PV is decreased to an esteem given by Ppv = (Pb max + Pl). This method of operation is known as non-MPPT mode. 3) Battery just (BO) mode: The framework works in BO mode when there is no PV control and the battery has the capacity to supply the heap request without being over released. 4) Shutdown mode: When Pmpp < Pl and the battery does not have the ability to supply Pl − Pmpp, the framework should be closed down to keep the battery from being over released. The control calculation that is utilized to choose the correct method of operation for the CONVERTER, contingent upon the status of the SOC of the battery opposite the accessibility of energy from the sunlight based cluster, is appeared in Fig.8. The best possible mode

choice is finished by four intelligent basic leadership pieces (DMBs). The control piece DMB-1 sets the reference for the PV exhibit voltage (Vpvref). It additionally chooses whether the framework will work in BO mode or in MPPT mode. When it is discovered that ipv > 0, in this way showing the accessibility of PV control, the MPPT method of operation is chosen, and the yield of the MPPT calculation square (i.e., Vmpp) sets Vpvref . At the point when the PV control isn't accessible, the BO mode is chosen, and Vpvref is taken as Vpvr wherein Vpvr is chosen in order to keep up the yield voltage Vdc inside the coveted scope of 350– 460 V according to (3). The mistake amongst Vpvref and VP V is gone through a PI controller to set the required reference for the inductor current (iLstar). A furthest farthest point IL max and a lower constrain IL min is forced on iLstar in light of the relationship given in (5) to anticipate cheating and over releasing of the battery, individually. The maximum and minimum limits are:

$$I_{L\,\max} = I_{b\,\max} + I_{pv}$$
$$I_{L\,\min} = I_{b\,\min} + I_{pv}$$

Where in Ib max and Ib min are the maximum permissible charging and discharging current of the battery, respectively. These two limits are set based on the SOC level and the allowable depth of discharge of the battery. The block DMB-4 is employed to carry out the aforementioned functions. The block DMB-2 sets the reference level for the inductor current iLref after resolving the constraints imposed by IL max and IL min. When iLref remains within its prescribed limit, the system operates either in MPPT mode (for ipv > 0) or in BO mode (for ipv ≤ 0). When iLref hits its lower limit, thereby indicating that the over discharge limit of the battery is reached, DMB-3 withdraws gating pulses from all the switches and shuts down the system. When the battery overcharging limit is attained, iLref hits its upper limit. This situation arises only when the system is operating in MPPT mode with Pmpp > Pl and the surplus power is more than Pb max. In this condition, iLref is limited to IL max to limit the battery charging current to Ib max, and the MPPT is bypassed. As the battery charging current is limited to Ib max, power consumed by the battery is restricted to Pb max. This makes the available PV power more than (Pl + Pb max). This extra PV power starts charging the PV capacitor, and its voltage increases beyond Vmpp, thereby shifting the PV operating point toward the right side of the MPP point, and the power extracted from the PV array reduces. This process continues until the power drawn from the PV array becomes equal to (Pl + Pb max). Hence, during operation of the system in non MPPT mode, the PV array is operated at a point on the right side of its true MPP, and hence, Ppv < Pmpp. If there is a decrement in load demand while operating in non-MPPT mode, power drawn from the PV array becomes more than (Pl + Pb max), and this excess power drawn starts charging the PV capacitor, thereby shifting the operating point of the PV further toward the right side of its previous operating point. In case of an increment in the load demand, the power drawn from the PV array falls short of supplying the load demand and the dc-link capacitors, and the PV capacitor starts discharging. As the voltage of the PV capacitor falls, the operating point of the PV array shifts toward the left side from its previous operating point. This leads to an increment in the power drawn from the PV array, and this process continues until the power balance is restored. In case the load demand increases to an extent such that the PV power available at its MPP falls short to supply this load, the battery will come out of its charging mode, iLref will become less than IL max, and the system operates in MPPT mode.

