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Grid and Islanded Operations of PV Energy Management System by Means of Reconfiguration of Controllers

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ABSTRACT*:* In this idea the investigation, configuration of a photovoltaic energy management system with battery reinforcement displayed. The proposed system is work in both grid connected and autonomous load operations. Main advantage of the proposed system is that, the inverter functions as a current source in phase with the grid voltage, infusing energy to the network and controlling the dc-link voltage in grid-connected mode. The converter manages the battery charge and discharge. In islanded mode, the inverter control is reconnect to work as a voltage source using droop schemes. The dc/dc converter manage the dc-link voltage to empower the MPPT. An operation convention is proposed to guarantee the quality of the energy supply and minimize the losses of energy. A battery bank is joined with the dc interface as stores the energy for islanded operation mode. The point of this paper is to demonstrate that the proposed framework performs accurately, without risky homeless people for the inverter or the loads. Recreation and trial results on a 3-kW model demonstrate the possibility of the proposed control system.

KEYWORDS: Battery backup, grid-connected mode, inverter, islanded mode, reconfigurable control scheme.

I.INTRODUCTION

Lately, the advancement of option energy sources has turn into a worldwide need, offering ascent to escalated research about less naturally contaminating renewable sources.

The foundation of littler and distributed power plants has been taken off possible in view of changes in both the power system idea and the economy of scale. The proximity with in the middle of generation and utilization focuses has recovered significance and distributed generation (DG) advances have progressed extraordinarily lately. One approach to embed DG frameworks into an electrical system is through micro grids. A micro grid can be characterized as a combination of loads and micro sources that give electric energy to a neighbourhood. The operation of a micro grid offers specific advantages to clients and utilities, i.e., enhanced energy efficiency , reduced ecological effect, and more reliability. A standout amongst the most important features of microgrids is that they can freely work in islanded mode without association with the distribution system when power system shortcomings or power blackouts happen. Various commercial photovoltaic (PV) inverters work as a current source in grid-connected mode. The control of inverters has grown after some time and is presently highly efficient for this operational mode. A few works manage the right operation of inverters working in grid connected and islanded modes. A possible solution is based on droop schemes. These plans use P−Q strategies in the inverters to appropriately share the power conveyed to the loads while avoiding critical communication lines. In [1] and [2], the inverters are controlled by method for droop schemes in both operational modes, with the goal that no advantage is taken from control calculations that inject the inverter yield current in stage with the grid voltage (current source calculations)) developed for commercial grid-connected inverters. In [3], the inverter acts as a current source by giving a constant current to the grid.The inverter distinguishes when islanding happens and changes to voltage source operation. The authors likewise propose a load shedding calculation for international islanding and a synchronization calculation for grid reconnection. During islanding operation, the reference imposed on the inverter voltage controller has affixed value, so that inverter parallelization for load power sharing is impractical. In [4], the inverters change their control structure depending upon the connection–disconnection status of the microgrid to the fundamental network. At the point when themain grid is connected, the inverters works as a current source. In an islanding circumstance, they act as voltage sources associated by robust controller region network communications. Be that as it may, this system requires an effectively working communication bus, and this increases the cost.

In different studies, for example, [5] and [6], reconfigurable control plans are proposed, based on a very simple and effective kind of control, in particular, a multi circle straight proportional–integral (PI) control system. This technique utilizes linear inner and external PI control loops to manage the framework state variables. On the other hand, these papers don't obviously clarify how inverters are parallelized when sharing the load power. There are various implementation choices for energy storage. A few authors propose an energy storage independent from generators. Another choice is to coordinate storage and generation in a single system. This dc bus has a fixed voltage, so that power converters for both generation and battery management are important to satisfactory the voltage and perform the maximum power point (MPP) and maximum power point tracking (MPPT) of the power sources. In [7], the proposed framework is made out of a PV generator and a battery bank interconnected by method for a dc/dc converter. The inverter and the dc/dc converter have the same dc bus. The dc bus voltage is the same as the PV panel yield voltage, which is imposed by an MPPT calculation.

