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Least Power Point Tracking Method for Photovoltaic Differential Power Processing Systems

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ABSTRACT

Differential power processing (DPP)systems are a promising architecture for future photovoltaic (PV) power systems that achieve high system efficiency through processing a faction of thefull PV power, while achieving distributed local maximum power point tracking (MPPT). In the PVto-bus DPP architecture, the power processed through the DPP converters depends on the string current, which must be controlled to minimize thepower processed through the DPP converters. A realtimeleast power point tracking (LPPT) method is proposed to minimize power stress on PV DPPconverters. Mathematical analysis shows theuniqueness of the least power point for the total power processed through the system. The perturband observe LPPT method is presented that enablesthe DPP converters to maintain optimal operatingconditions, while reducing the total power loss andconverter stress. This work validates throughsimulation and experimentation that LPPT in thestring-level converter successfully operates withMPPT in the DPP converters to maximize outputpower for the PV to- bus architecture. Hardware prototypes were developed and tested at 140 W and300 W, and the LPPT control algorithm showedeffective operation under steady-state operation andan irradiance step change. Peak system efficiencyachieved with a 140-W prototype DPP systememploying LPPT is 95.7%.

KEYWORDS: *Differential power processing systems,power converter, maximum power point tracker, leastpower point tracker, PWM, IC, string current.*

I. INTRODUCTION

This is a technique used commonly with wind turbines and photovoltaic (PV) solar systems to maximize power extractions under all conditions. Electrical circuits can be designed to present arbitrary loads to the photovoltaic cells and then convert the voltage, current, or frequency to suit other devices or systems. LPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.
Regardless of the ultimate destination of the solar power, though, the central problem addressed by MPPT is that the efficiency of power transfer from the solar cell depends on both the amount ofsunlight falling on the solar panels and the electrical characteristics of the load. As the amount of sunlight varies, the load characteristic that gives the highest power transfer efficiency changes, so that the efficiency of the system is optimized when the load characteristic changes to keep the power transfer at highest efficiency.

Solar cells have a complex relationship between temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. PWM controlled by MPPT algorithm and its including in on the boost converter and inverter power circuit and the circuit is connected through the grid. In this that the grid are having two different varities.On-grid and off-grid systems. More efficient and cost-effective PV modules are being developed and manufactured, in response to the concerns raised by the PV system developers, utilities and customers.

II. POWER POINT TRACKING TECHNIQUES

i) incremental conductance
ii) perturb-and-observe
iii) hill climbing
iv) fuzzy logic

i) incremental conductance:

This research was aimed to explore the performance of a maximum power point tracking system which implements incremental conductance method. The IC algorithm was designed to control the duty cycle of buck boost converter and to ensure the MPPT work at its maximum efficiency. The system performance of IC algorithm was compared to widely used algorithm – perturb and observe (p & o) on a Simulink environment. From the simulation, the IC method shows a better performance and also has a low oscillation.

ii) perturb-and-observe:

An improved P&O based MPPT method for PV system is developed. The method enhances the steady state performance of the conventional P&O. Proposed method minimizes the probability of losing the tracking direction. The energy yield is increased by 2% on average. No complex computation is required and hardware implementation is very simple.

iii) hill climbing:

The main objective is to track the maximum power point by using an adaptive hill climb searching techniques based on fuzzy logic controller and compare it with the conventional optimal torque control method for large inertia PV.

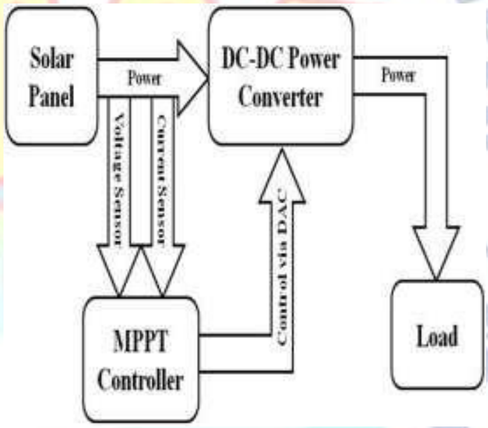
iv) fuzzy logic:

This paper proposed an intelligent method for maximum power point tracking based on fuzzy logic controller. This system consists of a photovoltaic solar module connected to a DC-DC buck-boost converter. The system has been experienced under disturbance in the photovoltaic temperature and irradiation level. It gives higherefficiency and better performance that theconventional perturbation and observation method.