MATLAB/SIMULATION RESULTS

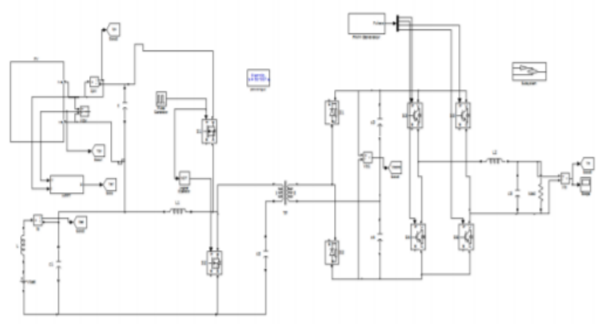
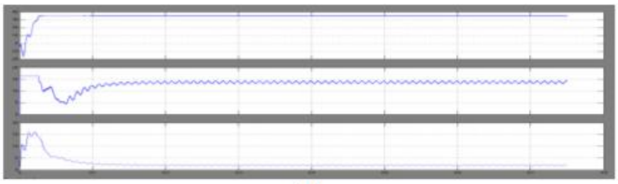
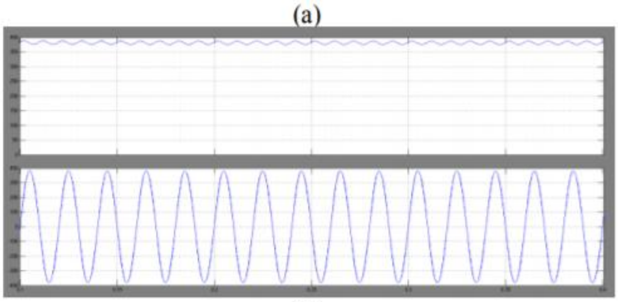


Figure.9.Matlab/Simulation model of under steady-state operation



(a)



(b)

Figure. 10. (a) vpv, ipv, and ib (b) vdc and load voltage in steadystate operation in MPPT mode

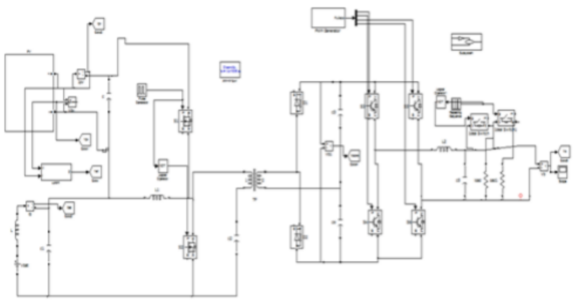
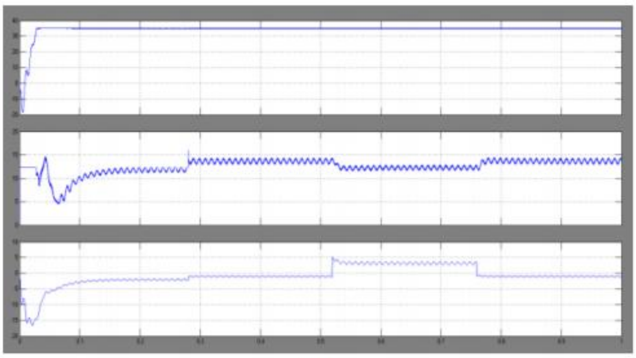
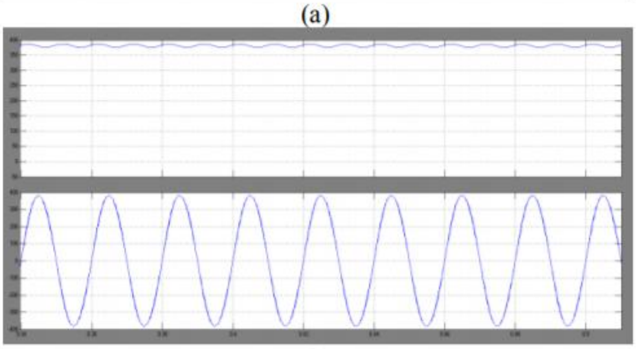


Figure.11. Matlab/Simulation model



(a)



(b)

Figure. 12. Simulated response of the system under changes in load and insolation level