This framework has been intended for stand-alone applications. This paper demonstrates a reconfigurable control scheme taking into account multi loop control in both operational modes. In grid connection mode, the inverter is controlled as a current source in phase with the grid voltage. At the point when the micro grid gets to be isolated from the grid, the inverters change their control design, functioning as voltage sources and utilizing a droop strategy [1], [7]and [8] to share the power demanded by the local loads. The droop system gives a better solution for parallelizing various inverters without utilizing communication. The proposed PV energy system gives energy storage capability and permits increasing the energy extracted from the PV panels in both operational modes. The framework incorporates a parallel energy storage system made out of a battery bank and a dc/dc converter that guarantees the MPPT of the PV source in islanded operation. Also, the proposed control reconfiguration is conceivable without dangerous transients for the inverter or the loads.

II. PV SYSTEM MODEL

The PV system under study, indicated in Fig.3.1, incorporates a 3-kW full-bridge single-stage inverter and a bidirectional dc/dc converter. The dc/dc converter is joined with the dc link at the input of the inverter. The dc/dc converter deals with the battery charge–discharge. The dc-link voltage Vdc is set by a MPP tracker in both islanded mode and grid connected mode. In islanded mode, the MPP tracker gives a reference voltage to the dc/dc converter, so that it manages Vdc. In grid connected mode, the MPP tracker conveys a reference voltage to the inverter, with the goal that it can perform Vdc regulation. The MPPT is implemented by method for a peturb and observe algorithm [9], [10]. The MPP tracker characterizes the set purpose of the dc-join voltage to concentrate the greatest yield power from the PV board. The PV plan gives a dc-link voltage of around Vdc= 380V at the MPP, which is sufficiently high to inject energy(power) to the network(grid) (230Vrmsat 50 Hz) without a set-up transformer. To perform the simulations, the PV array has been displayed as a current source that is dependent on the approaching irradiance.

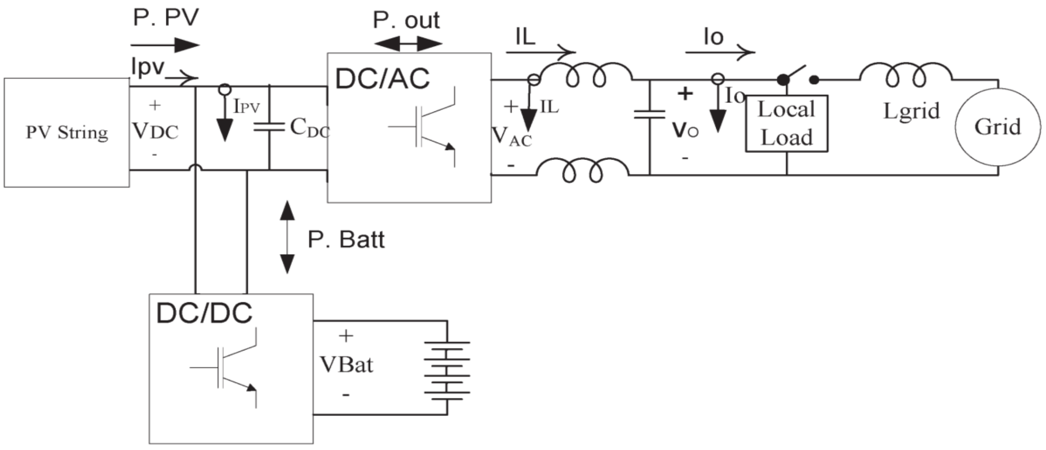

Fig.1. Block diagram of the PV system under study.

i).Single-Phase Inverter

Fig.2 demonstrates the plan and the control structure of the inverter that has been implemented. A current-controlled H-bridge single-stage inverter with bipolar pulse with modulation has been selected. This sort of inverter is common in grid connected PV frameworks . The inverter is fed by a dc programmable source in which the I−V curve of a PV board has been programmed to emulate an array of 14 series connected PV pnels. Table I demonstrates the electrical parameters of the PV inverter under study. The power of the inverter under study is 3 kW, with a switching frequency of 16 kHz.

