Photovoltaic Inverter control using Fuzzy based controller in a CERTS Microgrid

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ABSTRACT

In this paper, Micro grids are highly effective with Photo Voltaic (PV) sources due to ability to maintain balance among multiple renewable resources. Conventional grid-connected PV inverter control designs are fundamentally presented. The PV inverter utilizing the Consortium for Electric Reliability Technology Solutions (CERTS) ideas can control ac voltage and frequency but load transients are associated. During load transients, the PV micro source gets to be over-loaded with the likelihood of breaking down the dc bus voltage results in ac voltage drop. This paper introduces a PV inverter control methodology which enables PV to maintain as a voltage source and capable of maintaining stable dc bus voltage during load transient.

Key words— *Consortium for Electric Reliability Technology Solutions (CERTS), controller, microgrid, photovoltaic (PV).*

I. INTRODUCTION

The Consortium for Electric Reliability Technology Solutions (CERTS) micro grid refers to a cluster of micro sources what's more, storage with the capacity to separate and isolate itself from the utility consistently with almost no disturbance to the loads.

CERTS micro grids are exceptionally good with photo voltaic (PV) due to their capacity to inside total and adjust different distributed generations. Conventional PV inverters control systems can be for the most part partitioned into two classes as: 1) grid-connected control and 2) stand-alone control. The grid-connected control fundamentally specifically controls the currents of PV sources injected into the grid, which makes the PV source as present sources. These control strategies are suitable for the grid-connected mode because the grid voltage is usually stiff, so the PV sources can always output maximum power when the maximum power point tracking (MPPT) is installed. Be that as it may, because of the absence of the capacity to direct voltage furthermore, frequency, these control techniques don't permit PV sources to work alone in islanded mode. Contrast, the stand-alone control empowers PV sources to direct voltage and frequency, so the PV sources can fill in as voltage sources to supply load in islanded mode. In any case, because of the discontinuity of daylight, energy stockpiling must be associated with the dc bus, which expands the expense of the PV system. In a micro grid domain, the micro sources need to work in grid-connected mode what's more, islanded mode, and to accomplish consistent exchange between these two modes. A few micro sources adopt current sources control of micro sources in grid connected mode and voltage-sources control of micro sources in islanded mode, and switch control modes amid islanding. This procedure requires quick islanding identification to accomplish consistent exchange capacity. The disappointment of islanding identification may make the micro grid quit working. The IEEE Standard 1547.4-2011 recommends that the voltage-source mode is ideal for micro sources when made arrangements for islanding. The micro sources in the CERTS micro grid embrace a brought together CERTS controller, which guarantees them working in both modes without switching control strategies. The consistent exchange is effortlessly accomplished on the grounds that no islanding recognition is required. The CERTS ideas permit numerous micro sources to manage voltage and frequency freely also, cooperate in an islanded system to share the load. All CERTS micro sources act as voltage sources.

The PV sources that embrace the CERTS ideas can acquire the points of interest that the customary CERTS micro sources have. The PV micro grid is expected to be designed for a high export of solar energy when it is connected to the grid. During islanding, the PV with CERTS control can naturally back off its generation to meet the low-level load. Conventional current-sourced PV can't back off their generation easily. In a micro grid, there are various quick reacting micro sources, which show that the energy storage required by the dc bus of the PV to work in stand-alone mode is no more essential, which altogether decreases the expense of the PV system. Nonetheless, PV sources utilizing CERTS control have a noteworthy issue when PV gets to be overload. Any huge unsettling influences, for example, load drifters, or a change of daylight or temperature will bring about the over-load of PV with the likelihood of breaking down dc bus voltage, resulting in ac voltage drop.

This paper examines the utilization of PV sources in a micro grid with CERTS ideas. The single-stage PV inverter is talked about here for its lower cost and higher power change proficiency. A CERTS PV micro source controller is designed, Which empowers the PV to carry on as a voltage source, and gets to be equipped for keeping up dc bus voltage security during load homeless people The associations amongst PV and a customary micro source have been studied in two purposeful islanding occasions. It is demonstrated that with this outlined controller, the breakdown of dc bus voltage of PV could be maintained a strategic distance from. The outlined controller empowers PV micro sources to fill in as voltage sources in a CERTS micro grid