III. EXISTING SYSTEM

Among the various renewable green energysources, solar photovoltaic (PV) power generationcapacity is increasing worldwide. In addition to theconstruction of large, utilityscale solar farms,rooftop solar systems are also gaining wideacceptance in many areas. For PV power at boththe utility and residential scale, cost and efficiencyare crucial factors to maximizing watts-per-cost,which is a primary concern for PV system owners.Ease of installation with minimal power electronicsis also an important consideration. Increasingefficiency, decreasing system cost, and reducingthe size of the power converters are all importantfactors in developing future PV systems. Thisresearch focuses on a control algorithm for therecently-spotlighted converter architecture for PVsystems, called differential power processing(DPP), which shows promise in terms of efficiency,cost, and size improvements.

A. BLOCKDIAGRAM:



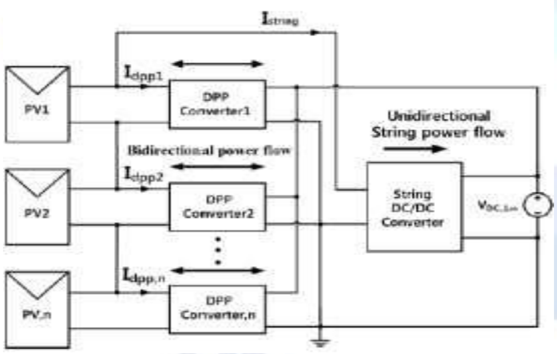
Hence, this algorithm does not have to scanthe entire *P–V* curve. If only one peak exists on the*P–V* curve, as is the case during uniform insolation,the algorithm may scan the entire range. To avoidthis, after the application of each large disturbance(ΔVlarge), oscillations in the power are measured. Ithas been observed that in case of uniforminsolation, as soon as the operating point shiftsclose to *I*SC (i.e., away from MPP), the applicationof a large disturbance in *V*ref results in largeoscillations in the array power. Hence, in such acase, if the oscillations are greater than a certaintolerable power variation (ΔPtol: 4%–5% of arraycapacity), the controller immediately restores theoperation to the GP. The modelling equations,obtained by the Kirchhoff's laws, are where iL isthe input current (equal to the PV array current), Lbis the boost inductance, Vbi is the input voltage(equal to the PV array voltage), d is the switchstate, VDC is the boost output voltage, CDC is theDC-link capacitor and iinv is the inverter input DCcurrent. This model. Therefore, we proposed a twostageintelligent PV system, which is similar tomodular configuration topology.

In an intelligentPV module instead of interconnection betweenmodules they are interconnected with associatedDCDC converter for MPPT tracking which ensuresoptimal operations of PV module. Various MPPTalgorithms exist in different literatures. In thisresearch, we propose perturb and observe (P&O)method to extract maximum possible power fromsolar panel. The overall simplicity andefficiency of PV system depends on the MPPTtechnique employed. Various alternativesarchitectures for grid connected PV systemconfigurations are available, such as centralizedmodule, AC module and modular configurationwhere the last topology perfectly fits with anintelligent PV module concept.

IV. PROPOSED SYSTEM

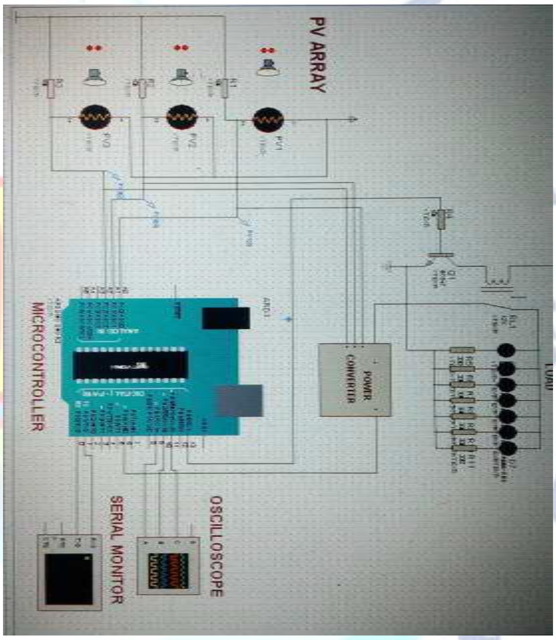
The proposed LPPT algorithm uses a P&Oalgorithm and was designed to worksimultaneously with a P&O MPPT algorithm. Thetime scale of the LPPT algorithm is significantlyshorter than that of the MPPT algorithm to ensurethat the algorithms' perturb and observe cycles donot interfere with each other.