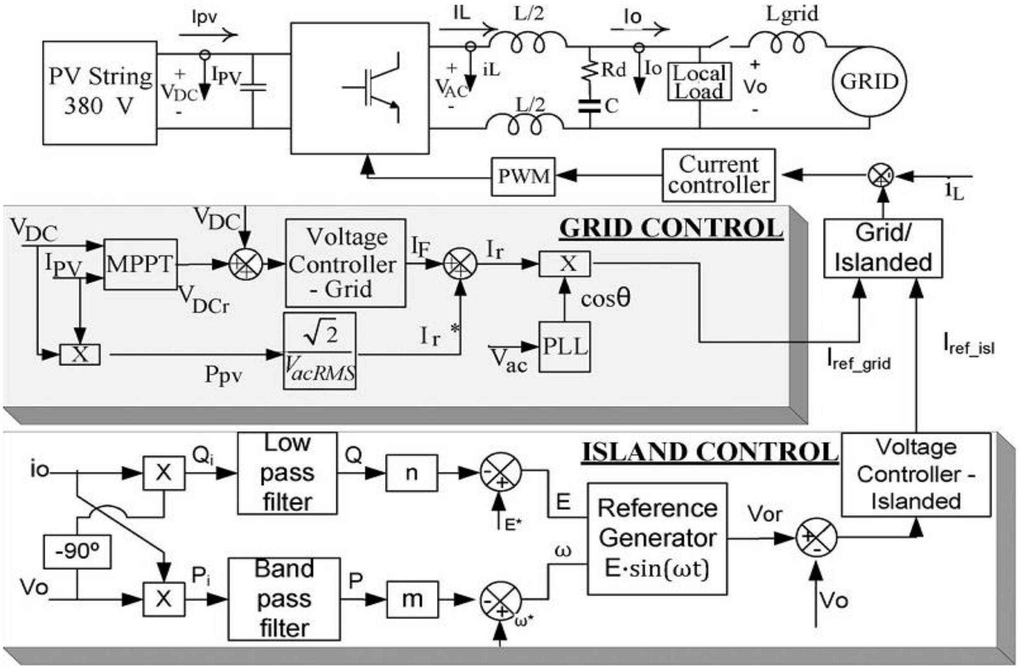

Fig.2. Control structure of the PV inverter.

TABLE I

ELECTRICAL PARAMETERS OF THE INVERTER UNDER STUDY

PARAMETER	VALUE
Power injected from PV panels($P_{pv\ MPP}$)	3 kW
DC-link voltage at MPP($V_{DC\ MPP}$)	380 V
Inverter output voltage	230 V_{RMS} ±10%
Fundamental frequency of the inverter	50 Hz
Inverter inductance	2.7 mH
DC-link capacitor	2mF
Inverter output capacitor	4.5μF

ii).Dc/Dc Converter

To enhance the power management in the microgrid, backup energy storage is incorporated. It comprises of a battery bank connected with the inverter dc link by method for a two-quadrant bidirectional dc/dc converter. The primary point of preference of this setup is that the dc/dc converter processes just a part of the generated power. This converter performs various functions: It serves as a battery charge controller(regulator) in grid-connected operation and a boost converter to convey energy from the batteries to the inverter when the PV source has insufficient energy to feed the local loads in islanded operation. In islanded mode, the most positive working condition happens when the load power and the PV extracted power agree, i.e., when the dc/dc converter does not process power. Fig.3 demonstrates the rearranged dc/dc converter power stage and its control structure. The islanded and grid-connected operational modes are clarified in the following areas.