II. CERTS MICROGRID CONCEPTS

A. Voltage Control

All together to maintain the voltage stability of an islanded micro grid, no less than one micro source is required to carry on as a voltage source. By considering the unwavering quality of the micro grid, more micro sources are relied upon to carry on as voltage sources. The following equations show the expressions of real power and reactive power Q from micro source:

$$P = \frac{EV}{X} \sin \delta \qquad (1)$$

$$Q = \frac{E}{X} (E - V \cos \delta) \qquad (2)$$

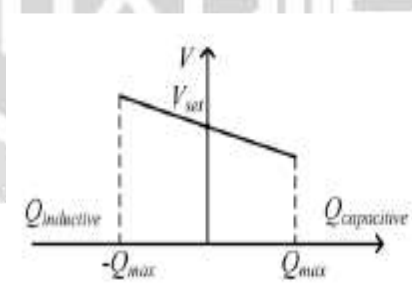


Fig. 1. Voltages versus reactive power droop.

Where is the inverter output voltage magnitude V is the micro grid- side voltage magnitude, X is the coupling reactance, and is the phase angle across X. In the event that is measured to make δ not exactly 10, P is direct with δ , and is Q straight with. All CERTS sources control the voltage however they additionally guarantee that there are no substantial coursing reactive currents between units. With small errors in voltage set points, the coursing current can surpass the appraisals of the units. This circumstance requires a voltage versus reactive power droop controller so that as the reactive power Q that is produced by the unit turns out to be more capacitive, the local voltage set point is lessened. Alternately, Q as turns out to be more inductive, the voltage set point is expanded. This droop is needy on the utility's voltage swings and reactive power available from the sources. Fig. 1 demonstrates V the versus Q droop.

B. Frequency Control

The CERTS micro sources control the frequency specifically. As appeared in Fig. 2, power versus frequency droop is utilized to adjust the power between micro sources. The slope is ordinarily chosen by allowing the frequency to drop by 0.5Hz as the force ranges from P_{min} too P_{max} .

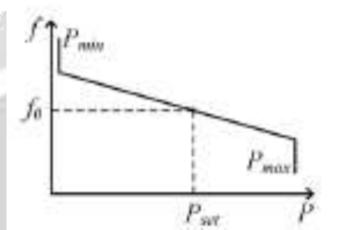


Fig. 2. Power versus frequency droop.

C. Overload Issue of CERTS Micro sources

The CERTS source is expressly protected from self-overloading by driving the frequency down when the unit gets to be over-loaded. A large load increase might cause the micro source to overshoot its power rating. A maintained

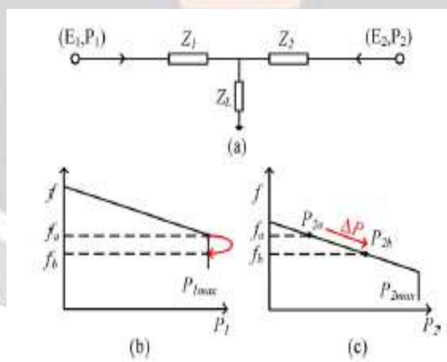


Fig. 3. Two-micro source network and versus droop. (a) two-micro source Network.
(b) Versus droop of $\mathrm{Microsource}_1$.
(c) Versus droop of $\mathrm{Microsource}_2$.

Over-load can stall the internal combustion engine (ICE) or collapse the dc bus voltage of the PV. In a micro grid, it is a common phenomenon that a few sources have come to their power limits while alternate sources have not. In these conditions, when a positive load transient occurs, all of the micro sources will instantaneously increase their output to make up for the additional load in view of their voltage-sources qualities. Be that as it may, the micro sources, which have come to their power limits, ought not to expand their output. On the off chance that measures are not taken, these micro sources may stop working due to the over-load.

III. PV SOURCES IN THE CERTS MICROGRID

A. Advantages of Making PV Source a Voltage Source

The PV micro grid is relied upon to be intended for high export of solar energy in grid-connected mode. As by setting the P_{set} as its appraised power, the maximum power point (MPP) moves around the left half of P_{set}, so the PV could simply output maximum power to the grid. At the point when IEEE 1547 occasions happen, the voltage-sourced PV can naturally back off the solar generation during low-load islanding, companioned with a little increment in frequency. Moreover, a voltage-sourced PV can manage voltage and frequency inside its energy rating, which expands the unwavering quality of the micro grid by considering the N-1 stability criterion.