A. PROPOSED BLOCK DIAGRAM:



This paper has introduced a LPPT algorithmfor the PV bus DPP architecture that aims tominimizes the power processed through the highstep-up, DPP fly-back converters. The LPPTalgorithm calculates the instantaneous powerprocessed through the DPP converters and controlsthe string current to operate at the least power pointof the DPP converters' power curve. Mathematicalanalysis was presented for the ideal case, showingthat the LPP will either be a single point that isequal to one of the PV currents or a continuousunique set of points that includes at least two PVcurrents. The proposed LPPT algorithm uses aP&O extremum-seeking algorithm and wasdesigned to work simultaneously with a P&O. MPPT algorithm. The time scale of the LPPTalgorithm is significantly shorter than that of theMPPT algorithm to ensure that the algorithms'perturb and observe cycles do not interfere witheach other. By varying the duty cycle of the buck boost converter, the source impedance can bematched to adjust the load impedance whichimproves the efficiency of the system. The LPPTalgorithm calculates the instantaneous powerprocessed through the DPP converters and controlsthe string current to operate at the least power pointof the DPP converters' power curve.

B. PROPOSED CIRCUIT DIAGRAM:

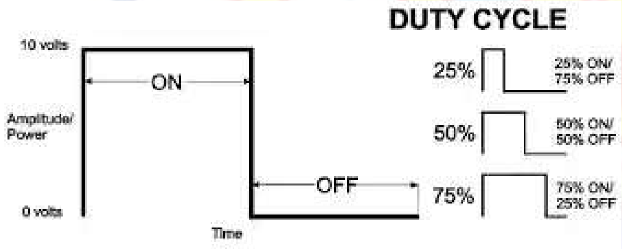


V. SYSTEM DESCRIPTION

a) PV PANEL:

Photovoltaics (PV) covers the conversionof light into electricity using semiconductingmaterials that exhibit the photovoltaic effect, aphenomenon studied in physics, photochemistry,and electrochemistry. A typical photovoltaicsystem employs solar panels, each comprising anumber of solar cells, which generate electricalpower. The first step is the photoelectric effectfollowed by an electrochemical process wherecrystallized atoms, ionized in a series, generate anelectric current. PV installations may be groundmounted,rooftop mounted or wall mounted. Theymay be mounted in a permanent orientation tomaximize production and value or they may bemounted on trackers that follow the sun across thesky. Solar PV generates no pollutionconversion ofsunlight to electricity occurs without moving partsof solar or wind energy. Advances in technologyand increased manufacturing scale have reducedthe cost, increased the reliability, and increased theefficiency of photovoltaic installations and the levelcost of electricity from PV is competitive, on akilowatt-hour basis, with conventional electricitysources in an expanding list of geographic regions

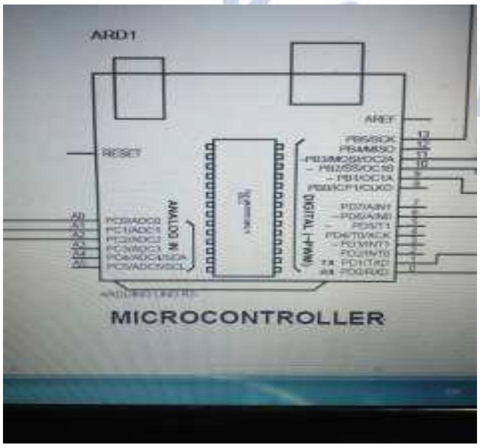
b) PWM:



Duty Cycle is an expression of the relationship of the "ON time" to "OFF time" of each cycle.

Pulse Width Modulation, or PWM, is atechnique for getting analog results with digitalmeans. Digital control is used to create a squarewave, a signal switched between on and off. Thison-off pattern can simulate voltages in between fullon (5 Volts) and off (0 Volts) by changing theportion of the time the signal spends on versus thetime that the signal spends off. The duration of "ontime" is called the pulse width modulation.

c) MICROCONTROLLER:



A microcontroller (or MCU formicrocontroller unit) is a small computer on asingle integrated circuit. In modernterminology, it is a System on a chip or SoC.A microcontroller contains one or more CPUs(processor cores) along with memory andprogrammable input/output peripherals.