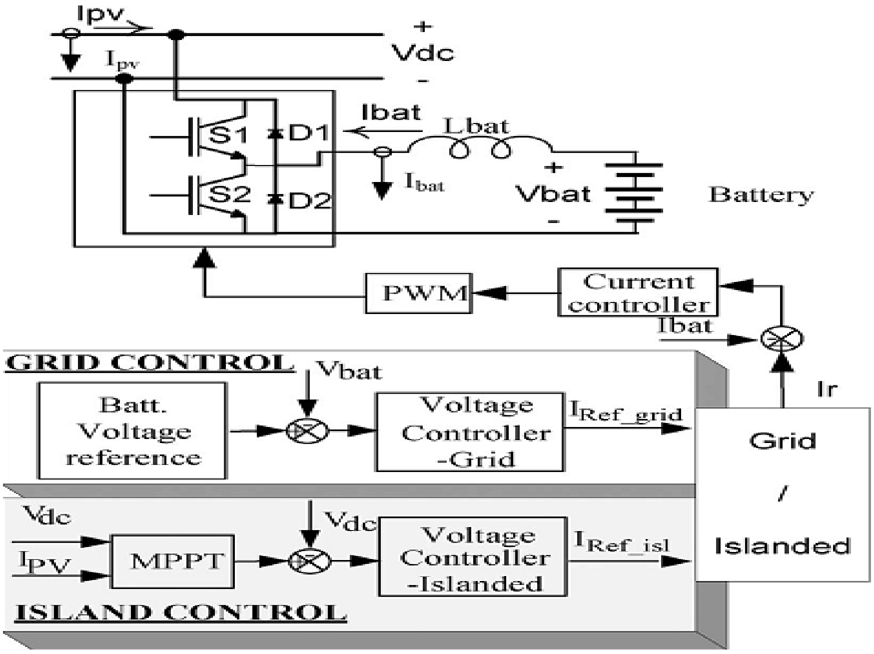

Fig.3. DC–DC converter schematic and control structure.

III. DYNAMIC ANALYSIS

The inverter switches from grid-connected mode to islanded mode by selecting between two current references: Iref_grid and Iref_isl, as indicated in Fig.2. The strategy depicted in is utilized to distinguish the islanding condition. A stability examination of the converters is demonstrated for both operation modes.

i) PV Power System Working In Grid-Connected Mode

In grid connected mode, the dc-link voltage (Vdc) control is performed by the inverter, after a reference gave by the MPPT calculation. A PI controller (voltage controller-grid component in Fig.2) is utilized for the inverter voltage loop in this operational mode. A food forward term Ir, expressed by (1), is added to the yield of the PI dc-link voltage controller IF, yielding the amplitude of the current loop reference Ir. The term I∗r is derived from the dynamic power or active power that is being conveyed by the PV source.

$$I_r^* = \frac{P_{PV}.\sqrt{2}}{V_{acRMS}} \qquad (1)$$

The amplitude Ir is multiplied by the term cosθ, gave by a phase locked loop (dqPLL) working from the grid voltage. The dqPLL is implemented utilizing the synchronous rotating reference frame procedure . The angle θ is that of the fundamental part of the grid voltage. The present controller was actualized by method for a harmonic compressor.

ii). PV Power System Working in Islanded Mode

In islanded mode, the inverter feeds the local loads, producing a similar load voltage waveform as in the grid connected situation. The inverter functions as an AC voltage source feeding local loads. Accordingly, it is important to have some energy storage component, for example, a battery, because the PV panels may not always be able to meet the power demand of the local loads. It ought to be considered that the power conveyed by the inverter must match the load power utilization. Consequently, it is important to discover the reference of the inverter yield voltage (Vor in Fig.2) as far as the active power and reactive power consumed by the loads. The strategy used to determinate this voltage reference is the droop system as indicated in Fig.2. In the system under study, a just PV inverter has been considered, with the objective of our exploration being the change from grid connected mode to islanded mode with a battery as extra energy storage, not the droop technique in itself. As one and only inverter in islanded mode has been considered, the droop system is unnecessary. All things considered, the inverter control has been created to work in a microgrid environment, in parallel with different inverters. In this manner, the analysis and the experimental results have been obtained with the full algorithm working (droop + inverter current and voltage loops). The voltage reference of the inverter yield voltage controller is synthesized by method for the droop scheme studied in [1]. In islanded operation mode, the dc-link voltage is controlled by the battery-side dc–dc converter after a reference set by the MPPT calculation