B. Challenges of Designing the CERTS PV Inverter Controller

There are a few difficulties in designing a CERTS PV inverter controller. Initial, a major difference which distinguishes PV from different micro sources is that the PV dc bus may collapse during an expansive load transient or sensational change in environment. The main inertia of a commercial PV inverter is the limited energy put away in the dc bus, which is ordinarily in the region of 0.01 p.u. - second. This shows the outlined controller needs to react in under 10 ms or the dc transport breakdown may Happen. Second, financial motivating forces require PV output most extreme power when it is conceivable. This requires a MPPT be implanted in the controller.

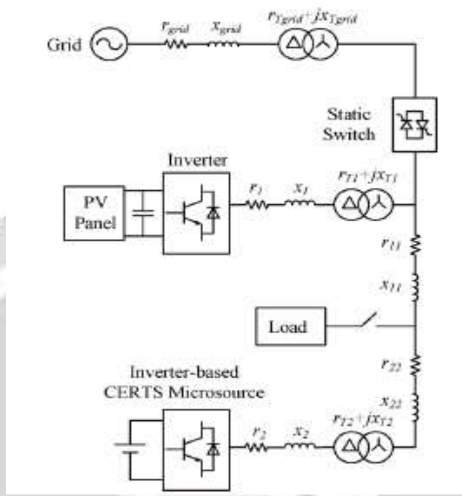
C. Stability Analysis of DC Bus Voltage of the PV Inverter

Reported that the current-sourced PV inverters may endure dc bus voltage (V_{dc}) breakdown during a disturbance in grid-connected mode. Similar problems also exist when PV sources supply the load as voltage sources. Fig. 6 demonstrates the power versus voltage (V_{dc}) bend of a 100-kW evaluated PV cluster in a specific domain. At the point when a solitary PV source supplies the load, the framework is steady just when V_{dc} is higher than the MPP voltage, where $dP/dV < 0$. The dc bus stability could be clarified as: If is below the MPP voltage, any positive load step will lead the drop V_{dc} of to release the power put away in the dc capacitor, and the drop of V_{dc} decreases the output power from the PV panal which further increases the drop of V_{dc}, so V_{dc} the at last falls. Conventional CERTS droop control does not consider the dc transport voltage soundness issue, and it doesn't control the dc bus voltage during a substantial load transient. In this manner, measures must be taken to keep the dc bus breakdown from occurring.

STUDIED MICROGRID SYSTEM

Keeping in mind the end goal to assess the impact of the designed controller, a two-source micro grid system is considered in this paper. The 2-source system speaks to the most serious overload issue of micro grid, in light of the fact that each micro source needs to stand a half of the additional load during a positive load step. The variation of sunlight furthermore, temperature is typically much slower than a quick load step, in the event that the controller is equipped for managing quick load transient, it can likewise manage the variety of daylight and temperature. Thusly, this paper just demonstrates the instances of load drifters.

The reduced CERTS/AEP Micro grid Laboratory Test Bed is displayed to ponder the collaborations between PV micro source what's more, a customary CERTS micro source. As appeared in Fig. 10, a 100 kW customary Inverter-based CERTS micro source furthermore, a 100 kW PV micro source are considered in a 480 Vrms micro grid. The micro grid is associated with the 13.8 kV lattice through a static switch and a transformer. The customary CERTS micro source receives the standard hang control and is expected to have enough operational force edges.



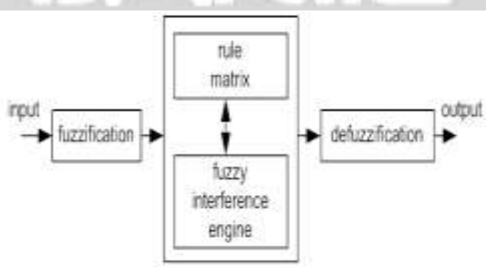
Reduced AEP/CERTS Micro grid laboratory test bed.

Extension topic

Fuzzy logic

Fuzzy logic is a form of many-valued logic in which the truth values of variables may be any real number between 0 and 1. By contrast, in Boolean logic, the truth values of variables may only be 0 or 1. Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. Further more, when linguistic variables are used, these degrees may be managed by specific functions.

Usually fuzzy logic control system is created from four major elements presented on Figure fuzzification interface, fuzzy inference engine, fuzzy rule matrix and defuzzification interface. Each part along with basic fuzzy logic operations will be described in more detail below.