Program memory in the form of FerroelectricRAM, NOR flash or OTP ROM is also oftenincluded on chip, as well as a small amount ofRAM. Microcontrollers are designed forembedded applications, in contrast to themicroprocessors used in personal computersor other general purpose applicationsconsisting of various discrete chips.

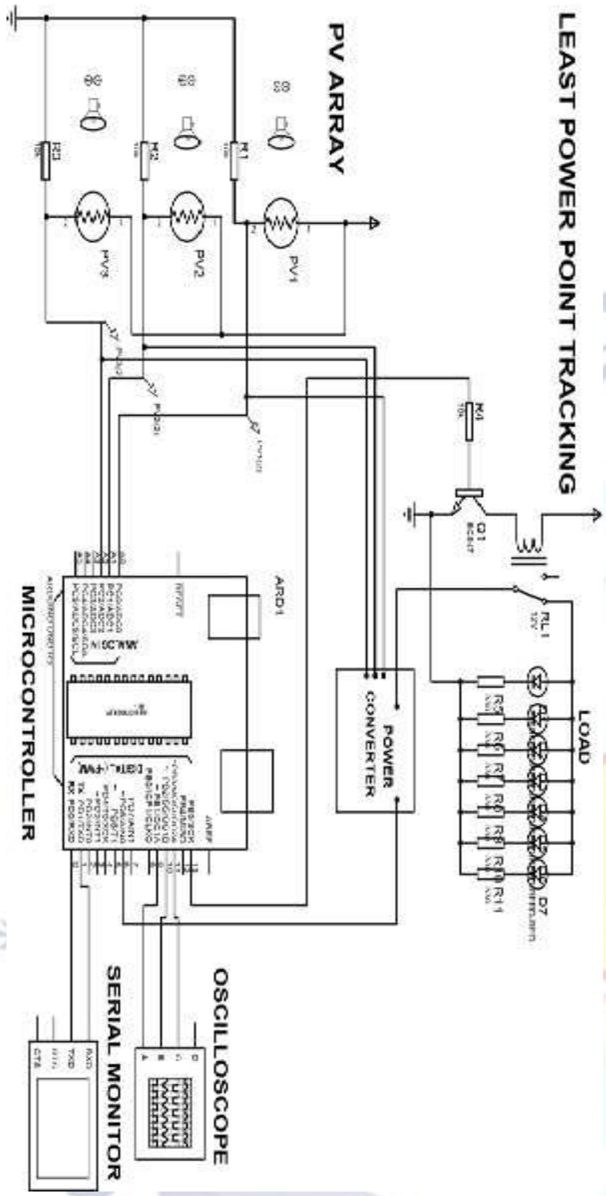
Microcontrollers are used in automaticallycontrolled products and devices, such asautomobile engine control systems,implantable medical devices, remote controls,office machines, appliances, power tools, toysand other embedded systems. By reducing thesize and cost compared to a design that uses aseparate microprocessor, memory, andinput/output devices, microcontrollers make iteconomical to digitally control even moredevices and processes. Mixed signalmicrocontrollers are common, integratinganalog components needed to control nondigitalelectronic systems.

D,Types:

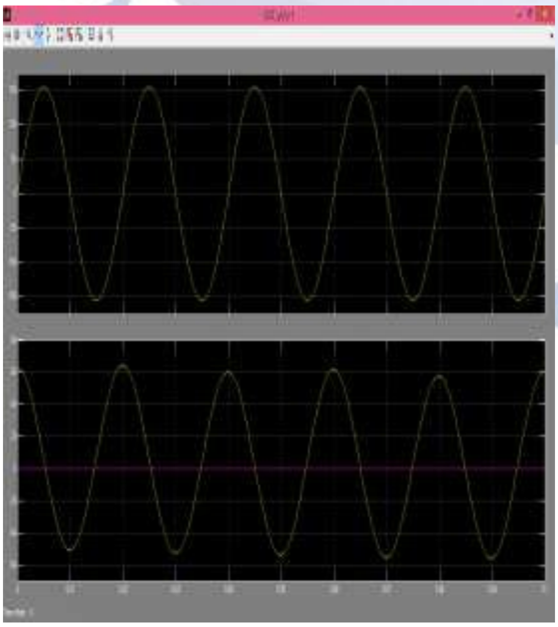
As of 2008, there are several dozenmicrocontroller architectures and vendorsincluding:

1) ARM core processors (many vendors)
2) ARM Cortex-M cores are specifically targetedtowards microcontroller applications
3) Atmel AVR (8-bit), AVR32 (32-bit), andAT91SAM (32-bit)
4) Cypress Semiconductor's M8C Core used intheir PSoC (Programmable System-on-Chip)
5) Freescale ColdFire (32-bit) and S08 (8-bit)
6) Freescale 68HC11 (8-bit), and others based onthe Motorola 6800 family
7) Intel 8051, also manufactured by NXPSemiconductors, Infineon and many others
8) NXP Semiconductors LPC1000, LPC2000,LPC3000, LPC4000 (32-bit), LPC900, LPC700 (8-bit)
9) Parallax Propeller
10) PowerPC ISE
11) Rabbit 2000 (8-bit)
12) Renesas Electronics: RL78 16-bit MCU; RX32-bit MCU; SuperH; V850 32-bit MCU; H8; R8C16-bit MCU

VI. SIMULATION VERIFICATIONS

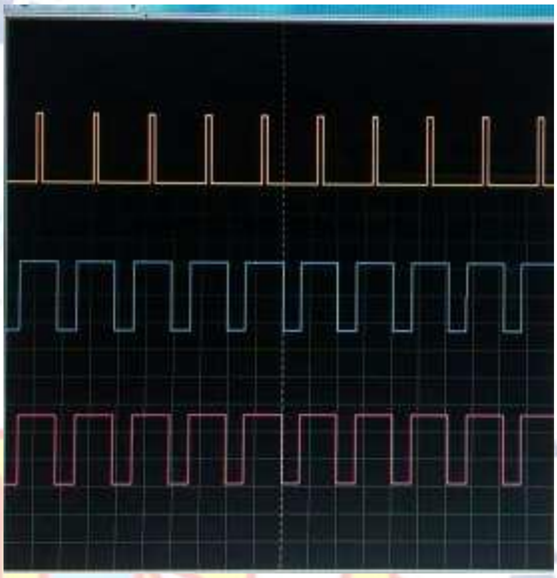


A. INVERTED VOLTAGE:



Inverter voltageThe AC output voltage of a power inverter is oftenregulated to be the same as the grid line voltage,typically 120 or 240 VAC at the distribution level,even when there are changes in the load that theinverter is driving. This allows the inverter topower numerous devices designed for standard linepower. Some inverters also allow selectable orcontinuously variable output voltages.

B. PWM PULSE:



Output of pwm pulsePulse-width modulation (PWM), isa modulation technique used to encode amessage into a pulsing signal. Although thismodulation technique can be used to encodeinformation for transmission, its main use is toallow the control of the power supplied to electricaldevices, especially to inertial loads such as motors.In addition, PWM is one of the two principalalgorithms used in photovoltaic solar batterychargers,[1] the other being least power pointtracking. The average value ofvoltage (and current) fed to the load is controlledby turning the switch between supply and load onand off at a fast rate. The longer the switch is oncompared to the off periods, the higher the totalpower supplied to the load. The PWM switchingfrequency has to be much higher than what wouldaffect the load (the device that uses the power),which is to say that the resultant waveformperceived by the load must be as smooth aspossible. The rate (or frequency) at which the power supply must switch can vary greatlydepending on load and application, The term *dutycycle* describes the proportion of 'on' time to theregular interval or 'period' of time; a low duty cyclecorresponds to low power, because the power is offfor most of the time. Duty cycle is expressed inpercent, 100% being fully on. The main advantageof PWM is that power loss in the switching devicesis very low. When a switch is off there ispractically no current, and when it is on and poweris being transferred to the load, there is almost novoltage drop across the switch. Power loss, beingthe product of voltage and current, is thus in bothcases close to zero. PWM also works well withdigital controls, which, because of their on/offnature, can easily set the needed duty cycle.