IV.ENERGY MANAGEMENT

Figs. 4 and 5 demonstrate the proposed energy management protocol in grid connected operation and in islanded operation, Respectively At the point when the grid is connected, the power required to charge the batteries can be separated from the PV array and from the grid. Fig. 4 demonstrates a possible scenario in this operational mode in regards to the power conveyed to the batteries at a constant available power from the PV source. Toward the starting, the available PV power is less than the important battery charge power, and the inverter takes the supplementary energy from the grid (Pout < 0). At the point when the battery charge power decreases, the inverter begins to inject power to the grid(Pout > 0). After the end of charge, all the possible PV energy is injected to the grid (PPV = Pout). Fig. 5 shows a possible situation in islanded operation mode. In this mode, the batteries function as an energy backup necessary if accessible PV power is less than the load power request. The batteries get energy from the PV source when the generated power is higher than that needed by the loads . At the point when the power needed by the loads is higher than that of PV generation ,the batteries convey the necessary extra power.

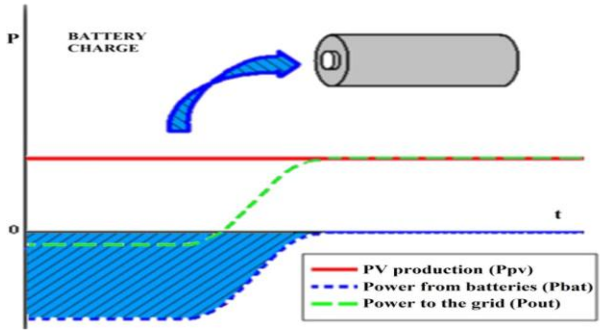

Fig. 4. Energy management protocol in grid-connected operation.

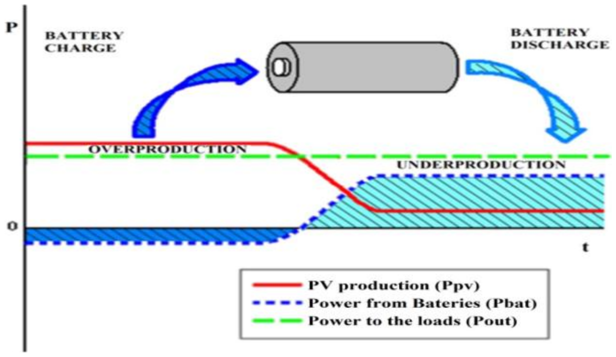

Fig. 5. Energy management protocol in islanded mode operation.

V. SIMULATION RESULTS

This section presents simulation results of the aforementioned system. These simulations were conducted using MATLAB software and tested on the PV inverter and grid previously. described in Section II. The grid inductance value chosen for simulations is Lgrid = 270 μH. In the simulations, the following nomenclature has been used.

1) *P*out: power delivered by the inverter to the ac side.
2) *P*bat: power delivered by the batteries.
3) *PPV*: power delivered by the PV source.

Fig.6 explains an irradiance variation (*P*PV is increased from 500 W to 2 kW), followed by a variation of the battery charge power (*P*bat varies from −880 to 0W) in grid-connected operation. The upper two graphs show the evolution of the point of common coupling (PCC) voltage and the ac current injected by the inverter. The third graph shows the evolution of the battery output current (*I*bat < 0 means that the batteries are being charged). The fourth graph shows the dc-link voltage evolution. The bottom graph shows the evolution of the power delivered by the inverter and batteries. In this operational mode, the dc-link voltage reference is established by the MPPT algorithm, and the inverter follows this reference.