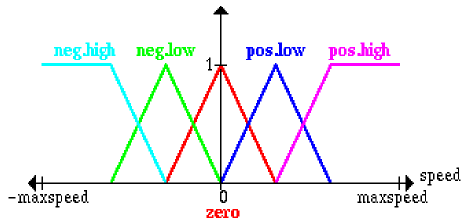


The fuzzy logic analysis and control methods shown in Figure 1 can be described as:

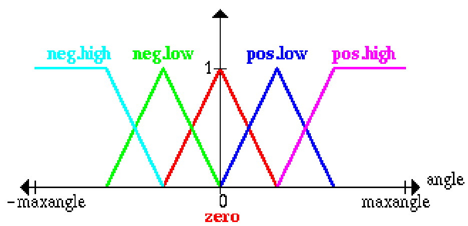
1. Receiving one or large number of measurements or other assessment of conditions existing in some system that will be analyzed or controlled.
2. Processing all received inputs according to human based, fuzzy "if-then" rules, which can be expressed in simple language words, and combined with traitional non-fuzzy processing.

3. Averaging and weighting the results from all the individual rules into one single output decision or signal which decides what to do or tells a controlled system what to do. The result output signal is a precise defuzzified value.

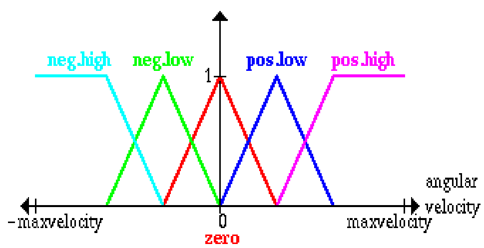
First of all, the different level of output (high speed, low speed etc.) of the platform is defined by specifying the membership functions for the fuzzy sets. The graph of the function is shown below

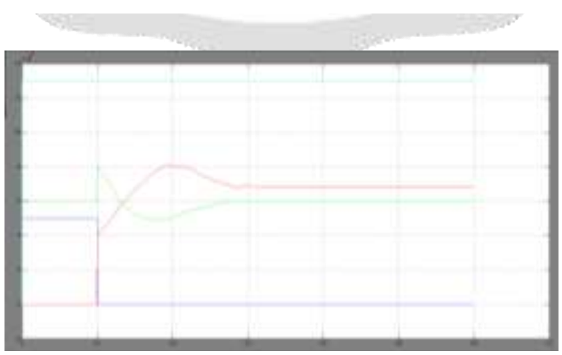


similarly, the different angles between the platform and the pendulum and...

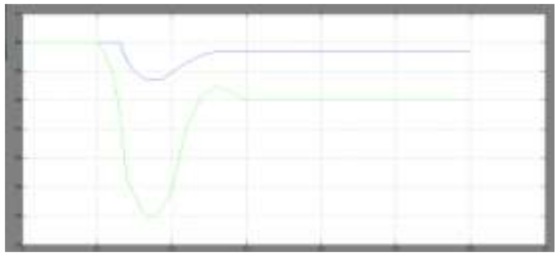


the angular velocities of specific angles are also defined

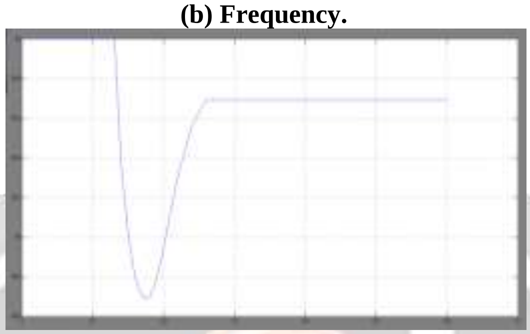




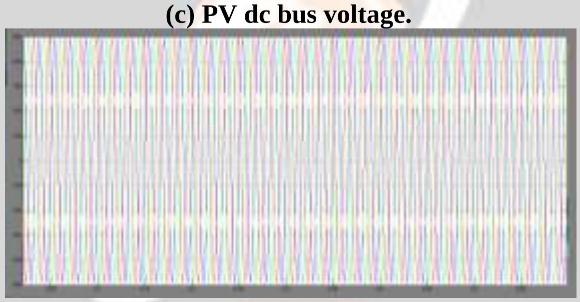
Dynamic responses of case A (a).Real power



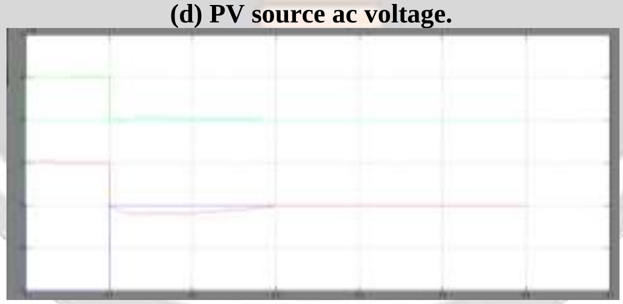
(b) Frequency.