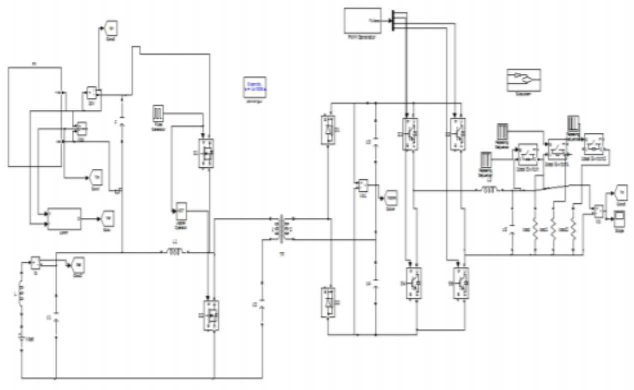
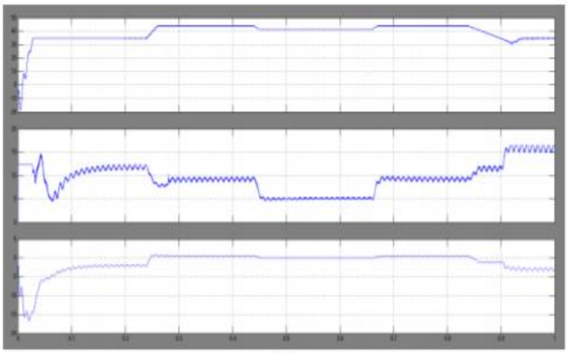
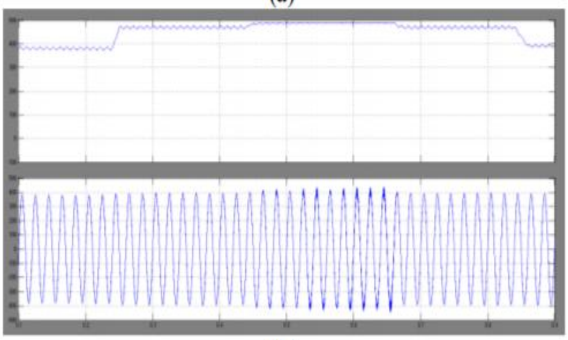


Figure.13. Matlab/Simulation model of under mode transition

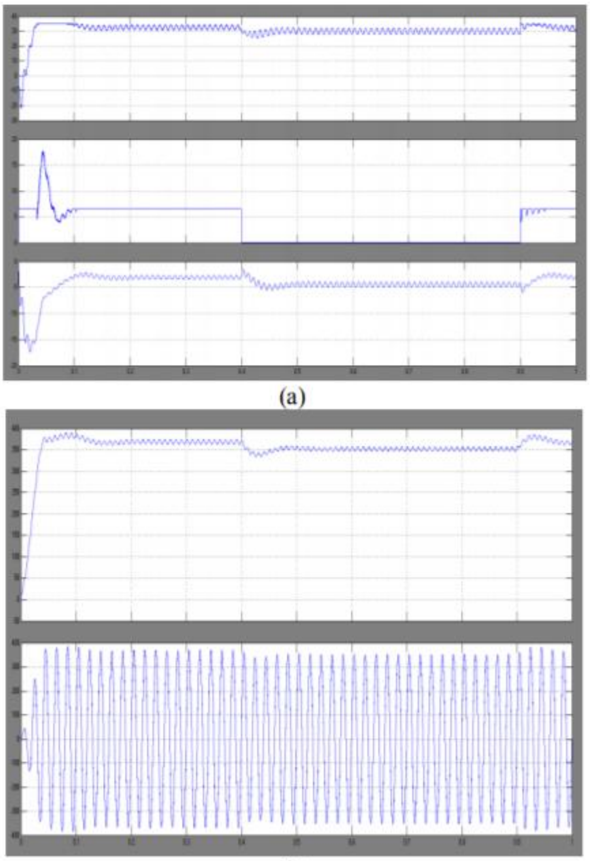


(a)



(b)

Figure. 14. Simulated response of the system under mode transition between MPPT and non-MPPT mode



(a)

(b)

Figure. 15. Response of the simulated system during mode transition between MPPT and BO modes

CONCLUSION

This papers gives the conceptual design and analysis of the rural based renewable energy generation using converter technique. This proposed technique is implemented by a full bridge power electronic equipment. The successful implementation of the proposed methodology lies within the radiation forecasting of solar power. The coordination between the topological interfaces will help in realization of the gird interfaced solar system for rural conditions. The auxillary aim will also be to supply reactive power compensation and minimize the amount of power distortions during the utilization of the power flow between the renewable energy source and gird. The system also takes the help of the standalone energy systems like batteries which store and supply the power when needed. The proposed framework enables mix of PV to control the loads which are connected with the gird. Depending of the KVAR compensation and requriements in gird , the PV power is adjusted to the power traded with the network or with the batteries.

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