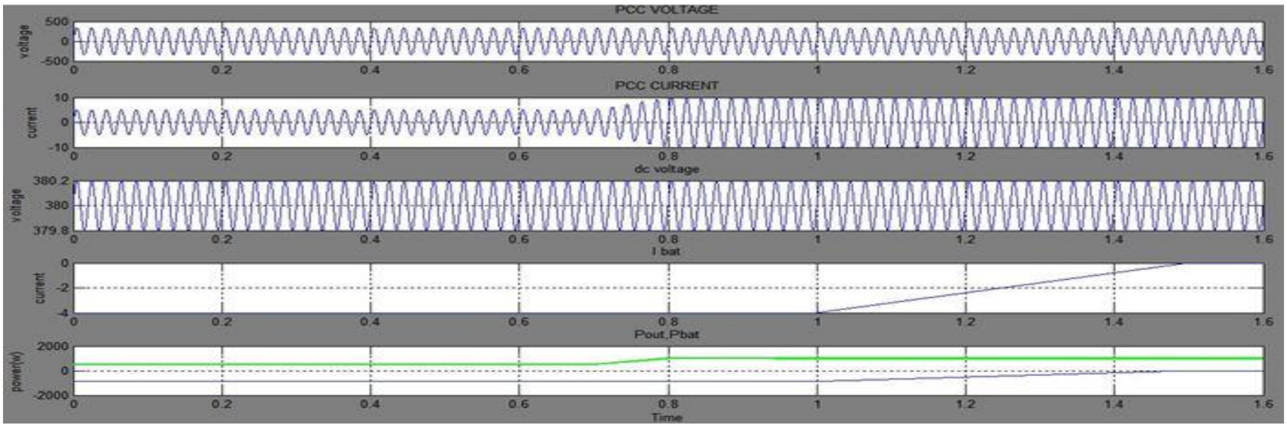

Fig. 6. Simulation of an irradiance variation followed by a battery charge variation in grid-connected mode.

Fig. 7 gives the response of the system to load steps (*P*out = 1 kW → 1.7 kW → 2.4 kW → 1.7 kW resistive load) working in islanded mode at a constant PV power (*PPV* =1.8 kW). The inverter output voltage is unaffected by the load step. Note that, when *P*bat < 0, the batteries are being charged whereas, when this power is positive, the batteries deliver the needed supplementary power to the loads. The inverter output power decreases or increases depending on the load power,whereas the PV output power and the dc-link voltage remain constant. The battery bank supplies or absorbs the necessary power to keep a constant dc-link voltage, tracking the MPP of the PV panel.

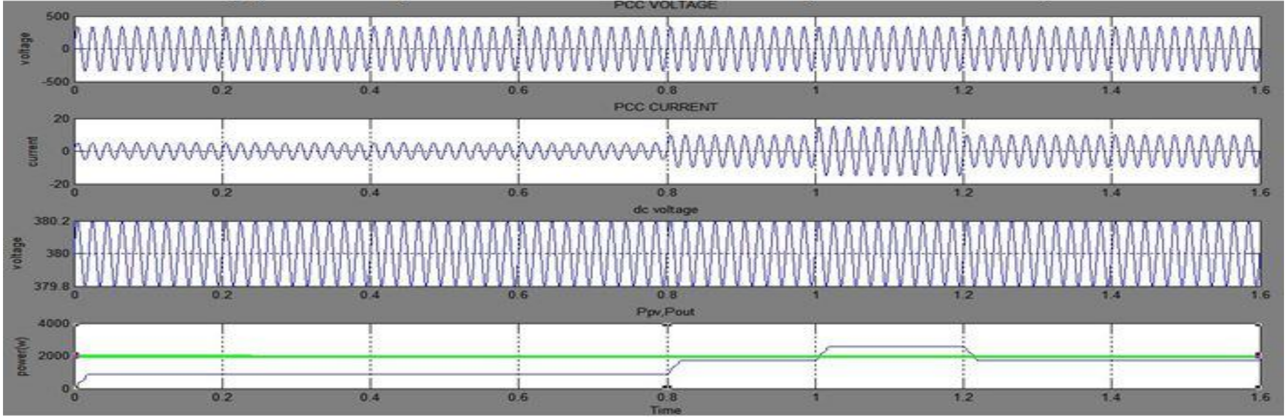

Fig.7. Simulations in islanded mode. Resistive load variations at a constant irradiation level.

Fig. 8 shows the transition from grid-connected mode to islanded mode at a constant irradiance of the PV array (*P*PV=1200 W). After the islanding, the local load power demand (1500-W resistive load) is higher than the PV-source generated power, and the batteries provide the difference. Note that the inverter output current produces a minimum variation of the PCC voltage in the transition to islanded mode. The fifth graph depicts the instant in which islanding occurs at *t* = 0.5 s.