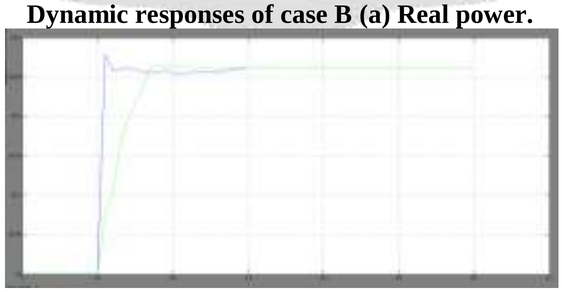
(c) PV dc bus voltage.



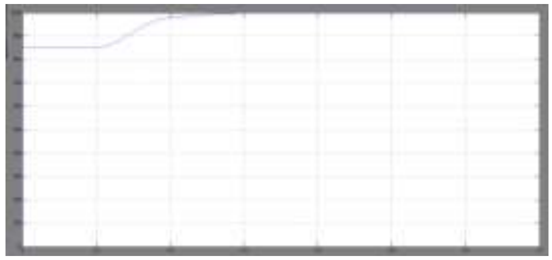
(d) PV source ac voltage.



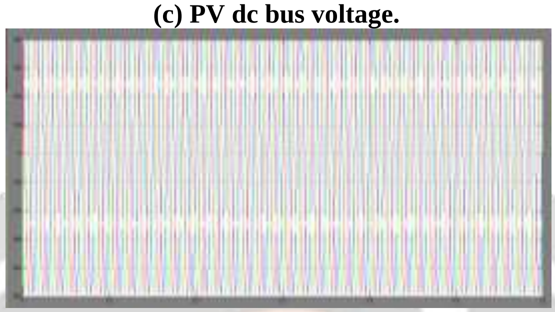
Dynamic responses of case B (a) Real power.



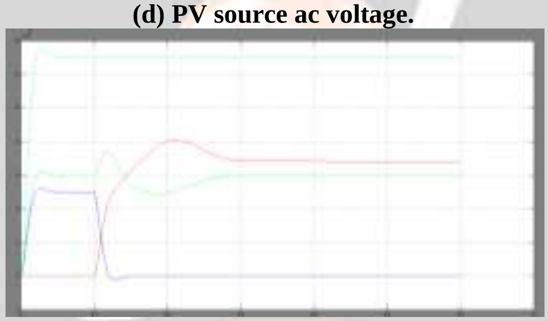
(b) Frequency.



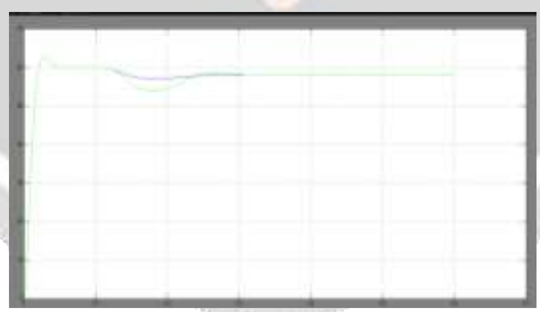
(c) PV dc bus voltage.



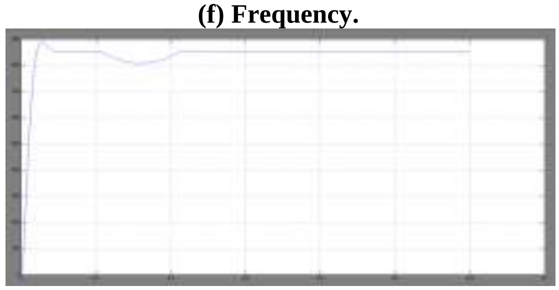
(d) PV source ac voltage.