VII. CONCLUSION

Mathematical analysis was presented for theideal case, showing that the LPP will either be asingle point that is equal to one of the PV currents or a continuous unique set of points that includes atleast two PV currents. The proposed LPPT algorithm uses a P&O extremum-seeking algorithm. The control algorithms were shown to work simultaneously to achieve both individual PVMPPT and system LPPT in both simulation and experimentation. This work validates through simulation and experimentation that LPPT in the string-level converter successfully operates with MPPT in the DPP converters to maximize output power for the PV to- bus architecture. Hardware prototypes were developed and tested at 140 W and300 W, and the LPPT control algorithm showed effective operation under steady-state operation and an irradiance step change. Peak system efficiency achieved with a 140-W prototype DPP system employing LPPT is 95.7%.

REFERENCES

[1] P. Fairley, "Big solar's big surge," IEEESpectrum, vol. 52, no. 1, pp.41–44, January 2015.

[2] A. Ahmed, L. Ran, S. Moon, and J.-H.Park, "A fast pv power tracking algorithm withreduced power mode," IEEE Trans. EnergyConversion,vol. 28, no. 3, pp. 565–575, Sept. 2013.

[3] D. Thayalan, H.-S. Lee, and J.-H. Park,"Low-cost high-efficiency discrete current sensingmethod using bypass switch for pv systems,"IEEETrans. Instrum. Meas., vol. 63, no. 4, pp. 769–780,Apr. 2014.

[4] P. S. Shenoy, K. A. Kim, B. B. Johnson,and P. T. Krein, "Differential power processing forincreased energy production and reliability ofphotovoltaic systems," IEEE Trans. PowerElectron., vol. 28, no. 6, pp.2968–2979, 2013.

[5] Hohm D. P. and Ropp M.E., Comparativeof maximum power point tracking techniques,Progress in photovoltaics: Research andapplications journal, vol. 11 (2003), pp. 47-62

[6] Faranda R., Leva S., Energy comparisonof MPPT techniques for PV systems, WSEASTransactions on Power Systems, issue 6, vol.3,2008

[7] Azevedo G.M.S., Cavalcanti M. C., et al.,Evaluation of maximum power point trackingmethods for grid connected photovoltaic systems,proceedings of the IEEE Power Electronicsspecialists Conference 2008 (PESC'08), 15-19June 2008, island of Rhodes, Greece

[8] Jain S. and Agarwal V., Comparison ofthe performance of maximum power point trackingschemes applied to single-stage grid-connectedphotovoltaic systems, IEEETransactions in electric Power Applications, vol.1,no.5, pp.753-762, 2007

[9] Chin C.S., Neelakantan P., et al., Fuzzylogic-based MPPT for Photovoltaic Modulesinfluenced by solar irradiation and celltemperature, proceedings of the 13th InternationalConference on Modelling and Simulation UKSim,2011

[10] A. Balouktsis, T. D. Karapantsios, K.Anastasiou, A. Antoniadis, and I. Balouktsis,"Load matching in a direct - coupled photovoltaicsystem-application to Thevenin's equivalent loads,"International Journal of Photoenergy, vol. 2006,Article ID 27274, 7 pages, 2006. View at Publisher· View at Google Scholar

[11] F. R. Rubio, M. G. Ortega, F. Gordillo, andM. López-Martínez, "Application of new controlstrategy for sun tracking," Energy Conversion andManagement, vol. 48, no. 7, pp. 2174–2184, 2007.View at Publisher · View at Google Scholar View at Scopus

[12] S. Jain and V. Agarwal, "New current controlbased MPPT technique for single stage gridconnected PV systems," Energy Conversion andManagement, vol. 48, no. 2, pp. 625–644, 2007.View at Publisher ·View at Google Scholar · Viewat Scopus

[13] M. R. Patel, Wind and Solar Power Systems,CRC Press, Boca Raton, Fla, USA, 1999.

[14] M. A. Green, "Photovoltaics: technologyoverview," Energy Policy, vol. 28, no. 14, pp. 989–998, 2000.View at Publisher · View at GoogleScholar · View at Scopus R. Messenger and J.Ventre, Photovoltaic System Engineering, CRCPress, Boca Raton, Fla, USA, 2000.

[15] A. D. Hansen, P. Sorensen, L. H. Hansen,and H. Bindner, Models for a Stand-Alone PVSystem, Danka Services International A/S, 2001.