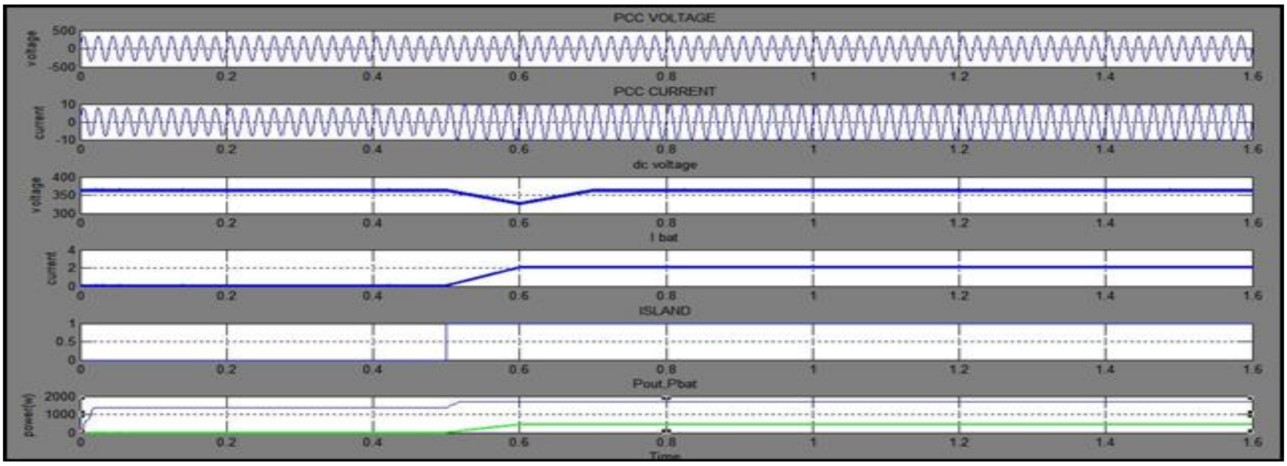

Fig. 8. Transition from grid-connected mode to islanded mode at a constant *P*PV. The local load is 1500 w resistive.

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Fig. 9 shows the simulation of a transition from islanded mode to grid-connected mode. This transition is produced after the inverter output phase synchronization with the grid phase [36]. The power demanded by the local load (2.1 kW resistive) is higher than the available PV power (*P*PV = 1.2 kW). Before the transition, the batteries provide the difference. In a smooth transition, there is a soft transient in the dc-link voltage. After the transition, the inverter works as a current source in phase with the grid voltage.

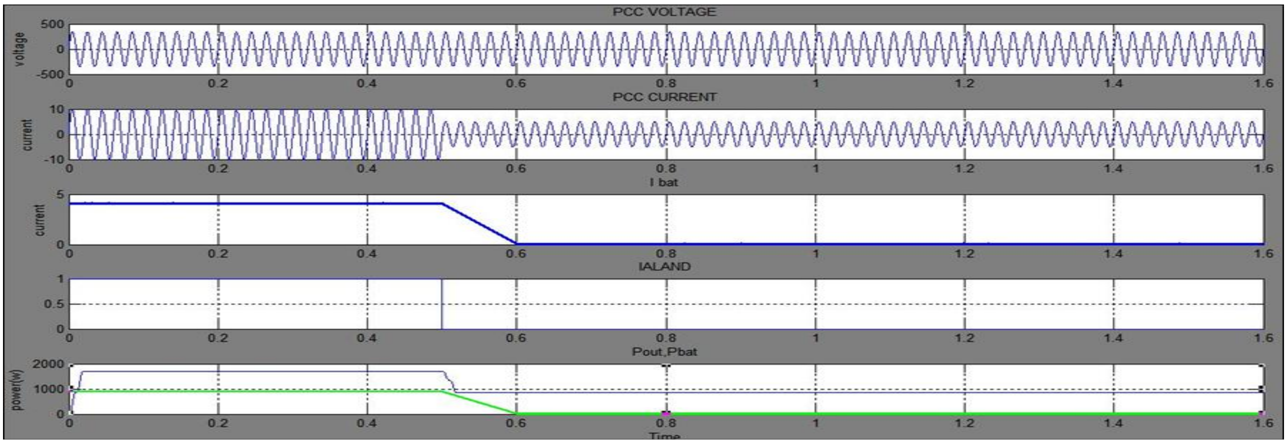

Fig. 9. Transition from islanded mode to grid-connected mode.