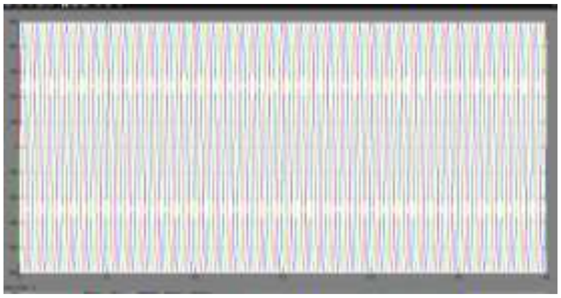
Dynamic responses of case A (e).Real power



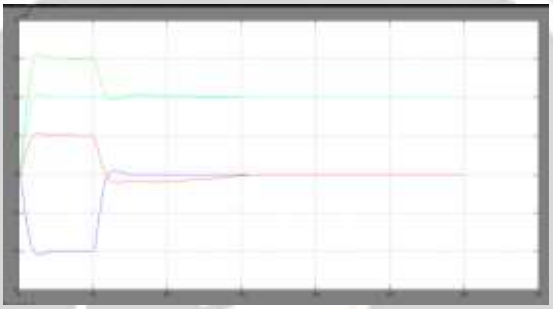
(f) Frequency.



(g) PV dc bus voltage.

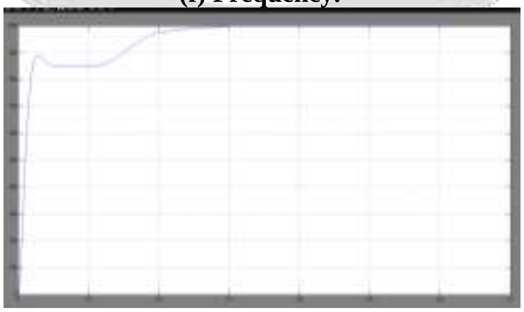


(h) PV source ac voltage

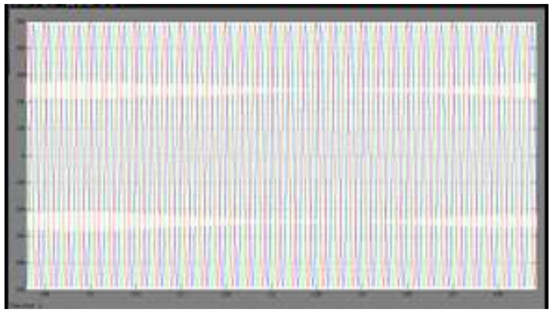


Dynamic responses of case B (e).Real power

(f) Frequency.



(g) PV dc bus voltage.



(h) PV source ac voltage

Conclusion

This paper designs a controller which empowers the PV source to carry on as a voltage source in the CERTS micro grid and maintains the dc bus voltage stability during load Trasients. Conventional CERTS droop control is adopted in the control design; what's more, another controller is imagined. The over-load issue of the CERTS micro grid and the dc bus voltage breakdown issue of the PV micro source are examined. The impacts of the parameters of the controller on system small signal security are broke down. Two deliberate islanding are simulated to exhibit how the outlined controller accomplishes the control destinations, for example, keeping up dc bus voltage stability during load transients, naturally backing off solar generation during low load islanding, and consistent exchange between grid-connected mode and islanded mode. It is demonstrated that the designed controller can effectively keep the dc bus voltage breakdown from occurring during the load transient, and the PV sources with CERTS droop control can have the focal points that the traditional CERTS micro sources have. The PV micro source can work as a voltage source in the CERTS micro grid with the designed controller.

REFERENCES

[1] R. H. Lasseter, "Micro Grids," presented at the Power Engin. Soc. Winter Meet., New York, USA, 2002.
[2] J. Selvaraj and N. A. Rahim, "Multilevel inverter for grid-connected PV system employing digital PI controller," IEEE Trans. Ind. Electron.,, vol. 56, no. 1, pp. 149–158, Jan. 2009.
[3] R. Teodorescu, F. Blaagjerg, U. Borup, and M. Liserre, "A new control structure for grid-connected LCL PV inverters with zero steady state error and selective harmonic compensation," in Proc. IEEE 19th Annnu. Appl. Power Electron.
[4] R. Gules, J. De Pellegrin Pacheco, H. L. Hey, and J. Imhoff, "A maximum power point tracking system with parallel connection for PV stand-alone applications," IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2674–2683, Jul. 2008.
[5] S. Duryea, S. Islam, andW. Lawrence, "A battery management system for stand-alone photovoltaic energy systems," IEEE Ind. Appl. Mag., vol. 7, no. 3, pp. 67–72, Jun. 2001.

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