VI.CONCLUSION

A PV power management framework with battery backup fit for both islanded and grid connected operations has been studied over in this paper. The framework is in view of a battery-side dc/dc converter connected with the dc connection of the PV inverter. The control of the dc-join voltage is performed by the dc/dc converter in islanded operation and by the inverter in grid associated mode. The MPPT calculation gives the dc-join voltage reference for both of the power converters. Just a piece of the generated power is processed by the dc/dc converter. The power flow in the batteries and their charge level are controlled by the dc/dc converter. The transition between grid-connected and islanded modes and vice versa is actualized by method for a reconfiguration of controllers. In grid connection mode, the inverter is controlled as a present source in stage with the grid voltage. At the point when the inverter gets to be isolated from the grid, the inverter changes its control setup, functioning as a voltage source and utilizing the droop strategy to feed the nearby loads. The batteries give the supplementary energy to the loads if the PV accessible power is insufficient.

REFERENCES

[1] J. M. Guerrero, J. C. Vasquez, J. Matas, M. Castilla, and L. G. de Vicuna,“Control strategy for flexible microgrid based on parallel line-interactive UPS systems,”IEEE Trans. Ind. Electron., vol. 56, no. 3, pp. 726–736,Mar. 2009.

[2] K. Jaehong, J. M. Guerrero, P. Rodriguez, R. Teodorescu, and N. Kwanghee, “Mode adaptive droop control with virtual output impedances for an inverter-based flexible ac microgrid,” IEEE Trans. Power Electron., vol. 26, no. 3, pp. 689–701, Mar. 2011.

[3] I. J. Balaguer, L. Qin, Y. Shuitao, U. Supatti, and F. Z. Peng, “Control for grid-connected and intentional islanding operations of distributed power generation,”IEEE Trans. Ind. Electron., vol. 58, no. 1, pp. 147–157,Jan. 2011.

[4] C. L. Chen, Y. Wang, J. S. Lai, Y. S. Lee, and D. Martin, “Design of parallel inverters for smooth mode transfer microgrid applications,”IEEE Trans. Power Electron., vol. 25, no. 1, pp. 6–15, Jan. 2010.

[5] K. Hyosung, Y. Taesik, and C. Sewan, “Indirect current control algorithm for utility interactive inverters in distributed generation systems,” IEEE Trans. Power Electron., vol. 23, no. 3, pp. 1342–1347, May 2008.

[6] M. A. Hassan and M. A. Abido, “Optimal design of microgrids in autonomous and grid-connected modes using particle swarm optimization,” IEEE Trans. Power Electron., vol. 26, no. 3, pp. 755–769, Mar. 2011.

[7] J. C. Vasquez, J. M. Guerrero, A. Luna, P. Rodriguez, and R. Teodorescu, “Adaptive droop control applied to voltage-source inverters operating in grid-connected and islanded modes,”IEEE Trans. Ind. Electron., vol. 56, no. 10, pp. 4088–4096, Oct. 2009..

[8] W. Yao, M. Chen, J. Matas, J. M. Guerrero, and Z. M. Qian, “Design and analysis of the droop control method for parallel inverters considering the impact of the complex impedance on the power sharing,”IEEE Trans. Ind. Electron., vol. 58, no. 2, pp. 576–588, Feb. 2011.

[9] T. Esram and P. L. Chapman, “Comparison of photovoltaic array maximum power point tracking techniques,” IEEE Trans. Energy Conv., vol. 22, no. 2, pp. 439–449, Jun. 2007.

[10] N. Femia, G. Petrone, G. Spagnuolo, and M. Vitelli, “A technique for improving P&O MPPT performances of double-stage grid-connected photovoltaic systems,” IEEE Trans. Ind. Electron., vol. 56, no. 11, pp. 4473–4482, Nov. 2009.